

# RAPPORT

## NL4202 - Aanlegsteiger Schipperskerk

### Constructieve Toetsing

Klant: Inter Boat Marinas B.V.

Referentie: BI7934-RHD-XX-ZZ-RP-Z-0002

Status: A1/C01

Datum: 11 augustus 2023

#### GEZIEN

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 Sittard-Geleen  
Born



INTER BOAT MARINAS



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Classificatie

Vertrouwelijk

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## Inhoud

|          |                                     |           |
|----------|-------------------------------------|-----------|
| <b>1</b> | <b>Inleiding</b>                    | <b>1</b>  |
| <b>2</b> | <b>Referenties</b>                  | <b>2</b>  |
| 2.1      | Projectspecifieke documenten        | 2         |
| 2.2      | Algemene normen, richtlijnen        | 2         |
| 2.3      | Aanvullende normen en richtlijnen   | 3         |
| 2.4      | Literatuur en overige referenties   | 3         |
| <b>3</b> | <b>Uitgangspunten</b>               | <b>3</b>  |
| 3.1      | Opbouw van de constructie           | 3         |
| 3.2      | Niveaus en waterstanden             | 6         |
| 3.3      | Geotechnische parameters            | 6         |
| 3.4      | Project-specifieke eisen            | 6         |
| 3.5      | Belastingen                         | 7         |
| 3.6      | Belastingcombinaties                | 8         |
| <b>4</b> | <b>Modellering</b>                  | <b>8</b>  |
| <b>5</b> | <b>Verificatie &amp; Resultaten</b> | <b>10</b> |
| 5.1      | Hoofdliggers                        | 10        |
| 5.2      | Dwarsliggers                        | 11        |
| 5.3      | Schoorstaven                        | 12        |
| 5.4      | Langsliggers                        | 12        |
| 5.5      | Stangen tussen palen en steiger     | 13        |
| 5.6      | Kabels                              | 13        |
| 5.7      | Palen                               | 14        |
| 5.8      | Vakwerkknopen en lassen             | 15        |
| 5.9      | Semi-flexibele koppeling            | 17        |
| 5.10     | Vingerpieren                        | 19        |
| <b>6</b> | <b>Conclusie en aanbevelingen</b>   | <b>19</b> |

## Tabellen

|                                                 |    |
|-------------------------------------------------|----|
| Tabel 1: Detail opbouw van de steiger elementen | 5  |
| Tabel 2: Geotechnische parameters               | 6  |
| Tabel 3: Verificatie resultaten hoofdligger     | 11 |

|                                                              |    |
|--------------------------------------------------------------|----|
| Tabel 4: Verificatie resultaten dwarsligger                  | 11 |
| Tabel 5: Verificatie resultaten end dwarsligger van loopbrug | 12 |
| Tabel 6: Verificatie resultaten schoorstaaf                  | 12 |
| Tabel 7: Verificatie resultaten aluminium langsligger        | 12 |
| Tabel 8: Verificatie resultaten aluminium langsligger        | 13 |
| Tabel 9 Karakteristieke waarde van kabel sterkte.            | 14 |
| Tabel 10: Verificatie resultaten verbindingen                | 16 |
| Tabel 11: Verificatie resultaten semi-flexibele koppeling    | 18 |
| Tabel 12: Verificatie resultaten vingerpielen                | 19 |

## Figuren

|                                                                                                                                |    |
|--------------------------------------------------------------------------------------------------------------------------------|----|
| Figuur 1-1: Project locatie [bron: Google Maps]                                                                                | 1  |
| Figuur 1-2: Bovenaanzicht                                                                                                      | 1  |
| Figuur 3-1: Doorsnede van de loopbrug en steiger.                                                                              | 3  |
| Figuur 3-2: Bovenaanzicht van de steiger met verschillende steigerelementen.                                                   | 4  |
| Figuur 3-3: Typische doorsnede steigerelemen (Doorsnede is van een 3.0m breed drijvende steiger, principe van 1.5m is gelijk)t | 5  |
| Figuur 3-4: Bovenaanzicht steigerframe (steigerdeel, 12m lengte)                                                               | 5  |
| Figuur 4-1: 3D aanzicht van SCIA-model                                                                                         | 9  |
| Figuur 4-2: Bovenaanzicht steiger elementen.                                                                                   | 9  |
| Figuur 4-3: Windbelastingen toegepast op model                                                                                 | 10 |
| Figuur 5-1: Werkelijke vs. geïdealiseerde doorsnede C-Profiel                                                                  | 11 |
| Figuur 5-2 Normaalkracht in kabels.                                                                                            | 13 |
| Figuur 5-3: Relatie tussen talud heling en ineffectieve grond hoogte als functie van paaldiameter.                             | 15 |
| Figuur 5-4: Reactiekrachten voor het paalontwerp.                                                                              | 15 |
| Figuur 5-5: Verbinding van dwarsligger aan het uiteinde.                                                                       | 17 |
| Figuur 5-6: Omhullende normaalkracht in dwarsdragers, UGT.                                                                     | 17 |
| Figuur 5-7: Schets van semi-flexibele koppeling                                                                                | 18 |
| Figuur 5-8: Koppeling vingerpier aan steiger.                                                                                  | 19 |

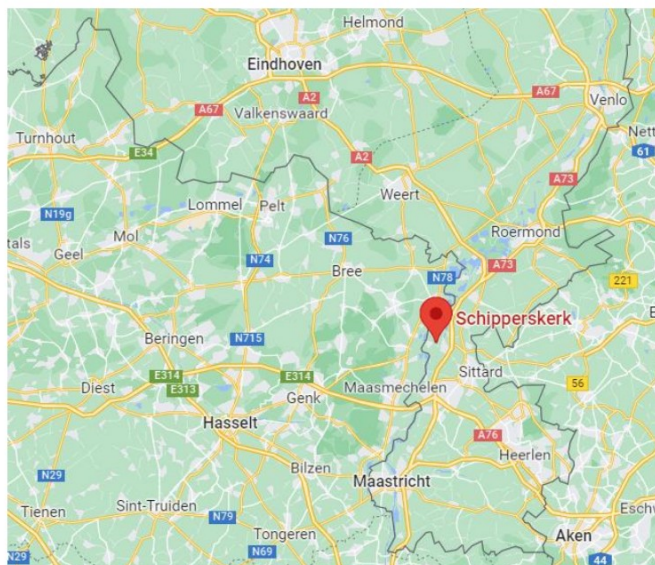
## Bijlagen

|    |                         |
|----|-------------------------|
| A1 | Berekeningsinvoer       |
| A2 | SCIA Berekeningsverslag |
| A3 | Verificaties            |

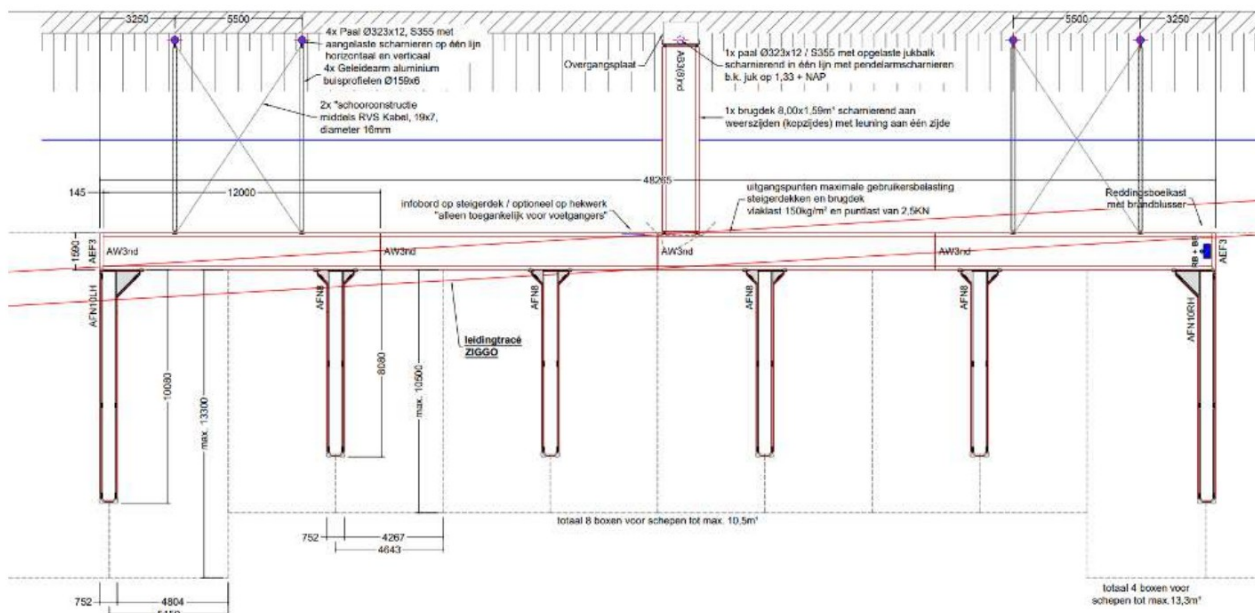
## 1 Inleiding

### Aanleiding

In het kader van het project Aanlegsteiger te Schipperskerk is in opdracht van Inter Boat Marinas B.V. (IBM) een constructieve toetsing uitgevoerd van de drijvende steigerelementen, type AW0, waaruit de aanlegsteiger is opgebouwd. En de constructieve elementen t.b.v. fixatie van de aanlegsteiger.



Figuur 1-1: Project locatie [bron: Google Maps]



Figuur 1-2: Bovenaanzicht

### Scope

De constructieve toetsing omvat de volgende elementen:

- Afleiden van de belastingen en randvoorwaarden van de berekening
- Opstellen van een rekenmodel om de krachten in de constructie te bepalen



- Ontwerpen stalenbuispalen voor horizontale fixatie van het steigerframe
- Bepalen hoofdprofielen van de buizen en kabels tussen de palen en steiger
- Toetsing van de sterkte van het steigerframe inclusief:
  - Doorsnedes & stabiliteit van de aluminium en stalen profielen
  - Verbindingen van de vakwerkknoppen inclusief lassen
  - Semi-flexibele koppelingen en starre koppeling t.p.v. het passtuk.

### Afbakening

De volgende aspecten en elementen vallen buiten de scope van de constructieve toetsing:

- Drijfvermogen, vervormingen en stabiliteit; het standaard drijvende steigertype AW0 wordt toegepast binnen de grenzen van de gebruiksbelasting.
- Dekplanken zijn geselecteerd door IBM uit de producentencatalogus op basis van de beoogde belastingen en overspanningen.
- Extreme belastingen zoals een aanvaring of kruidend ijs zijn uitgesloten.
- Ontwerp van de Vingerpielen.
- Toetsing op de lokaal krachtsinleiding ter plaatse van de Vingerpielen
- Verbindingen tussen de buizen, kabels, palen, brug en steigerdek.

### Leeswijzer

In dit rapport worden de uitgangspunten, methodiek van de rekenkundige modelering, en de uitgevoerde verificaties inclusief resultaten kort toegelicht. Voor de berekeningen en gedetailleerde onderbouwing wordt verwezen naar de volgende bijlagen:

1. Berekeningsinvoer
  - a. Berekening van specifieke belastingen (wind, eigengewicht etc.)
  - b. Berekening van specifieke randvoorwaarden (stijfheid van steunpunten, drijvers)
2. SCIA-berekeningsverslag
3. Verificaties & Resultaten

## 2 Referenties

### 2.1 Projectspectifieke documenten

De onderstaande projectspectifieke documenten zijn gebruikt als uitgangspunt voor de berekening:

Tekeningen ontvangen in PDF

- IBM, AW3UACE aanzichten/doorsneden/details, AW3UACE\_P1-1\_0, Rev 0, 25-01-2018
- IBM, AW3UACE Uitvergroting, AW3UACE\_P1-2\_0, Rev 0, 25-01-2018
- IBM, AW3UACE Items, AW3UACE\_P1-3\_0, Rev 0, 25-01-2018
- IBM, Voorstel aanlegsteiger en aanzichten LW en HW, NL4202\_A1-2\_C, Rev G, 09-08-2023

### 2.2 Algemene normen, richtlijnen

De volgende algemene vigerende normen en richtlijnen zijn van toepassing en vormen de grondslag van het ontwerp/ toetsing. De nationale bijlages behorende bij de onderstaande normen zijn inbegrepen. Deze zullen worden aangevuld met specifieke normen en richtlijnen, zoals gegeven in de volgende paragraaf:

- NEN-EN 1990+A1+A1\_C2\_2019 – Grondslagen van het constructief ontwerp
- NEN-EN 1991-1-1+C1+C11-2019 – Belastingen op constructies - Algemeen
- NEN-EN 1991-1-4+A1+C2-2011 – Belastingen op constructies - Windbelastingen
- NEN-EN 1993-1-1-C2-A1-2011 – Staalconstructies - Algemeen
- NEN-EN 1993-1-3-2006 – Staalconstructies - Koudgevormde profielen



- NEN-EN-1993-1-5 – Staalconstructies – Constructieve Plaatvelden
- NEN-EN 1993-1-8-C2-2011 – Staalconstructies - Verbindingen
- NEN-EN 1999-1-1-A1-2011 – Aluminium profielen
- NEN9997 – Geotechnisch Ontwerp van constructies - Algemeen

## 2.3 Aanvullende normen en richtlijnen

De volgende normen en richtlijnen worden ter aanvulling gebruikt voor specifieke facetten van de toetsing:

- BS6349-6-1989 – Maritime Structures – Part 6: Design of inshore moorings and floating structures
- CUR-CIRIA - Rock Manual, 2007

## 2.4 Literatuur en overige referenties

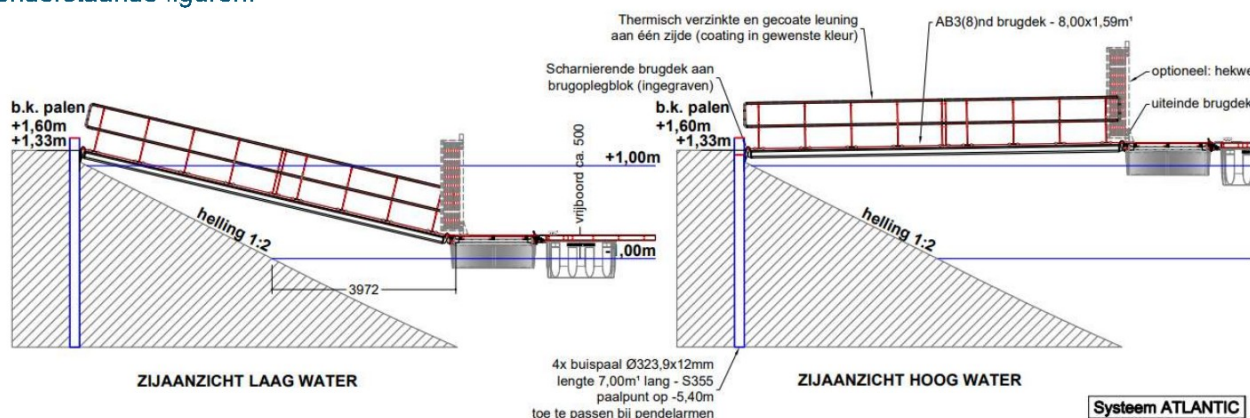
De volgende literatuur en overige referenties zijn geraadpleegd:

- Bouwen Met Staal – Technisch Dossier 4 – Koudgevormde Profielen, 2010
- Bouwen Met Staal – Rekentools Koudgevormde Profielen,  
<https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

# 3 Uitgangspunten

## 3.1 Opbouw van de constructie

De drijvende aanlegsteiger heeft een totale lengte van ca. 48m en is opgelegd op de drijvers. Zijdelingse ondersteuning wordt geboden door een 4-tal palen en een loopbrug zoals aangegeven in de onderstaande figuren.

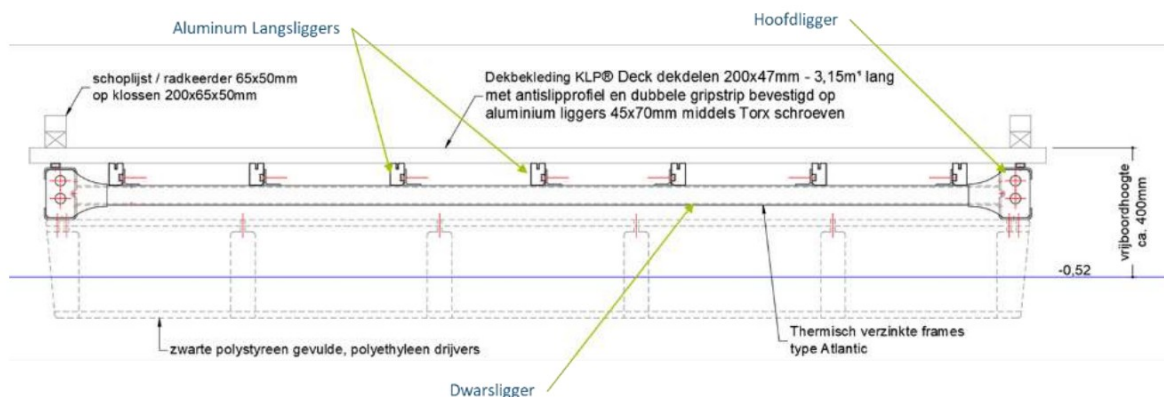


Figuur 3-1: Doorsnede van de loopbrug en steiger.

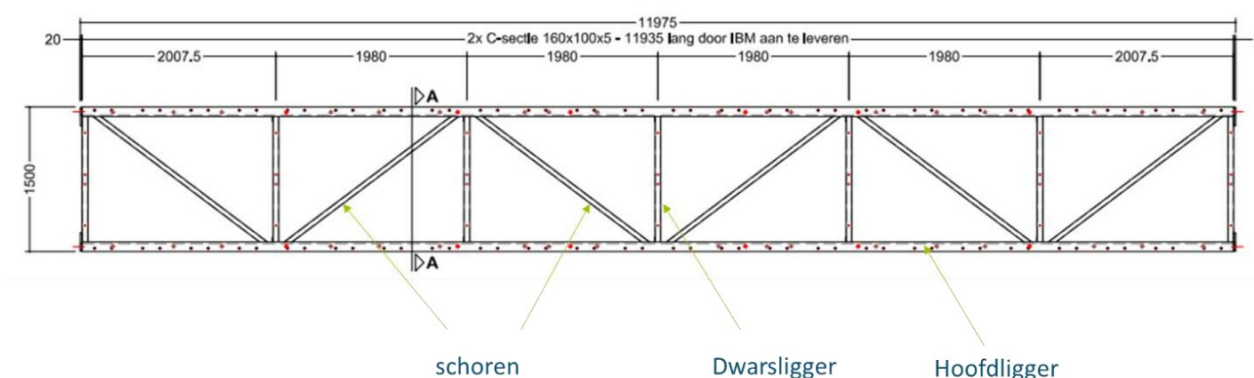
De loopbrug wordt ondersteund door de opleggingen ter plaatse aan de landhoofd zijde en aan de aanlegsteiger zijde wordt het scharnierend aan de aanlegsteiger verbonden. Door het leidingtracé van Ziggo in de grond kunnen de palen niet direct naast de aanlegsteiger geplaatst worden. In het ontwerp wordt ervan uitgegaan dat de palen ook ter plaatse van het landhoofd geheid worden. De afstand tussen de palen en aanlegsteiger is 8.0m en de verbinding tussen de palen en overstek wordt door stangen gerealiseerd. De stangen zijn scharnierend aan de aanlegsteiger en palen verbonden. De belastingen in de lengte richting van de aanlegsteiger dienen naar de palen afgedragen te worden en dit wordt gerealiseerd door het plaatsen de roestvasten stalen kabels tussen de stangen, zoals in Figuur 3-2 is weergegeven.

De steigerelementen zijn opgebouwd uit een dek, bestaande uit dekplanken en langsliggers welke de krachten afdragen naar het stalen steigerframe. Dit frame is uitgevoerd als een vakwerk en biedt horizontale stijfheid. Via de wandstaven (hoofdliggers) worden de verticale krachten afgedragen naar de drijvers, die bevestigd zijn aan de hoofdligger. Tevens verzorgt dit profiel ook de verbinding met andere onderdelen zoals de koppelingen, stangen, kabels en brugdek. In de onderstaande figuren is de opbouw van de steigerelementen weergegeven, details m.b.t. de profielen, afmetingen en materialen zijn gegeven in Tabel 1.





Figuur 3-3: Typische doorsnede steigerelement (Doorsnede is van een 3.0m breed drijvende steiger, principe van 1.5m is gelijk)



Figuur 3-4: Bovenaanzicht steigerframe (steigerdeel, 12m lengte)

Tabel 1: Detail opbouw van de steiger elementen

|             | Functie / Omschrijving                                                                                                                                                                                                       | Afmeting, Materiaal                                                                                |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Dekplanken  | Vormen het loopoppervlak van de drijvende aanlegsteiger. Steunen af op de aluminium langsliggers<br><br>Als alternatief mag er een GVK rooster toegepaste worden van 23mm dik                                                | Kunststof 200x47mm<br><br>Alternatief: Rooster 23mm                                                |
| Langsligger | Ondersteuning van de dekplanken. Draagt alleen verticale belastingen af naar dwarsliggers. Werkt niet mee in de stijfheid van het steigerframe / vakwerk.<br><br>Als alternatief kunnen er aluminium kokers worden toegepast | Extrusie Profiel 70x45mm, Aluminium - 6063T6<br><br>Alternatief: koker 70x40x3mm Aluminium -6063T6 |
| Dwarsligger | Draagt belastingen vanuit de aluminium langsliggers af naar de hoofdliggers c.q. drijvers. Functioneert tevens als vakwerkstaaf t.b.v. horizontale stijfheid.                                                                | Koker 60x60x4mm, Staal S235                                                                        |
| Hoofdligger | Wandligger van het vakwerk, voorziet verbindingen met drijvers, koppelingen, paalbeugels. Verdeelt de verticale belastingen naar drijvers en landhoofd                                                                       | Koudgevormd C-profiel 160x100x35x5mm, Staal S355                                                   |
| Schoorstaaf | Vakwerkstaaf t.b.v. horizontale stijfheid.                                                                                                                                                                                   | Koker 50x50x4mm, Staal S235                                                                        |



|                                       |                                                                                                                                                         |                                                      |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
|                                       | Voor een drijvende steiger met vingerpielen van maximaal 8.08m                                                                                          |                                                      |
| Schoorstaaf                           | Vakwerkstaaf t.b.v. horizontale stijfheid.<br>Voor een drijvende steiger met vingerpielen van maximaal 8.08m                                            | Koker 60x60x5mm, Staal S235                          |
| Stangen tussen palen en aanlegsteiger | Horizontale ondersteuning voor aanlegsteiger, horizontale krachten worden afgedragen naar de palen.                                                     | Buis 159x6, Aluminium -6063T6                        |
| Kabels tussen de stangen              | Zorgt voor horizontale stabiliteit van de stangen, overdragen de belastingen in de lengte richting van de aanlegsteiger naar de palen.                  | Kabel, 19x7, diameter 16mm, RVS                      |
| Bouten, semiflexibele koppeling       | Voorzien de koppeling tussen onderlinge steigerelementen. Bestaan uit een bout in een overmaats gat (in kopplaat van hoofdligger) en rubberen schijven. | M24, 8.8<br>Kopplaat t = 20mm, Staal S235            |
| Drijvers                              | Steigerdeel 4x drijver per element<br>Loopbrug 1x drijver                                                                                               | ca. 1.2m x 1.5m, polyethyleen gevuld met polystyreen |

## 3.2 Niveaus en waterstanden

De onderstaande niveaus en waterstanden zijn gegeven:

|                 |             |
|-----------------|-------------|
| Niveau maaiveld | 1.33 m PEIL |
| Hoogwaterstand  | 1.0 m PEIL  |
| Laagwaterstand  | -1.0 m PEIL |

Voor de berekening van de paal is de grondwaterstand gelijk aan maaiveld aangehouden dit is een conservatieve benadering.

Het niveauverschil tussen het landhoofd en het steigerdek is groot, daarom worden al verbindingen t.b.v. fixatie van het steigerdek scharnierend verbonden.

## 3.3 Geotechnische parameters

Met behulp van Dino-Loket zijn de geotechnische parameters bepaald. Er wordt een conservatieve aanname gedaan.

Uit Dino-Loket volgt dat de grond bestaat uit de bovenste 6m leem, daaronder zand. De grondwaterstand wordt conservatief aangehouden gelijk aan maaiveld.

Tabel 2: Geotechnische parameters

| Soil Layer Name | Spring Type | Top Level [m] | Dry Density [kN/m <sup>3</sup> ] | Wet Density [kN/m <sup>3</sup> ] | Cohesion [kPa] | Friction Angle [deg] | Initial Mod Subgrade [kN/m <sup>3</sup> ] | Load Type |
|-----------------|-------------|---------------|----------------------------------|----------------------------------|----------------|----------------------|-------------------------------------------|-----------|
| Leem            | API Sand    | +1.33         | 19                               | 19                               | 0              | 27.5                 | 8000                                      | Static    |

## 3.4 Project-specifieke eisen

De volgende project-specifieke eisen zijn van toepassing:

|                                     |                                                                                       |
|-------------------------------------|---------------------------------------------------------------------------------------|
| Constructietype                     | Drijvende steiger voor voetgangers                                                    |
| Gevolklasse, betrouwbaarheidsklasse | CC1, RC1                                                                              |
| Ontwerplevensduur                   | 50 jaar                                                                               |
| Corrosiebescherming                 | Stalen onderdelen zijn gegalvaniseerd<br>Overige onderdelen zijn van aluminium of RVS |
| Corrosietoeslag op steiger          | Geen                                                                                  |
| Corrosietoeslag op palen            | 0.6 mm dikte afname vanaf buiten kan in rekening gebracht.                            |
| Lassen                              | Minimale keeldiameter 4mm                                                             |

### 3.5 Belastingen

#### Eigengewicht:

Het eigengewicht van de constructieve onderdelen van het steigerframe is automatisch berekend door Scia Engineer met de volgende volumieke massa.

$$\rho_{\text{staal}} = 7850 \text{ kg/m}^3$$

$$\rho_{\text{alm}} = 2700 \text{ kg/m}^3$$

Onderdelen die niet zijn gemodelleerd, maar wel effect hebben op de constructieve toetsing zijn hieronder benoemd en zijn geschematiseerd als extra (gelijkmatig verdeelde) belasting op de constructie.

|                                                               |                       |
|---------------------------------------------------------------|-----------------------|
| Dekplanken (KLP – planken 200 x 47 mm)                        | 37.6kg/m <sup>2</sup> |
| Bekleding, verstijvingen, plaatjes etc en zink (galvanisatie) | 7 kg /m <sup>2</sup>  |

#### Gebruiksbelastingen:

Er zijn geen specifieke norm-eisen voor de belastingen op drijvende steigers. Deze worden normaliter afgestemd op het beoogde gebruik. Voor de voetgangers en fietsers die gebruik zullen maken van de drijvende aanlegsteiger zijn de volgende gebruiksbelastingen gedefinieerd:

|                                 |                            |
|---------------------------------|----------------------------|
| Gelijkmatig verdeelde belasting | $Q_k = 150 \text{ kg/m}^2$ |
| Geconcentreerde last            | $F_k = 2.5 \text{ kN}$     |

Aanbevolen wordt om duidelijk te maken dat de aanlegsteiger alleen geschikt is voor voetgangers. Dit kan door middel van een bordje met de toegestane belasting.

#### Windbelasting:

De windbelastingen op de steiger (winddruk en -wrijving) zijn bepaald conform de NEN-EN1991-1-4 + Nationale Bijlage.

|                   |                |
|-------------------|----------------|
| Windgebied        | III (Geleen)   |
| Terreinklasse     | II (Onbebouwd) |
| Basiswindsnelheid | 24.5 m/s       |

Voor het bepalen van de stuwdruk wordt gerekend met een hoogte van 0.5m, dit komt overeen met de vrijboordhoogte inclusief de schoplijst zoals aangegeven op tekening. Voor het bepalen van de windwrijving wordt de volledige breedte van de steiger gehanteerd.



De windbelasting is in rekening gebracht in zowel dwars als lengterichting van de aanlegsteiger. De windbelasting van de schepen wordt via de vingerpielen naar de aanlegsteiger overgedragen. Op de tekening is weergegeven dat ter plaatse van eind vingerpielen een schip met een maximale lengte van 13.3 m aanwezig kan zijn. De schepen bij tussenliggende vingerpielen hebben een maximale lengte van 10.5 m. De windbelasting loodrecht op de aanlegsteiger is gerekend met volledige aanwezigheid van de schepen bij de vingerpier.

Voor de windbelasting evenwijdig aan de aanlegsteiger, wordt de belasting bepaald met het uitgangspunt dat ter plaatse van de elke vingerpier één schip aanwezig is. De windbelasting op het eerste en laatste schip is volledig in rekening gebracht en voor tussen liggende schepen wordt 70% van de windbelasting meegenomen. Het is aangenomen dat de windbelasting in het midden van het schip aangrijpt.

#### **Golfbelastingen:**

De golfbelasting is niet relevant voor deze steiger. Het wordt daarom verder niet beschouwd.

#### **Belastingen in de constructiefase**

Gezien het geringe eigen gewicht van de constructie worden hijsbelastingen van het frame als niet-maatgevend aangenomen.

### **3.6 Belastingcombinaties**

Voor de constructieve toetsing is alleen de Uiterste Grens Toestand (UGT) beschouwd, omdat alleen de sterkte wordt getoetst:

- Extreme belastingen zoals een aanvaring of kruiend ijs zijn uitgesloten.
- Eisen voor de bruikbaarheidsgrenstoestand van een drijvende steiger zijn niet gegeven, afgezien van het drijfvermogen en de stabiliteit. Deze aspecten vallen buiten de scope van deze toetsing.

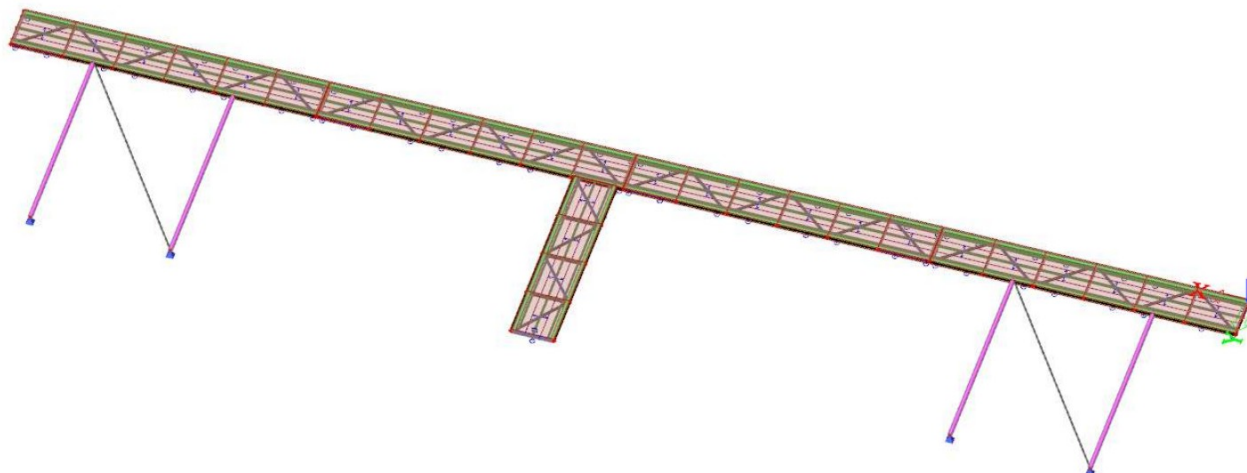
Belastingcombinaties voor de UGT zijn opgesteld conform de NEN-EN-1991-1. Hierbij is SET B (vergelijking 6.10b) aangehouden, omdat de veranderlijke belastingen een dominante rol spelen op de krachtwerking. De belastingfactoren en combinatiefactoren voor licht verkeer (voetgangers en fietsbruggen) zijn aangehouden.

Voor details m.b.t. de belastingcombinaties wordt verwezen naar Bijlage A1 Berekeningsinvoer (belastingfactoren en combinatiefactoren), en Bijlage A2 SCIA-berekeningsverslag (toegepaste combinaties).

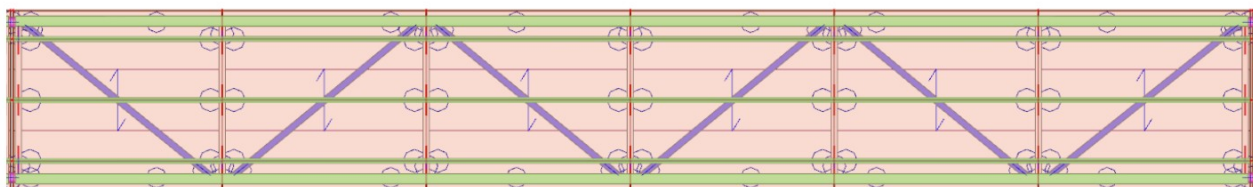
## **4 Modelling**

Het Eindige Elementen softwareprogramma SCIA-engineer (v21.1-32bit) is gebruikt om het constructieve 3D rekenmodel van de steiger te maken. Met dit model worden de interne krachten en vervormingen in de constructie berekend. In deze paragraaf wordt een korte omschrijving van het model gegeven. Voor de volledige in- en uitvoer van de berekening wordt verwezen naar Bijlage A2.





*Figuur 4-1: 3D aanzicht van SCIA-model*

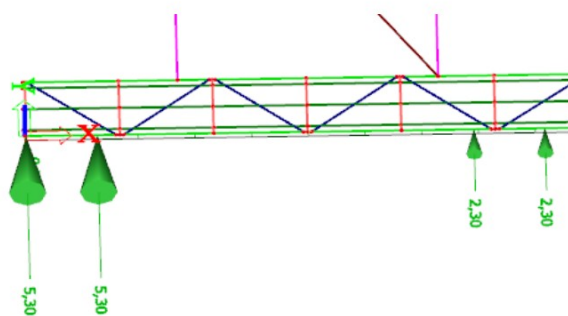


*Figuur 4-2: Bovenaanzicht steiger elementen.*

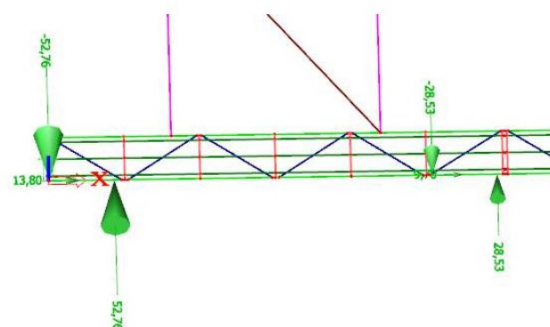
Een overzicht van het model is weergegeven in de bovenstaande figuren. Het model is opgebouwd uit 1D staven waarbij zowel het steigerframe (vakwerk) als de langsliggers zijn gemodelleerd. De belangrijkste aandachtspunten en aannames in de modellering zijn hieronder beschreven:

- **De dekplanken of rooster** zijn niet gemodelleerd, het eigengewicht van de dekplanken/rooster is als verdeelde belasting op de constructie toegepast. Om de dekbelastingen naar de langsliggers te verdelen is gebruikgemaakt van load panels. Dit zijn (niet constructieve) 2D platen die de bovenbelasting naar de langsliggers verdelen o.b.v. de onderlinge h.o.h.-afstand.
- **De aluminium langsliggers** zijn zodanig verbonden met de dwarsliggers dat er een glijdende oplegging gerealiseerd wordt, die tevens in het vlak scharnierend is. Hiermee wordt voorkomen dat de langsliggers bijdragen aan de constructieve stijfheid van het vakwerk maar wel fungeren als doorgaande ligger die de verticale belastingen afdraagt.
- **Het vakwerk** van het steigerframe is gemodelleerd met scharnierende verbindingen (in het vlak) t.p.v. de vakwerkknopen. Zodanig kunnen de schoorstaven en dwarsstaven alleen normaalkracht en dwarskracht overbrengen bij werking van het frame als vakwerk (in het vlak).
- **De drijvers** zijn gemodelleerd als verende ondersteuning t.p.v. de verbindingen met de hoofdligger. De veerwaarde is berekend o.b.v. de afmetingen van de drijver, zie bijlage A1.
- **De palen** zijn gemodelleerd als starre steun. Deze modellering is conservatief voor de krachtswerking van de steiger.
- **De oplegging t.p.v. het landhoofd** waarbij de loopbrug opgelegd wordt is gemodelleerd in het midden van de dwarsdrager en de translaties in alle drie richtingen en rotatie in het vlak van de brug zijn vastgezet. Omdat alle belastingen vanuit de brug via deze oplegging afgedragen worden, wordt de eind dwarsdrager van de loopbrug verzwaard naar HEA 100.
- **De dekbelastingen** zijn in een schaakbordpatroon op de constructie gezet. Hierbij wordt getracht de meest ongunstige positionering van de verdeelde of geconcentreerde lasten te verkrijgen. SCIA combineert de verschillende patronen in de belastingcombinaties automatisch 1 voor 1.

- **De windbelasting van de schepen** wordt afgedragen via de vingerpielen naar de steiger waarbij uitgegaan wordt dat de vingerpielen een breedte van 1.7 m hebben ter plaatse van de aansluiting met de steiger. De windbelasting in de loodrecht richting van de aanlegsteiger is toegepast als puntlast op de hoofdligger. De windbelasting evenwijdig aan de aanlegsteiger wordt overgedragen naar de hoofdligger als een buigmoment en normaalkracht. Dit buigmoment grijpt in de zwakke as van de hoofdligger. Het buigmoment wordt ontbonden als trek- en drukkracht waarbij de arm tussen deze krachten 1.7 m gehanteerd is. Opgemerkt wordt dat door de lange schepen een groot buigmoment optreedt t.g.v. de windbelasting evenwijdig aan de steiger en dit is ongunstig voor de hoofdligger.  
Om deze ongunstige effecten te verminderen, worden de vingerpielen op gunstige locaties geplaatst waarbij de resulterende trek- en drukkrachten t.g.v. het buigmoment meer dicht bij de knoppen van het vakwerk kunnen terechtkomen. Dit resulteert in een acceptabel buigmoment in de zwakke as van de hoofdligger.
- **De stangen en kabels** zijn gemodelleerd als 1D staaf en de verbinding tussen deze elementen en de steiger wordt als scharnierend beschouwd. Opgemerkt wordt dat in het model één kabel is gemodelleerd en in werkelijkheid worden er kruisend twee kabels toegepast. De enkele kabel is zodanig gemodelleerd dat erin geen drukkracht optreedt wat het met het werkelijk gedrag van de kabel overeenkomt.



Windbelasting loodrecht aan de aanlegsteiger



Windbelasting in evenwijdig aan de aanlegsteiger

Figuur 4-3: Windbelastingen toegepast op model

## 5 Verificatie & Resultaten

### 5.1 Hoofdliggers

De hoofdliggers (koudgevormd C-profiel) zijn handmatig geverifieerd conform de EN1993-1-3 voor koudgevormde, dunwandige staalprofielen. Hierbij is gebruikgemaakt van de standaard rekensheets van Bouwen Met Staal om de effectieve doorsnede eigenschappen te bepalen. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- Door de relatief dikke wanddikte behoeft er geen reductie te worden toegepast op de doorsnede-eigenschappen. Dit betekent dat de doorsnedeklasse tussen Klasse 2 en Klasse 3 zit en mag de plastische weerstand van het profiel deels worden gemobiliseerd.
- Het effect van de gaten in het C-profiel is meegenomen in de verificatie. De doorsnedegrootheden van de doorsnede met gaten zijn bepaald door Scia Engineer door de doorsnede met gaten modelleren.
- Het C-profiel heeft een verstijving in het lijf, halverwege de hoogte. Deze verstijving/ geul heeft geen constructieve functie maar dient ter doorgang van de zink-vloeistof tijdens galvaniseren. Voor de verificatie is de doorsnede vereenvoudigd tot een normaal C-profiel zonder verstijving.

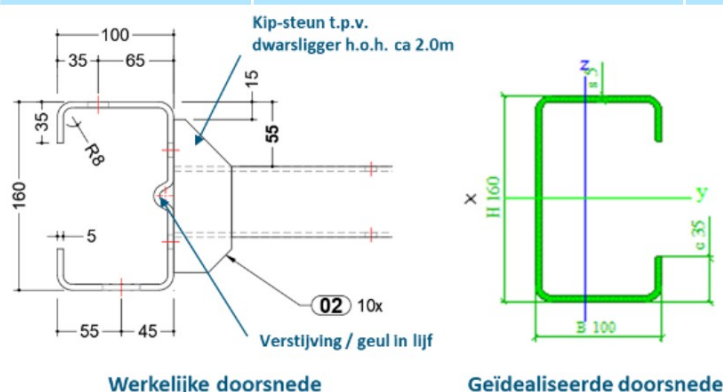


- De verstijving heeft een positief of nihil effect op de netto doorsnede voor normaalkracht en buiging om de sterke as.
- De verstijving heeft mogelijk een klein negatief effect op de dwarskracht (knikstabiliteit van lijf). Echter is deze toetsing niet maatgevend.

De toetsingen zijn uitgevoerd op basis van de omhullende interne krachten van alle staven en belastingcombinatie. De maximale normaalkracht is gecombineerd bij het bijbehorende buigende momenten en het maximale buigmoment is gecontroleerd met de bijbehorende interne krachten.

Tabel 3: Verificatie resultaten hoofdlijger

| Mechanisme           | Maatgevende Toets                         | Unity Check [U.C. ≤ 1.0] |
|----------------------|-------------------------------------------|--------------------------|
| Doorsnede-capaciteit | Moment<br>Dubbele buiging + normaalkracht | <b>0.98</b>              |
| Stabiliteit          | Buigknik + kip (gecombineerd)             | <b>0.64</b>              |



Figuur 5-1: Werkelijke vs. geïdealiseerde doorsnede C-Profiel

## 5.2 Dwarsliggers

De dwarsliggers (standaard kokerprofiel) zijn m.b.v. SCIA Engineer geverifieerd conform de EN1993-1-1 voor algemene staalprofielen. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- Kip- en kniklengtes zijn handmatig ingevoerd in SCIA Engineer en de systeem lengte als kniklengte aangehouden.
- Er is geen rekening gehouden met gat-af trek ( $d=10\text{mm}$  in boven en onder flens). Dit is OK indien de  $U.C. < 0.87$ . Anders dient de weerstand nauwkeuriger geverifieerd te worden.

Tabel 4: Verificatie resultaten dwarslijger

| Mechanisme           | Maatgevende Toets             | Unity Check [U.C. ≤ 1.0] | Opmerking                  |
|----------------------|-------------------------------|--------------------------|----------------------------|
| Doorsnede-capaciteit | Torsie                        | <b>0.52</b>              | t.p.v. midden overspanning |
| Stabiliteit          | Buigknik + kip (gecombineerd) | <b>0.63</b>              |                            |

In het hoofdstuk modellering werd al vermeld dat de eind dwarsdrager van de burg is verzwakt door de oplegcondities. Hiervoor wordt een dwarsdrager met HEA100 toegepast. Deze dwarsdrager is ook met Scia Engineer geverifieerd conform de EN 1993-1-1 voor algemeen staalprofielen. Detail van de verificatie zijn opgenomen in bijlage A3. Hieronder zijn de resultaten van deze verificatie samengevat.



Tabel 5: Verificatie resultaten end dwarsligger van loopbrug

| Mechanisme           | Maatgevende Toets         | Unity Check [U.C. ≤ 1.0] | Opmerking                  |
|----------------------|---------------------------|--------------------------|----------------------------|
| Doorsnede-capaciteit | Dubbele buiging           | 0.53                     | t.p.v. midden overspanning |
| Stabiliteit          | Geen stabiliteit controle | -                        | Niet van toepassing        |

### 5.3 Schoorstaven

De schoorstaven (standaard kokerprofiel) zijn m.b.v. SCIA Engineer geverifieerd conform de EN1993-1-1 voor algemene staalprofielen. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- Kip- en kniklengtes zijn handmatig ingevoerd in SCIA Engineer en de systeem lengte als kniklengte aangehouden.

Tabel 6: Verificatie resultaten schoorstaaf

| Mechanisme           | Maatgevende Toets | Unity Check [U.C. ≤ 1.0] | Opmerking                    |
|----------------------|-------------------|--------------------------|------------------------------|
| Doorsnede-capaciteit | Normaalkracht     | 0.44                     | Schoorstaaf in buitenste vak |
| Stabiliteit          | Knik              | 0.78                     | Schoorstaaf in buitenste vak |

### 5.4 Langsliggers

De aluminium langsliggers (extrusieprofiel) zijn handmatig geverifieerd conform de EN1999-1-1 voor aluminium constructies. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- Voor de verificatie is het extrusieprofiel geïdealiseerd tot een aluminium kokerprofiel (70x45x1.5mm). Het schematiseren als koker levert een lager netto oppervlak en weerstandsmoment op dan de werkelijke geometrie, en kan daarom als conservatief worden beschouwd.
- De slankheidsverhoudingen voor het lijf en de onderflens zijn gecontroleerd. Het profiel mag beschouwd worden als doorsnedeklasse 3 voor buiging en als Niet-Slank voor afschuiving
- Als alternatief kunnen er aluminium kokers 70x40x3mm worden toegepast, deze zijn aanzienlijk sterker dan het extrusieprofiel en zijn daarom niet afzonderlijk getoetst.

Tabel 7: Verificatie resultaten aluminium langsligger

| Mechanisme           | Maatgevende Toets | Unity Check [U.C. ≤ 1.0] | Opmerking                        |
|----------------------|-------------------|--------------------------|----------------------------------|
| Doorsnede-capaciteit | Moment            | 0.88                     | t.p.v. midden overspanning       |
| Stabiliteit          | Kip               | -                        | n.v.t. door steun van dekplanken |

## 5.5 Stangen tussen palen en steiger

De horizontale fixatie van de steiger is gerealiseerd door de stalenbuis palen en de verbinding tussen de palen en steiger wordt met een aluminium buis gemaakt. De aluminium buis is handmatig geverifieerd conform de EN1999-1-1 voor aluminium constructies. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

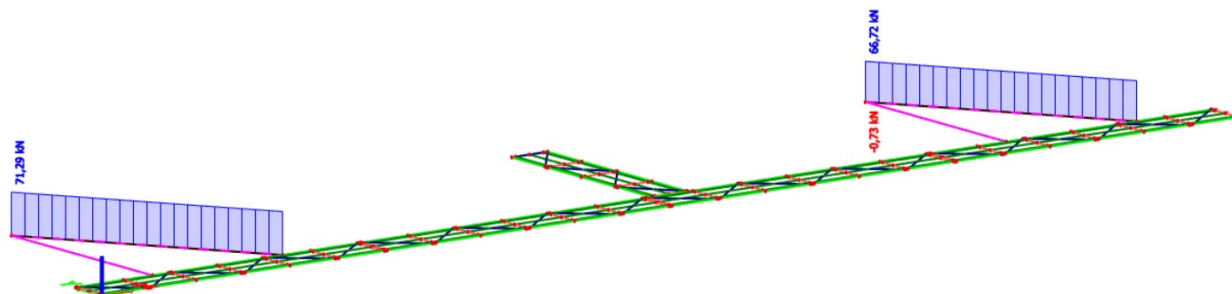
- Kniklengte van de buis is gelijk aan de systeem lengte.
- De toetsing is uitgevoerd voor omhullende interne krachten vanuit alle combinatie en alle buisprofielen.

Tabel 8: Verificatie resultaten aluminium langsligger

| Mechanisme           | Maatgevende Toets    | Unity Check [U.C. ≤ 1.0] | Opmerking |
|----------------------|----------------------|--------------------------|-----------|
| Doorsnede-capaciteit | Normaalkracht – Druk | 0.13                     |           |
| Stabiliteit          | Knik                 | 0.88                     |           |

## 5.6 Kabels

De horizontale stabiliteit in langsrichting van de steiger is verzorgd door de stalen kabels die tussen de aluminium stalen in een kruisende vorm geplaatst is. De kabels brengen de horizontale belastingen met trekkracht naar de palen.



Figuur 5-2 Normaalkracht in kabels.

Conform onderstaande tabel, heeft de kabel 1x19 met een diameter 16 mm breuksterkte van 182 kN. Dit is de karakteristieke waarde en de rekenwaarde is berekend door het delen deze waarde met de veiligheidsfactor. Voor dit ontwerp wordt de veiligheidsfactor 2 aangehouden en het is conservatief t.o.v. factor van 1.5 uit EN 1993-1-11.

$$F_{Rd} = 182/2 = 91 \text{ kN}$$

$$F_{Ed} = 72.3 \text{ kN}$$

$$UC = 72.3/91 = 0.79$$



Tabel 9 Karakteristieke waarde van kabel sterkte.

| SS Stainless Steel - Open Strands                                                                                                                                                                                                                                    |      |                       |                                |                          |       |        |                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------|--------------------------------|--------------------------|-------|--------|------------------|
|  1x19  1x61  1x91 |      |                       |                                | Material: Grade 316      |       |        |                  |
| NOMINAL<br>CABLE DIAMETER                                                                                                                                                                                                                                            |      | CABLE<br>CONSTRUCTION | METALLIC<br>CROSS SECTION AREA | MINIMUM<br>BREAKING LOAD |       |        | WEIGHT<br>APPROX |
| mm                                                                                                                                                                                                                                                                   | in.  |                       |                                | kN                       | kg    | lb     |                  |
| 2.5                                                                                                                                                                                                                                                                  | -    | 1 x 19                | 3.7                            | 4.9                      | 500   | 1100   | 0.031            |
| 3.0                                                                                                                                                                                                                                                                  | 1/8  | 1 x 19                | 5.4                            | 7.0                      | 720   | 1580   | 0.045            |
| 4.0                                                                                                                                                                                                                                                                  | 5/32 | 1 x 19                | 9.6                            | 12.6                     | 1280  | 2830   | 0.079            |
| -                                                                                                                                                                                                                                                                    | 3/16 | 1 x 19                | 13.5                           | 18.9                     | 1930  | 4255   | 0.113            |
| 5.0                                                                                                                                                                                                                                                                  | -    | 1 x 19                | 15.0                           | 19.6                     | 2000  | 4410   | 0.124            |
| -                                                                                                                                                                                                                                                                    | 7/32 | 1 x 19                | 18.0                           | 24.2                     | 2470  | 5440   | 0.145            |
| 6.0                                                                                                                                                                                                                                                                  | -    | 1 x 19                | 21.5                           | 28.0                     | 2870  | 6340   | 0.178            |
| -                                                                                                                                                                                                                                                                    | 1/4  | 1 x 19                | 24.1                           | 34.0                     | 3440  | 7584   | 0.198            |
| 7.0                                                                                                                                                                                                                                                                  | 9/32 | 1 x 19                | 29.2                           | 35.0                     | 3540  | 7800   | 0.243            |
| 8.0                                                                                                                                                                                                                                                                  | 5/16 | 1 x 19                | 38.2                           | 45.4                     | 4640  | 10220  | 0.317            |
| -                                                                                                                                                                                                                                                                    | 3/8  | 1 x 19                | 54.2                           | 64.0                     | 6546  | 14434  | 0.446            |
| 10.0                                                                                                                                                                                                                                                                 | -    | 1 x 19                | 59.7                           | 71.0                     | 7250  | 15980  | 0.495            |
| -                                                                                                                                                                                                                                                                    | 7/16 | 1 x 19                | 73.7                           | 86.0                     | 8770  | 19335  | 0.624            |
| 12.0                                                                                                                                                                                                                                                                 | -    | 1 x 19                | 86.0                           | 102.0                    | 10400 | 22930  | 0.713            |
| -                                                                                                                                                                                                                                                                    | 1/2  | 1 x 19                | 96.3                           | 119.0                    | 12101 | 26678  | 0.804            |
| 14.0                                                                                                                                                                                                                                                                 | 9/16 | 1 x 19                | 117.0                          | 139.0                    | 14170 | 31240  | 0.971            |
| 16.0                                                                                                                                                                                                                                                                 | 5/8  | 1 x 19                | 153.0                          | 182.0                    | 18550 | 40910  | 1.270            |
| 19.0                                                                                                                                                                                                                                                                 | 3/4  | 1 x 19                | 215.0                          | 212.0                    | 21610 | 47660  | 1.780            |
| 22.0                                                                                                                                                                                                                                                                 | 7/8  | 1 x 19                | 289.0                          | 285.0                    | 29060 | 64070  | 2.360            |
| 26.0                                                                                                                                                                                                                                                                 | 1    | 1 x 19                | 404.0                          | 398.0                    | 40580 | 89470  | 3.300            |
| 28.6                                                                                                                                                                                                                                                                 | -    | 1 x 61                | 477.0                          | 578.0                    | 58970 | 129870 | 3.700            |
| 32.1                                                                                                                                                                                                                                                                 | -    | 1 x 91                | 602.0                          | 730.0                    | 74480 | 164020 | 4.700            |
| 36.6                                                                                                                                                                                                                                                                 | -    | 1 x 91                | 780.0                          | 945.0                    | 99420 | 212330 | 6.100            |

## 5.7 Palen

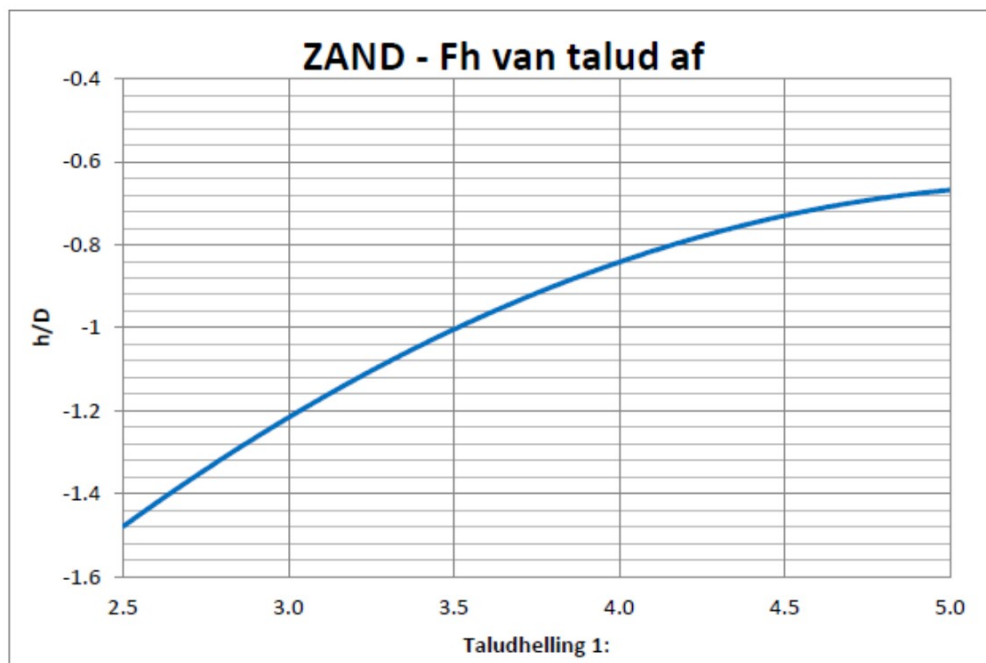
De palen zijn ontworpen met interne gevalideerde rekentool. In de rekentool worden de waterstand, eigenschappen van het grondprofiel en de paal doorsnede ingevoerd. Het grondprofiel wordt vertaald naar niet-lineaire veren en dit toegepast aan de paal als een horizontale ondersteuning. Met deze informatie wordt een model gebouwd in Scia Engineer waaruit de vervormingen en interne krachten uitgelezen worden waarmee de doorsnede toetsing uitgevoerd wordt.

De palen worden echter dichtbij een talud geheid waardoor de grond op het bovenste deel niet volledig effectief is, dit dient in rekening gebracht te worden. Het Havenbedrijf Rotterdam heeft hiervoor een onderzoek uitgevoerd en daaruit volgt dat ineffektieve grondhoogte afhankelijk is van de talud helling en diameter van de paal. Deze resultaten zijn uitgedrukt in een grafiek zoals hieronder weergegeven wordt.

In Figuur 3-1 wordt de helling van het talud weergegeven als 1:2. In de onderstaande figuur wordt de relatie tussen de ineffektieve grond hoogte en helling minimaal voor 1:2.5 weergegeven. Om de waarde voor de helling 1:2 te bepalen wordt de lijn tussen de helling 1:2.5 en 1:3 lineair beschouwd en met extrapolatie wordt de waarde voor het talud met een helling van 1:2 bepaald.

|                  |                                         |
|------------------|-----------------------------------------|
| Voor 1:2.5       | $h/D = -1.48$                           |
| Voor 1:3.0       | $h/D = -1.21$                           |
| Voor 1:2.0 wordt | $h/D = (-1.48 - -1.21) + -1.48 = -1.75$ |

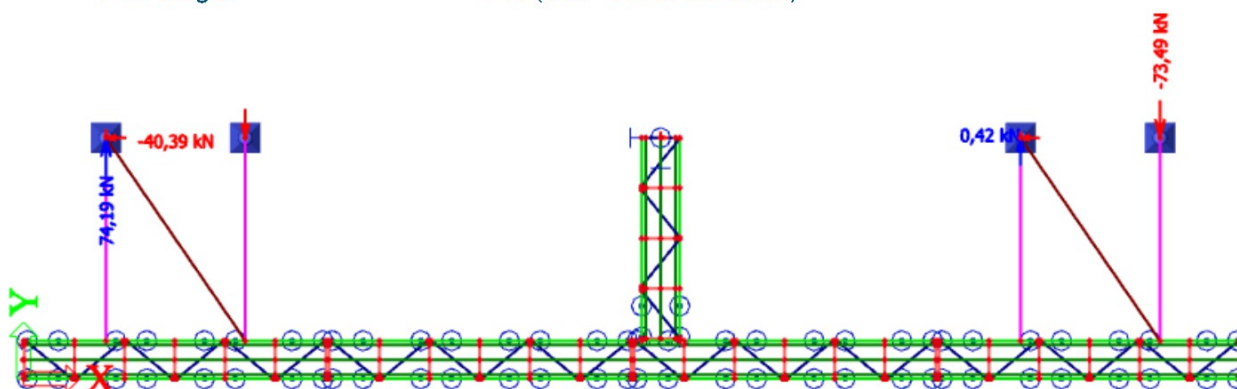
Voor een paaldiameter van 0.323m dient het maaiveld met  $0.323 \times -1.75 = -0.56$  m verlaagd te worden. Het gehanteerd maaiveld niveau is  $+1.33 \text{ m} - 0.56 \text{ m} = +0.7 \text{ m}$  (afgerond).



Figuur 5-3: Relatie tussen talud helling en ineffektieve grond hoogte als functie van paaldiameter.

De horizontale reactiekrachten van de opleggingen zijn omgerekend naar een resulterende kracht en hiermee worden de palen ontworpen. Detail van de ontwerpberekeningen zijn opgenomen in bijlage A3. De berekeningsresultaten zijn als volgt samengevat.

|                 |                                             |
|-----------------|---------------------------------------------|
| Kracht          | $(74.2^2 + 40.4^2)^{0.5} = 84.5 \text{ kN}$ |
| Stalenbuis paal | 323x12, S355                                |
| Paal lengte     | 7 m (van +1.6 m tot -5.4m)                  |



Figuur 5-4: Reactiekrachten voor het paalontwerp.

## 5.8 Vakwerkknoppen en lassen

De verbindingen in het vakwerk zijn handmatig geverifieerd conform de NEN-EN-1993-1-8. Hierbij zijn de knopen als Y (schoorstaaf) en T (dwarsligger) verbindingen geschematiseerd omdat de afstand tussen de



staven te groot is om gemodelleerd te worden als K-T knoop. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- De excentriciteiten van de staven in de knopen zijn gemodelleerd in het rekenmodel. Hierdoor worden de bijkomende momenten en dwarskrachten in de verbinding automatisch meegenomen.
- De toetsing voor Y- en T-knopen conform NEN-EN1993-1-8-tabel 7.1 is geldig voor verbindingen tussen kokerprofielen. De randligger is geïdealiseerd als kokerprofiel terwijl het in werkelijkheid een C-profiel is. Dit wordt acceptabel geacht omdat de bezwijkmechanismen vergelijkbaar zijn.
- Alleen de maatgevende verbindingen zijn getoetst. Omdat de dwarsliggers aan het uiteinde van het frame op de kopplaat gelast zitten, zal de weerstand van deze verbinding hoger zijn.
- De keeldoorsnede van de las is aangenomen op 4mm, dit is de minimum door IBM gebruikte lasdikte voor de steigerframes. Door deze las voor de meest kritische verbindingen te verifiëren, mag aangenomen worden dat de overige lassen ook voldoen.
- Alleen de lassen aan de onder- en bovenzijde van de staven zijn in rekening gebracht.
  - Aan de zijkanten zijn de staven deels gelast.
  - Omdat de schoorstaven met een bepaalde hoek aan de hoofdligger verbonden worden, is de laslengte is langer dan de flens breedte van het koker profiel. De laslengte van de schoorstaven is daarom 65 mm aangehouden i.p.v. 60 mm flens breedte.
  - Voor het toetsen van de dwarsstaaf wordt de verstijvingsplaat die dient als kip-/kniksteun niet in rekening gebracht (conservatief).

Tabel 10: Verificatie resultaten verbindingen

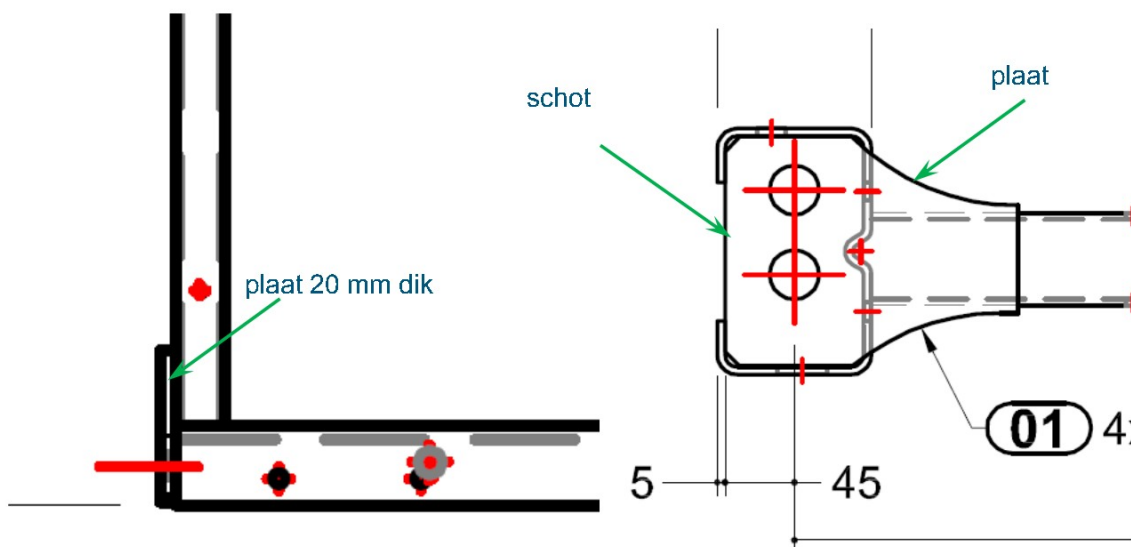
| Mechanisme             | Maatgevende Toets                      | Unity Check [U.C. ≤ 1.0] | Opmerking       |
|------------------------|----------------------------------------|--------------------------|-----------------|
| Verbinding Dwarsligger | Vloeien van het lijf van het C-profiel | 1.07                     | Zie onderstaand |
| Las Dwarsligger        | Gecombineerde spanningen               | 0.70                     | -               |
| Verbinding Schoorstaaf | Vloeien van het lijf van het C-profiel | 0.96                     | -               |
| Las Schoorstaaf        | Gecombineerde spanningen               | 0.95                     | -               |

Uit de berekening volgt dat de verbinding tussen dwarsdrager en hoofdligger niet voldoet op bezwijken van het lijf van de hoofdligger. De toetsing is uitgevoerd met maximale normaalkracht die in de dwarsligger aan het uiteinde van de steiger optreedt. De aansluiting is beschouwd als een verbinding tussen twee kokerprofielen waarbij de krachten in de dwarsdrager door het lijf van de hoofdligger overgedragen wordt. In de werkelijkheid, wordt deze verbinding wat anders uitgevoerd. Er wordt een plaat aan het lijf van de dwarsdrager gelast en deze plaat wordt met een las verbinding verbonden aan een schot die in dwarsrichting binnen de hoofdligger gelast is, zie Figuur 5-5. De plaat is stijver dan het lijf van de hoofdligger waardoor het groot deel van de normaalkracht in de dwarsligger door deze plaat wordt overgedragen. Op basis van deze redenering, wordt deze unity check acceptabel geacht.

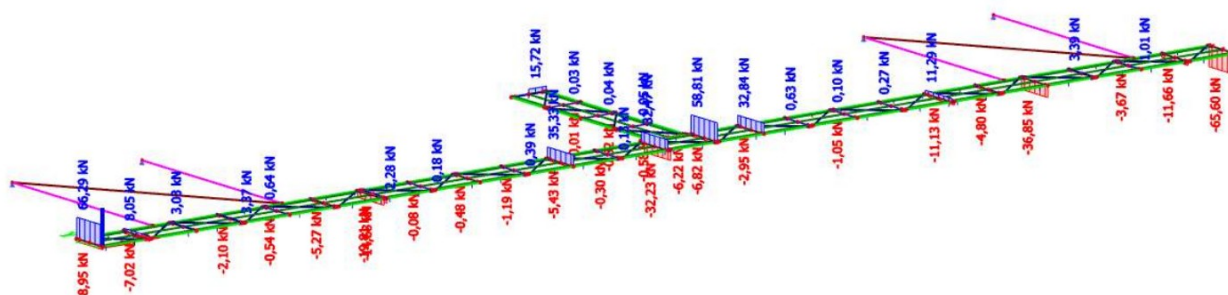
De kopplaat heeft een dikte van 20mm. De minimale breedte van de kopplaat is 70mm.

De toelaatbare kracht is  $F_{Rd} = 70 \times 20 \times 235 = 329 \text{ kN} \gg F_{Ed} = 66 \text{ kN}$ .

Zoals in Figuur 5-6 weergegeven wordt, is de normaalkracht in tussen liggende dwarsdragers veel lager en de verbinding van deze staven zal ook voldoen.



Figuur 5-5: Verbinding van dwarsligger aan het uiteinde.



Figuur 5-6: Omhullende normaalkracht in dwarsdragers, UGT.

## 5.9 Semi-flexibele koppeling

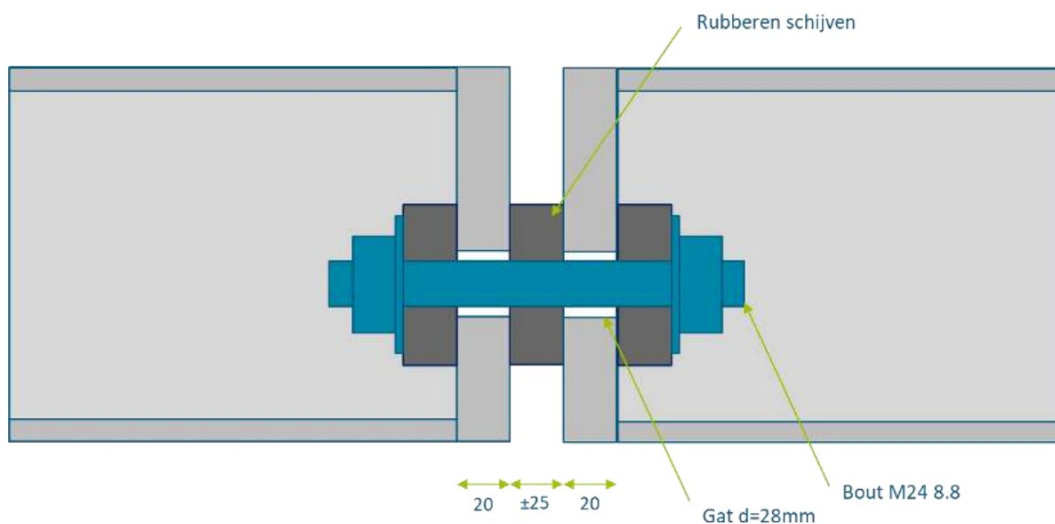
De semi-flexibele koppeling, die de steigerelementen met elkaar verbindt, is handmatig geverifieerd conform de NEN-EN-1993-1-8 als boutverbinding. Details van de verificatie zijn te vinden in bijlage A3, hieronder zijn de aandachtspunten en resultaten van de verificatie gepresenteerd:

- De koppeling (bout M24) is getoetst op een combinatie van normaalkracht, dwarskracht en buigend moment. Dit moment komt voort uit een theoretische inklemming aan één zijde (zoals gemodelleerd in SCIA). In werkelijkheid zal dit moment niet zodanig optreden, vanwege de rubberen schijven. Echter geeft dit wel een bovengrens van de mogelijke spanningen in de bout. Voor het functioneren van de koppeling dient er compatibiliteit in verticale richting te worden gerealiseerd. Hiervoor dient een dwarskracht overgedragen te kunnen worden zonder dat de bout schrank komt te zitten. Hiervoor dient er een overdracht van dwarskracht door wrijving plaats te vinden. Of door een evenwicht gemaakt met een buigend moment om dwarskracht te kunnen overdragen. Dit kan via een koppel tussen drukkracht in het rubber en trek in de bout, of enkel door buigend moment in de bout. Die laatste is het meest conservatief v.w.b. de toetsing.
- De maximaal berekende hoekverdraaiing ter plaatse van de koppeling is ca. 11grd, op basis van de geometrie van de koppeling. Figuur 5-7 zou dit geen probleem moeten zijn.



Tabel 11: Verificatie resultaten semi-flexibele koppeling

| Mechanisme               | Maatgevende Toets                            | Unity Check [U.C. ≤ 1.0] | Opmerking                                                      |
|--------------------------|----------------------------------------------|--------------------------|----------------------------------------------------------------|
| Doorsnedecapaciteit bout | Moment (incl reductie door normaaltrekkraft) | 0.47                     | -                                                              |
| Sterkte van de plaat     | Stuik van de plaat                           | 0.21                     | Pons is niet maatgevend vanwege drukverdeling rubberen schijf. |



Figuur 5-7: Schets van semi-flexibele koppeling

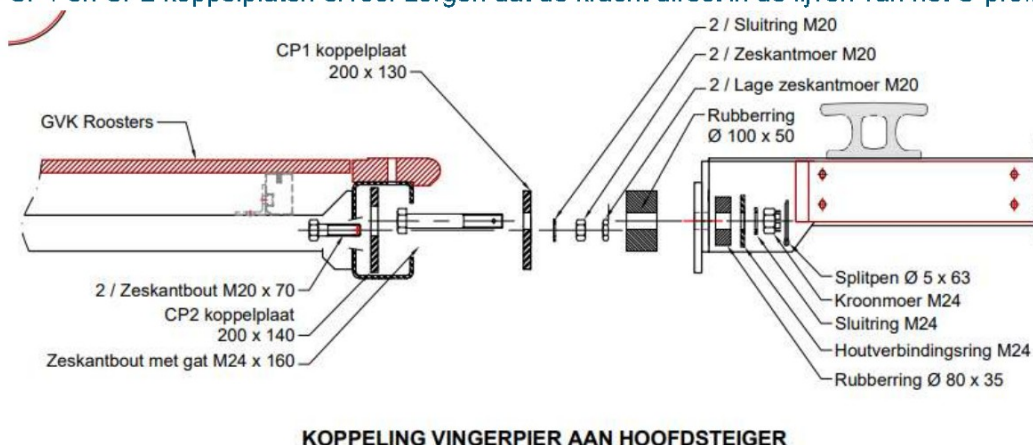
## 5.10 Vingerpielen

Door Royal HaskoningDHV is een spreadsheet opgesteld, waarin alle vingerpielen worden gecontroleerd. Zie bijlage A1. Tabel 12 geeft de conclusie.

Tabel 12: Verificatie resultaten vingerpielen

| Mechanisme             | Unity Check<br>[U.C. ≤ 1.0] |
|------------------------|-----------------------------|
| Lengte vingerpier 10 m | 0.9                         |
| Lengte vingerpier 8 m  | 0.8                         |

Figuur 5-8 geeft het aansluitingsdetail tussen de vingerpier en de steiger weer. Hierin is te zien dat de CP1 en CP2 koppelplaten ervoor zorgen dat de kracht direct in de lijven van het C-profiel worden ingeleid.



Figuur 5-8: Koppeling vingerpier aan steiger.

## 6 Conclusie en aanbevelingen

In het kader van het project "Drijvende aanlegsteiger" te Schipperskerk, is door RHDHV in opdracht van Inter Boat Marinas B.V. een constructieve toetsing van het steigerframe uitgevoerd. Op basis van de uitgevoerde berekeningen en verificaties wordt het volgende geconcludeerd een voetgangersbelasting van 150kg/m<sup>2</sup>:

- Het stalen frame en de langsliggers ter ondersteuning van het dek zijn voldoende sterk, voor zowel het brugdeel als het steigerdeel. Alle Unity Checks zijn < 1.0;
- De semiflexibele koppelingen zijn voldoende sterk.
- De verbindingen voldoen en een lasdikte van a = 4mm is voldoende

Aanbevelingen:

- Er wordt aanbevolen een passende maatregel te nemen om duidelijk te maken dat de aanlegsteiger alleen geschikt is voor voetgangers. Dit kan middels een bordje met de maximaal toegestane belasting.



## A1 Berekeningsinvoer

**Project:**  
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**Datum:**  
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BI7934 InterBoat - Oudega  
Bijlage 1 - Berekeningsinvoer  
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**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum:**  
**Pagina's**

0  
[Redacted]  
18/07/2023  
3

## Berekeningsinvoer SCIA model

### Beschrijving van de berekening:

In deze rekenaarsheet worden bepaalde belastingen en randvoorwaarden voor het scia model berekend.

### Referenties:

EN1990 Grondslagen van het ontwerp incl nationale bijlage (NB)  
EN1991-1-1 Belastingen op constructies incl Nationale bijlage (NB)  
EN1991-1-4 Windbelastingen incl Nationale bijlage (NB)  
BS6349-6 Design of inshore moorings and floating structures

## Betrouwbaarheidsklasse en belastingfactoren EN1990

Betrouwbaarheidsklasse  
Nationale bijlage

**CC1/RC1**  
**NL**

### Belastingfactoren (combinatie 6.10b)

De belastingfactoren worden conform combinatie 6.10b opgesteld omdat het eigengewicht een geringe bijdrage levert aan de krachten. Veranderlijke belastingen zijn leidend

Factor op eigengewicht  $\gamma_G$  1.1  
Factor op verkeers- en voetgangersbelastingen  $\gamma_{Q,verkeer}$  1.2  
Factor op overige veranderlijke belastingen  $\gamma_{Q,overig}$  1.35

Tabel NB.15 – A2.4(B) — Rekenwaarden voor de belastingen (STR/GEO) (groep B)

| Blijvend en tijdelijke onderwerpsituaties | Blijvende belastingen                                                |                              | Voorspanning      | Overheersende veranderlijke belasting <sup>a)</sup> | Tegelijkertijd optredende veranderlijke belastingen <sup>a)</sup> |                                   |
|-------------------------------------------|----------------------------------------------------------------------|------------------------------|-------------------|-----------------------------------------------------|-------------------------------------------------------------------|-----------------------------------|
|                                           | Ongunstig                                                            | Gunstig                      |                   |                                                     | Belangrijkste (indien aanwezig)                                   | Andere                            |
| (Vgl. 6.10a)                              | $\gamma_{G,1sup} G_{k,1sup}$                                         | $\gamma_{G,1inf} G_{k,1inf}$ | $\gamma_{\Phi P}$ |                                                     | $\gamma_{Q,1} \psi_{0,1} Q_{k,1}$                                 | $\gamma_{Q,i} \psi_{0,i} Q_{k,i}$ |
| (Vgl. 6.10b)                              | $\frac{F_d}{F_d} \gamma_{G,1sup} G_{k,1sup}$<br>waarbij $F_d = 0.89$ | $\gamma_{G,1inf} G_{k,1inf}$ | $\gamma_{\Phi P}$ | $\gamma_{Q,1} Q_{k,1}$                              |                                                                   | $\gamma_{Q,i} \psi_{0,i} Q_{k,i}$ |

<sup>a)</sup> Veranderlijke belastingen zijn die, die zijn beschouwd in tabellen NB.12 – A2.1, NB.13 – A2.2 en A2.3.

### Combinatiefactoren

Om de belastingcombinatie te formuleren worden de combinatiefactoren uit de nationale bijlage gehanteerd. Deze zijn specifiek afgeleid voor fiets- en voetgangersbruggen  $\Psi_1$  en  $\Psi_2$  worden eventueel gebruikt bij het analyseren van incidentele of bruikbaarheidsgrenstoestanden

|                                                      | $\Psi_0$ | $\Psi_1^*$ | $\Psi_2$ |
|------------------------------------------------------|----------|------------|----------|
| Verkeersbelasting (voetgangers, fietsen) Gelijkmatic | 0.8      | 0.8        | 0.8      |
| Verkeersbelasting (voetgangers, fietsen) Puntlast    | 0        | 0.8        | 0        |
| Wind en Golven (samen gecombineerd)                  | 0.3      | 0.6        | 0        |

\* Bij aanrijdingen (aanvaringen) mag  $\Psi_1$  voor wind, golven en verkeer als puntlast als 0 zijn aangehouden

## Gebruiksbelasting

### Voetgangers en fietsers

Gelijkmatic verdeelde belasting (voetgangers en fietser)

**150** kg/m  
**1.47** kN/m<sup>2</sup>

Puntlast (voetgangers en fietser)

**2.5** kN

## Eigengewicht

Het eigen gewicht van de meeste constructie onderdelen wordt expliciet in het rekenmodel meegenomen. De overige onderdelen, zoals de dekplanken, plaatjes, fenders zinktoeslag etc.

### Dekplanken

Type dekplanken KLP 200x47  
Gewicht dekplank per m<sup>1</sup> 7.5 kg/m  
Dikte van dekplanken 0.047 m  
Breedte van dekplanken 0.2 m  
Gewicht per m<sup>2</sup> 37.5 kg/m<sup>2</sup>  
Belasting **0.37** kN/m<sup>2</sup>

### Het eigengewicht van de overige onderdelen

(Staal plaatjes, fenders, zinktoeslag etc)

**0.07** kN/m<sup>2</sup> [Aaname gelijkmatige verdeeld]

Totaal

**0.44** kN/m<sup>2</sup>



**Project:**  
**Onderdeel:**  
**Datum:**  
**Auteur:**

BI7934 InterBoat - Oudega  
Bijlage 1 - Berekeningsinvoer  
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A. Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum:**  
**Pagina's**

0  
18/07/2023  
3

## Berekeningsinvoer SCIA model

### Windbelasting conform EN1991-1-4

#### Windsnelheid en stuwdruk EN1991-1-4 art 4 (+NB)

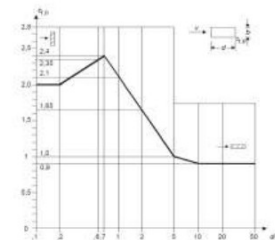
|                                           |                       |                                |
|-------------------------------------------|-----------------------|--------------------------------|
| Hoogte van steigerdek                     | 0.5 m                 |                                |
| Breedte van steigerdek                    | 3.15 m                |                                |
| Windgebied                                | III                   | art 4.2-NB (Geleen)            |
| Terreinklasse                             | I - Onbebouwd         |                                |
| Basiswindsnelheid                         | $V_{b0}$              | 24.5 m/s EN1991-1-4-NB tab 4.1 |
| Seizoens- en Richtingsfactoren            | $C_{dir}, C_{season}$ | 1 - EN1991-1-4-NB art 4.2(2)   |
| Basis windsnelheid                        | $V_b$                 | 24.5 EN1991-1-4-NB art 4.2(2)  |
| Ruwheidslengte (terreinklasse)            | $Z_0$                 | 0.2 m                          |
| Minimale hoogte voor bepalen van stuwdruk | $Z_{min}$             | 4 m                            |
| Aangehouden hoogte $\max(h, z_{min})$     | $Z$                   | 4 m                            |

#### Extreme stuwdruk EN1991-1-4 art 4 (+NB)

|                                     |             |                                                                                              |
|-------------------------------------|-------------|----------------------------------------------------------------------------------------------|
| Terreinfactor                       | $K_t$       | 0.21 - $K_t = 0.19 + \left( \frac{Z_0}{0.05} \right)^{0.07}$                                 |
| Ruwheidsfactor                      | $C_s(Z)$    | 0.63 - $C_s(Z) = K_s \ln \left( \frac{Z}{Z_s} \right)$ voor $Z_{min} \leq Z \leq Z_{max}$    |
| Orografiefactor                     | $C_o(Z)$    | 1 - $C_o(Z) = C_o(Z_{max})$ voor $Z < Z_{min}$                                               |
| Gemiddelde windsnelheid op hoogte z | $V_m(Z)$    | 15.4 m/s $V_m(Z) = C_s(Z) \cdot C_o(Z) \cdot V_b$                                            |
| Turbulentie-factor                  | $k_t$       | 1 - $I_v(z) = \frac{\sigma_v}{V_m(z)}$                                                       |
| Standaard afwijking van turbulentie | $\sigma_v$  | 5.13 - $\sigma_v = k_t \cdot V_b \cdot I_v$                                                  |
| Turbulentie-intensiteit             | $I_v(z)$    | 0.33                                                                                         |
| Dichtheid van lucht                 | $\rho_{w0}$ | 1.25 kg/m <sup>3</sup>                                                                       |
| Extreme stuwdruk                    | $q_p$       | 0.49 kN/m <sup>2</sup> $q_p(z) = (1 + 7 I_v(z)) \cdot \frac{1}{2} \cdot \rho \cdot V_m^2(z)$ |

#### Windkrachten EN1991-1-4 art 5.3

|                                                  |            |                         |
|--------------------------------------------------|------------|-------------------------|
| Bouwerfactor                                     | $c_{scd}$  | 1 - [hoogte < 15m]      |
|                                                  | B/H        | 6.3 -                   |
|                                                  | $C_{f0}$   | 0.974 -                 |
| Reductiefactor afgeronde hoeken                  | $\psi_r$   | 1 -                     |
| Eind effect factor                               | $\psi_s$   | 1 -                     |
|                                                  | H          | 0.5 m                   |
| Wind belasting op steiger (lijnlast op frame)    | $Q_w$      | 0.24 kN/m               |
| Wrijvingsfactor                                  | $C_{fr}$   | 0.02 - [ruw]            |
| Windwrijving op steiger (oppervlaktelast op dek) | $P_{w,fr}$ | 0.010 kN/m <sup>2</sup> |



Figuur 7.23 — Coëfficiënt  $c_s$  voor rechthoekige doornaden met scherpe hoeken en zonder eindeffecten

### Golfbelasting en -stroming conform BS6349-6

Aangenomen wordt dat de steiger grotendeels vericaal en horizontaal mee-beweegt met de golven en er dus GEEN staande golf optreed tegen de steiger. Wel wordt er een horizontale "drift" belasting op de constructie toegepast bij zij-waarts invallende golven. Verticale belastingen door golven worden gemodelleerd door verticale lasten toe te passen t.p.v. de drijvers. Naast golfbelastingen wordt ook de belasting door stroming berekend indien van toepassing.

Deze belasting simuleert de verhoogde (golftop) of verlaagde (golfdal) waterstand t.p.v. de drijver.

- 1 Golfpatroon in lengte richting van de steiger - zonder horizontale belasting
- 2 Golfpatroon dwars op de steiger

#### Golfhoogte

|                         |       |                        |                            |
|-------------------------|-------|------------------------|----------------------------|
| Significante golfhoogte | $H_b$ | 0.27 m                 | Zie golfberekeningsuitvoer |
| Ontwerp golfhoogte      | $H_d$ | 0.49 m                 |                            |
| Dichtheid van water     |       | 1000 kg/m <sup>3</sup> |                            |

#### Verticale golfbelasting

De amplitude van de waterstand is gelijk aan 0.5 x de golfhoogte. Hierdoor is de kracht t.p.v. de ondersteuning gelijk aan  $F_{golf} = 0.5 \times H_d \times k$

|                                                          |                 |           |                            |
|----------------------------------------------------------|-----------------|-----------|----------------------------|
| Veerwaarde van de drijvende ondersteuning                | $k$             | 4.41 kN/m | [zie berekening hieronder] |
| Puntlast op het steunpunt ter schematisering van de golf | $F_{golf-vert}$ | 1.07 kN   |                            |

#### Horizontale golfbelasting - Drift

|                                            |                  |           |                        |
|--------------------------------------------|------------------|-----------|------------------------|
| Percentage doorsnede voorzien van drijvers | $f$              | 78%       |                        |
| Drift force coefficient                    | $R^2$            | 0.5       | [BS6349-6 art 2.4.4.3] |
| Horizontale golfbelasting door drift       | $Q_{golf,drift}$ | 0.28 kN/m |                        |

**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Oudega  
Bijlage 1 - Berekeningsinvoer  
#####  
A. Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

0  
[Redacted]  
18/07/2023  
3

### Berekeningsinvoer SCIA model

#### Stroming

|                                     |                       |                                        |                    |
|-------------------------------------|-----------------------|----------------------------------------|--------------------|
| Stroomsnelheid                      | v                     | <input type="text" value="2"/> m/s     | Geen stroming      |
| Diepgang                            | d                     | <input type="text" value="0"/> m       |                    |
| Weerstandcoëfficiënt                | C <sub>y</sub>        | 0.75 -                                 | [BS6349-6 table 3] |
| Horizontale belasting door stroming | Q <sub>stroming</sub> | <input type="text" value="0.00"/> kN/m |                    |

#### Veerwaardes ter modelering van de drijvers en palen

##### Drijvers

|                                       |      |                                                     |
|---------------------------------------|------|-----------------------------------------------------|
| Breedte van de drijver                | B.dr | <input type="text" value="1.2"/> m                  |
| Lengte van de drijver                 | L.dr | <input type="text" value="1.5"/> m                  |
| Water doorsnijdend oppervlak          |      | 1.80 m <sup>2</sup>                                 |
| Aantal veren gemodelleerd per drijver |      | <input type="text" value="4"/>                      |
| Dichtheid van water                   |      | <input type="text" value="1000"/> kg/m <sup>3</sup> |
| Veerstijfheid per ondersteuning       |      | <input type="text" value="4.41"/> kN/m              |

##### Palen

De stijfheid van de palen is op basis van ervaring en snelle handberekening aangenomen. De exacte stijfheid heeft een geringe invloed op de berekening en de ingeschatte waarde is een "realistische" ondergrens.

|                                      |   |                                                  |           |
|--------------------------------------|---|--------------------------------------------------|-----------|
| Diameter van de paal                 | D | <input type="text" value="273"/> mm              | [aanname] |
| Wanddikte                            | t | <input type="text" value="8"/> mm                | [aanname] |
| Type grond                           |   | <input type="text" value="Slap (klei of veen)"/> | [aanname] |
| Inklemingsdiepte factor (x diameter) | f | <input type="text" value="12"/> x D              | [aanname] |
| Horizontale veerstijfheid            | k | <input type="text" value="180"/> kN/m            |           |

Project: BI7934 Inter Boat Marinas  
Part: Standard load inputs for fingerpier design  
Date: 01/10/2023  
Author: [REDACTED]

Version: 1  
Checked by: [REDACTED]  
Date: 18/07/2023  
Pages: 3

## Standard load inputs for fingerpier design - and structural optimization potential estimate

### Description

This calculation sheet summarizes the various loads acting on finger piers for a standardized set of viny pier types and design vessels. The first sheet presents the inputs and definitions used in the calculations. The sheets after, the (horizontal) design loads on a single finger pier are calculated. The load calculation take the WIND load as leading and assumes 2 maximum design vessels at a single finger pier. [local design situation]  
From the wind loads, equivalent current and berthing loads are calculated. Finally a simplified structural assessment is carried out to estimate the optimization potential. This has been done by comparing the Unity Check for the compression in the main chord to calculated Unity Checks for strength and stability using a FEM calculation. Note that the assessment of joints (between frame elements and at the connection with the main walkway) have not been included

**NOTE:** The loads calculated are only to be used for the structural design of a single finger pier and its connection to a main element. For an overall floating marina structure lower loads shall be used as it is unlikely that all fingerpiers will be loaded by 2 design vessels (full marina with only max size vessels). The reduction should be assessed per project but an average load would be 50-80% of the load used for a single finger pier

### Loads overview

|                                                                             |                       |                        |                                                                                          |
|-----------------------------------------------------------------------------|-----------------------|------------------------|------------------------------------------------------------------------------------------|
| Wavelength without further study                                            | $Q_{\text{goff}}$     | 2 kN/m                 | [AS3962-2001 - 4.8.2.3 and tab 4.2]                                                      |
| Berthing velocity for small marina craft (< 20m)                            | $V_b$                 | 0.3 m/s                | [AS3962-2001 - 4.9]                                                                      |
| Minimum flow velocity                                                       | $V_c$                 | 1 m/s                  | [AS3962-2001 art 4.8.4.2]                                                                |
| Bollard load, standard 1ton bollard                                         | $F_{\text{bollard}}$  | 10.0 kN                |                                                                                          |
| Center to center distance of bollards                                       | $h_{\text{obollard}}$ | 10 m                   | Assumption                                                                               |
| Minimum equivalent line load due to bollards                                | $Q_{\text{berth}}$    | 1.00 kN/m              |                                                                                          |
| Deck load - for structural elements                                         | $Q_{\text{deck}}$     | 3 kN/m <sup>2</sup>    | [AS3962-2001 - art 4.7.2]                                                                |
| Concentrated deck load - for structural elements                            | $F_{\text{deck}}$     | 4.5 kN                 | [AS3962-2001 - art 4.7.3]                                                                |
| Basic wind speed [10min duration gust, 10m height]                          | $V_b$                 | 24.5 m/s               | EN1991-1-4NB Wind area III                                                               |
| Extreme wind pressure for short gusts (1-5s), standard EN1991-1-4 load      | $Q_b$                 | 0.49 kN/m <sup>2</sup> | [EN1991-1-4 NL Wind area I - Non built remain - zmin = 4m]                               |
| Extreme wind pressure for 30s gusts, used for boats and floating structures | $Q_{p,30s}$           | 0.37 kN/m <sup>2</sup> | [Reduction $v_{30s} = 0.87 \times v_{3s} \rightarrow qp_{30s} = 0.87^2 \times qp_{3s}$ ] |

### Factors for determining the wind loads

|                                 |           |     |     |                                                                       |
|---------------------------------|-----------|-----|-----|-----------------------------------------------------------------------|
| Friction coefficient            | $C_f$     | 1.1 | [-] | [AS3962-2001-tab 4.3]                                                 |
| Reduction factor for netto area | $C_{A,w}$ | 1   | [-] | [assumed that AS3962 windage areas are netto areas, see tables below] |

### Factors for determining current loads

|                                               |                |      |     |                      |                                                                                                                                                                                 |
|-----------------------------------------------|----------------|------|-----|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Combination factor for wind and current loads |                | 0.7  |     | [-]                  | [Assumption BS6349 allows combination factors of 0.5 (wind) and 0.6 (operational current) however 0.7 is assumed as there is some correlation between bad weather and flooding] |
| Area reduction factor - bow / stern           | $C_{A,c,head}$ | 0.5  | 0.4 | [-]                  | [Assumption, based on experience and blockfactor]                                                                                                                               |
| Area reduction factor - beam                  | $C_{A,c,beam}$ | 0.6  | 0.4 | [-]                  | [Assumption, based on experience and blockfactor]                                                                                                                               |
| Density of water                              | $\rho_w$       | 1005 |     | [kg/m <sup>3</sup> ] |                                                                                                                                                                                 |
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### Berth configuration coefficient for determining wind and current loads on fingerpier

#### For standard finger piers

|                                                              |                      |        |     |                                                                              |
|--------------------------------------------------------------|----------------------|--------|-----|------------------------------------------------------------------------------|
| Factor for load to finger pier with bow-line to main walkway | $F_{\text{red,max}}$ | 50%    | [-] | [Assumption, see sketch]                                                     |
| Maximum load to main walkway & pile via bow line             |                      | 7.1 kN |     | $F_{\text{bollard}} / v_2$ used as limiting value for load reduction to pier |
| Location of resultant force with 50% of load to bow line     |                      | 0.75   | [-] | $X_{w,LOA}$                                                                  |
| Location of resultant force with 0% of load to bow line      |                      | 0.5    | [-] | $X_{w,LOA}$                                                                  |

#### For "opstap" piers

|                                                  |                      |         |     |                                                                                         |
|--------------------------------------------------|----------------------|---------|-----|-----------------------------------------------------------------------------------------|
| Factor for load to finger pier (opstap steiger)  | $f_{\text{pier}}$    | 30%     | [-] | [Assumption, loads should pass through lines, however take some load as contingency]    |
| Maximum load to main walkway & pile via bow line | $F_{\text{red,max}}$ | 14.1 kN |     | $2 \times F_{\text{bollard}} / v_2$ - used as limiting value for load reduction to pier |
| Factor for load to finger pier (head stern)      | $f_{\text{opstap}}$  | 50%     | [-] | [Assumption, loads should pass through lines, however take some load as contingency]    |
| Location of resultant force for opstap steiger   |                      | 0.5     | [-] | $X_M/L_{\text{pier}}$                                                                   |

#### Factors for 2nd boat

|                                                         |                         |      |     |                                                            |
|---------------------------------------------------------|-------------------------|------|-----|------------------------------------------------------------|
| Factor for 2nd boat head / stern                        | $f_{\text{boat2,head}}$ | 100% | [-] | [full load, no shadowing effect]                           |
| Factor for 2nd boat down wind on other side of pier     | $f_{w,boat2,beam}$      | 20%  | [-] | [AS3962-2001-art 4.8.3.3 2nd ship down wind is loaded 20%] |
| Factor for 2nd boat down currents on other side of pier | $f_{c,boat2,beam}$      | 20%  | [-] | [above also assumed to apply for currents]                 |

### Factors for determining the berthing load - Treilerborg Fender Design Manual based on (PIANC 2002, ROM3.1)

|                                                         |                       |                            |                              |                                                                     |
|---------------------------------------------------------|-----------------------|----------------------------|------------------------------|---------------------------------------------------------------------|
| Berthing velocity for small marina craft (< 20m)        | $V_b$                 | 0.3                        | m/s                          | [AS3962-2001 - 4.9, may be smaller for larger boats PIANC]          |
| Factor for "abnormal berthing"                          | $F_{s,abn}$           | 1.5                        | [-]                          | [Reference?]                                                        |
| 3D Block coefficient                                    | $C_b$                 | <b>Motor boats</b><br>0.25 | <b>Sailing boats</b><br>0.15 | [-] [Assumption, based on vessel data PIANCWG121 en ROM3.1]         |
| Estimated allowable relative deflection of vingerpier   | $U_p/L_{\text{pier}}$ | 0.01                       | [-]                          | [Assumption based on calculation estimates]                         |
| Configuration coefficient                               | $C_c$                 | 1                          | [-]                          | [1 = open constructie]                                              |
| Softness coefficient                                    | $C_s$                 | 1                          | [-]                          | [1 = hard contact]                                                  |
| Added mass coefficient                                  | $C_m$                 | 1.8                        | [-]                          | [Assumption, water can be relatively deep compared to vessel draft] |
| Berthing angle                                          | $\alpha$              | 10                         | [-]                          | [Assumption]                                                        |
| Factor for distance C.O.G vessel to impact point on bow | $y/LOA$               | 0.50                       | [-]                          | [Assumption]                                                        |

### Windage area data from AS3962-2001-Tab4.4 for extra/interpolation

Note the below tables are used to calculate the effective height of the vessels which is used to estimate the windage area's of a large vessel range by inter/extrapolation  
It is assumed that these windage areas are netto areas representative for the maximum design vessels and therefore no further reduction coefficient should apply.

| Motor Vessels      |      |                   |                   |  | Calculated   |              |
|--------------------|------|-------------------|-------------------|--|--------------|--------------|
| AS3962-2001-tab4.4 |      |                   |                   |  | $H_{w,head}$ | $H_{w,beam}$ |
| L                  | B    | $A_{w,head}$      | $A_{w,beam}$      |  | [m]          | [m]          |
| [m]                | [m]  | [m <sup>2</sup> ] | [m <sup>2</sup> ] |  |              |              |
| 8                  | 2.75 | 5                 | 16                |  | 1.82         | 2.00         |
| 10                 | 3.25 | 7                 | 22                |  | 2.15         | 2.20         |
| 12                 | 4    | 11                | 29                |  | 2.75         | 2.42         |
| 15                 | 4.5  | 18                | 45                |  | 4.00         | 3.00         |
| 18                 | 5    | 22                | 64                |  | 4.40         | 3.55         |
| 20                 | 5.5  | 24                | 76                |  | 4.35         | 3.80         |
| 25                 | 6    | 30                | 95                |  | 5.00         | 3.80         |
| 30                 | 7    | 45                | 120               |  | 6.43         | 4.00         |

| Yachts             |      |                   |                   |  | Calculated   |              |
|--------------------|------|-------------------|-------------------|--|--------------|--------------|
| AS3962-2001-tab4.4 |      |                   |                   |  | $H_{w,head}$ | $H_{w,beam}$ |
| L                  | B    | $A_{w,head}$      | $A_{w,beam}$      |  | [m]          | [m]          |
| [m]                | [m]  | [m <sup>2</sup> ] | [m <sup>2</sup> ] |  |              |              |
| 8                  | 2.75 | 4                 | 11                |  | 1.45         | 1.38         |
| 10                 | 3.25 | 5                 | 15                |  | 1.54         | 1.50         |
| 12                 | 3.75 | 6                 | 20                |  | 1.60         | 1.67         |
| 15                 | 4.5  | 9                 | 28                |  | 2.00         | 1.87         |
| 18                 | 5    | 11                | 40                |  | 2.20         | 2.22         |
| 20                 | 5.25 | 12                | 44                |  | 2.29         | 2.20         |
| 30                 | 7    | 35                | 92                |  | 5.00         | 3.07         |

### References

NEN-EN-1990-2019+NB - General  
NEN-EN-1990-1-4-2011+NB - Wind loads  
AS3962-2001 - Australian Standard - Guidelines for marina's  
PIANC WG149 - Guidelines for marina design  
PIANC WG121 - Harbour Approach Channels (Ship data)  
BS6349-1-1-2013- Maritime Works - General  
BS6349-1-2-2018 - Maritime Works - Code of practice for assessment of loads  
BS6349-6-1989 - Design of inshore moorings and floating structures  
Treilerborg - Fender application design manual

### Remarks / IBM approach

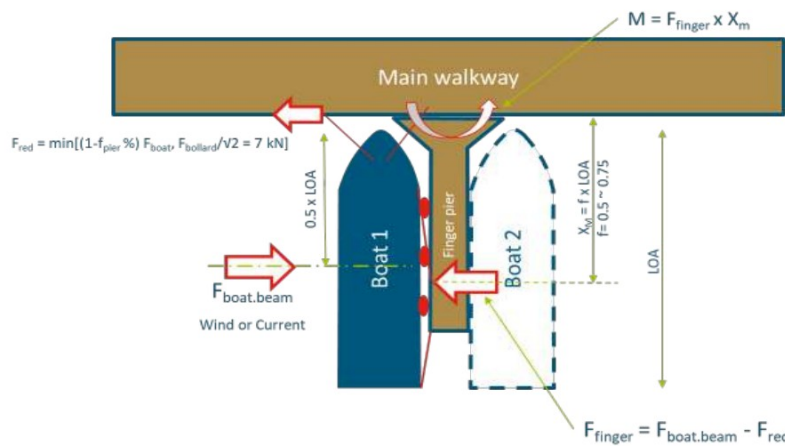
Wavelengths can coincide with windloads, however in typical dutch / german marinas these will be very small. Ship waves will not occur with a storm, however some cases ship waves may be significant.  
Berthing loads should not be governing. IBM experience is that finger piers also deflect vertically and that if damage occurs this is due to reckless berthing. Equivalent berthing velocity calculated in this sheet are for reference only  
In typical dutch marina's there is no or minimal current <<1m/s. In more inland cases, along rivers currents may occur but it is unlikely to coincide (timing & direction), therefore a combinatin factor of 0.7 is assumed to determine combined current load. This may still be conservative for inland cases.  
-  
-  
Only for comparison to wind loads

BM standard load = **150kg/m<sup>2</sup>** *!!it would be better to design structural strength higher than floation load that would correspond to approach of AS3962-4.7 and PIANC. Even if IBM uses lower overall loads this pricipie should apply*

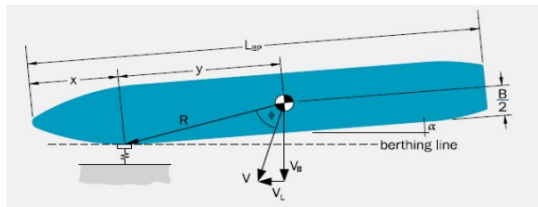
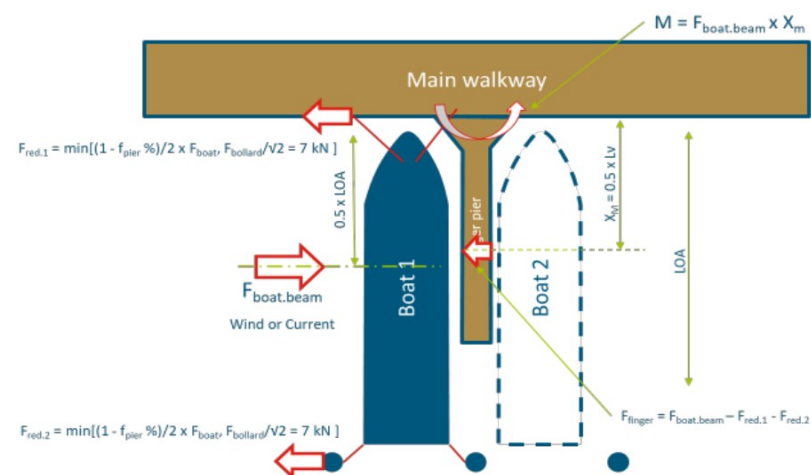
BM standard load = **2.5kN** *!!see remark above*

-  
For wind area III or mainland areas (Du) this can be about 20-30% lower, however, in Germany often Reliability Class RC2 applies resulting in 10% higher load factors  
Using the 30s wind gust is permitted by AS3962 and PIANC WG149, factor of 0.87 is given in PIANC WG149.

### Side Forces (beam) on standard berth configuration - Finger Pier



### Side Forces (beam) on "Opstap" berth configuration - Finger Pier



### Input for structural capacity estimates

|                                 |           |          |                                                                                                                                |
|---------------------------------|-----------|----------|--------------------------------------------------------------------------------------------------------------------------------|
| Profile of main chord           | As        | 120x60x4 | mm                                                                                                                             |
| Gross section area              | A_s       | 1330     | mm <sup>2</sup>                                                                                                                |
| Steel grade (yield strength)    | f_yd      | 235      | N/mm <sup>2</sup>                                                                                                              |
| Axial capacity of chord         | N_Rd      | 313      | kN                                                                                                                             |
| Profile width                   | B_p       | 0.06     | [m]                                                                                                                            |
| Load factor for wind & currents | gamma     | 1.35     |                                                                                                                                |
| Target Unity Check              | UC target | 0.6      | [Based on FEM analysis of 12m finger pier, with this factor UC < 1.0 with some local exceptions, assesment of joints excluded] |

### Remark regarding optimization potential

The optimization potential is calculated by  $UC_N / UC_{\text{target}}$ . This gives an idea on how much optimization potential may be realized, however it is not exact, please see below guidance on how to interpret the results  
This accounts only for the section and stability analysis of the structural members, joint details have not yet been included.

|                                                                                       |
|---------------------------------------------------------------------------------------|
| << 1.0 (well below 1.0) = optimization potential                                      |
| <1.0> (near 1.0) = local optimization potential, but some reinforcement may be needed |
| >1.0 (near 1.0) = optimization potential, but some reinforcement may be needed        |





Project: BI7934 Inter Boat Marinas  
Part: Standard load inputs for fingerpier design  
Date: 01/10/2023  
Author: [REDACTED]

Version: 1  
Checked by: [REDACTED]  
Date: 18/07/2023  
Pages: 3

Standard load inputs for fingerpier design - and structural optimization potential estimate

| Motor boats and yachts - Wind, Bollard, Current and Berthing loads on finger piers |      |      |                |                     |                |  |                        |                     |                     |                     |                     |                     |                     |                     |     |                       |                      |                |                |                    |                     |                     |                        |                        |                          |                          |                   |      |      |                                  |      |                |                   |                   |                   |                               |                      |                  |                      |                 |      |      |     |     |
|------------------------------------------------------------------------------------|------|------|----------------|---------------------|----------------|--|------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-----|-----------------------|----------------------|----------------|----------------|--------------------|---------------------|---------------------|------------------------|------------------------|--------------------------|--------------------------|-------------------|------|------|----------------------------------|------|----------------|-------------------|-------------------|-------------------|-------------------------------|----------------------|------------------|----------------------|-----------------|------|------|-----|-----|
| Input (Inter Boat Marina Data)                                                     |      |      |                |                     |                |  | Wind and Bollard loads |                     |                     |                     |                     |                     |                     |                     |     |                       | Current (equivalent) |                |                |                    | Current (combined)  |                     | Berthing (equivalent)  |                        |                          |                          |                   |      |      | Structural check - rule of thumb |      |                |                   |                   |                   |                               |                      |                  |                      |                 |      |      |     |     |
| LOA                                                                                | B    | D    | L <sub>f</sub> | L <sub>finger</sub> | B <sub>f</sub> |  | F <sub>w,head</sub>    | F <sub>w,beam</sub> | A <sub>w,head</sub> | A <sub>w,beam</sub> | F <sub>w,head</sub> | F <sub>w,beam</sub> | F <sub>w,head</sub> | F <sub>w,beam</sub> | Xm  | M <sub>w,finger</sub> | Q <sub>w,eq</sub>    | F <sub>b</sub> | M <sub>b</sub> | M <sub>b,max</sub> | A <sub>c,head</sub> | A <sub>c,beam</sub> | V <sub>c,eq,head</sub> | V <sub>c,eq,beam</sub> | V <sub>c,comb,head</sub> | V <sub>c,comb,beam</sub> | VD                | MD   | K    | R                                | CE   | U <sub>s</sub> | F <sub>a,eq</sub> | E <sub>a,eq</sub> | V <sub>a,eq</sub> | Check with AS6392 requirement | F <sub>w,max,d</sub> | Z <sub>int</sub> | N <sub>chord,d</sub> | N <sub>rd</sub> | UCN  | OPT  |     |     |
| [m]                                                                                | [m]  | [m]  | [m]            | [m]                 | [m]            |  | [m]                    | [m]                 | [m <sup>2</sup> ]   | [m <sup>2</sup> ]   | [kN]                | [kN]                | [kN]                | [kN]                | [m] | [kNm]                 | [kN/m]               | [kN]           | [kNm]          | [kNm]              | [m <sup>2</sup> ]   | [m <sup>2</sup> ]   | [m/s]                  | [m/s]                  | [m/s]                    | [m/s]                    | [m <sup>3</sup> ] | [t]  | [m]  | [m]                              | [m]  | [m]            | [m]               | [m]               | [kN]              | [kNm]                         | [m/s]                | > 0.3 [OK]       | [kNm]                | [m]             | [kN] | [kN] | [m] | [m] |
| 4                                                                                  | 2.25 | 0.5  | 3              | 3                   | 0.6            |  | 1.15                   | 1.60                | 2.6                 | 6.4                 | 1.1                 | 2.6                 | 2.1                 | 1.6                 | 3.0 | 5                     | 1.0                  | 10             | 30             | 30                 | 0.56                | 1.20                | 2.5                    | 2.7                    | 1.4                      | 1.5                      | 1.1               | 1.1  | 0.63 | 2.3                              | 0.23 | 0.03           | 10.00             | 0.15              | 0.65              | > 0.3 [OK]                    | 41                   | 0.6              | 67.5                 | 313             | 0.2  | 0.4  |     |     |
| 4.5                                                                                | 2.25 | 0.5  | 4              | 4                   | 0.6            |  | 1.23                   | 1.65                | 2.8                 | 7.4                 | 1.1                 | 3.0                 | 2.3                 | 1.8                 | 3.4 | 6                     | 0.8                  | 10             | 40             | 40                 | 0.56                | 1.35                | 2.6                    | 2.7                    | 1.4                      | 1.5                      | 1.3               | 1.3  | 0.71 | 2.5                              | 0.23 | 0.04           | 10.00             | 0.20              | 0.70              | > 0.3 [OK]                    | 54                   | 0.6              | 90.0                 | 313             | 0.3  | 0.5  |     |     |
| 5                                                                                  | 2.25 | 0.5  | 4              | 4                   | 0.6            |  | 1.31                   | 1.70                | 3.0                 | 8.5                 | 1.2                 | 3.5                 | 2.4                 | 2.1                 | 3.8 | 8                     | 1.0                  | 10             | 40             | 40                 | 0.56                | 1.50                | 2.7                    | 2.8                    | 1.5                      | 1.5                      | 1.4               | 1.4  | 0.79 | 2.7                              | 0.24 | 0.04           | 10.00             | 0.20              | 0.67              | > 0.3 [OK]                    | 54                   | 0.6              | 90.0                 | 313             | 0.3  | 0.5  |     |     |
| 5.5                                                                                | 2.25 | 0.5  | 4              | 5                   | 0.6            |  | 1.40                   | 1.75                | 3.1                 | 9.6                 | 1.3                 | 3.9                 | 2.6                 | 2.4                 | 4.1 | 10                    | 1.2                  | 10             | 40             | 40                 | 0.56                | 1.65                | 2.8                    | 2.8                    | 1.5                      | 1.5                      | 1.5               | 1.6  | 0.87 | 3.0                              | 0.24 | 0.04           | 10.00             | 0.20              | 0.63              | > 0.3 [OK]                    | 54                   | 0.6              | 90.0                 | 313             | 0.3  | 0.5  |     |     |
| 6                                                                                  | 2.25 | 0.5  | 5              | 5                   | 0.6            |  | 1.48                   | 1.80                | 3.3                 | 10.8                | 1.4                 | 4.4                 | 2.7                 | 2.6                 | 4.5 | 12                    | 1.0                  | 10             | 50             | 50                 | 0.56                | 1.80                | 2.8                    | 2.8                    | 1.5                      | 1.6                      | 1.7               | 1.7  | 0.95 | 3.2                              | 0.24 | 0.05           | 10.00             | 0.25              | 0.67              | > 0.3 [OK]                    | 68                   | 0.6              | 112.5                | 313             | 0.4  | 0.6  |     |     |
| 6.5                                                                                | 2.5  | 0.5  | 5              | 5                   | 0.6            |  | 1.57                   | 1.85                | 3.9                 | 12.0                | 1.6                 | 4.9                 | 3.2                 | 2.9                 | 4.9 | 14                    | 1.1                  | 10             | 50             | 50                 | 0.63                | 1.95                | 2.9                    | 2.9                    | 1.6                      | 1.6                      | 2.0               | 2.0  | 1.02 | 3.5                              | 0.24 | 0.05           | 10.00             | 0.25              | 0.62              | > 0.3 [OK]                    | 68                   | 0.6              | 112.5                | 313             | 0.4  | 0.6  |     |     |
| 7                                                                                  | 2.5  | 0.75 | 6              | 6                   | 0.6            |  | 1.65                   | 1.90                | 4.1                 | 13.3                | 1.7                 | 5.4                 | 3.4                 | 3.3                 | 5.3 | 17                    | 0.9                  | 10             | 60             | 60                 | 0.94                | 3.15                | 2.4                    | 2.4                    | 1.3                      | 1.3                      | 3.3               | 3.3  | 1.10 | 3.7                              | 0.24 | 0.06           | 10.00             | 0.30              | 0.53              | > 0.3 [OK]                    | 81                   | 0.6              | 135.0                | 313             | 0.4  | 0.7  |     |     |
| 7.5                                                                                | 2.5  | 0.75 | 6              | 6                   | 0.6            |  | 1.73                   | 1.95                | 4.3                 | 14.6                | 1.8                 | 6.0                 | 3.5                 | 3.6                 | 5.6 | 20                    | 1.1                  | 10             | 60             | 60                 | 1.03                | 3.38                | 2.5                    | 2.4                    | 1.3                      | 1.3                      | 3.5               | 3.5  | 1.18 | 4.0                              | 0.24 | 0.06           | 10.00             | 0.30              | 0.51              | > 0.3 [OK]                    | 81                   | 0.6              | 135.0                | 313             | 0.4  | 0.7  |     |     |
| 8                                                                                  | 2.75 | 0.75 | 6              | 6                   | 0.6            |  | 1.82                   | 2.00                | 5.0                 | 16.0                | 2.0                 | 6.5                 | 4.1                 | 3.9                 | 6.0 | 23                    | 1.3                  | 10             | 60             | 60                 | 1.03                | 3.60                | 2.6                    | 2.5                    | 1.4                      | 1.3                      | 4.1               | 4.1  | 1.26 | 4.2                              | 0.24 | 0.06           | 10.00             | 0.30              | 0.47              | > 0.3 [OK]                    | 81                   | 0.6              | 135.0                | 313             | 0.4  | 0.7  |     |     |
| 8.5                                                                                | 2.75 | 0.75 | 7              | 7                   | 0.8            |  | 1.90                   | 2.05                | 5.2                 | 17.4                | 2.1                 | 7.1                 | 4.3                 | 4.3                 | 6.4 | 27                    | 1.1                  | 10             | 70             | 70                 | 1.03                | 3.83                | 2.6                    | 2.5                    | 1.4                      | 1.4                      | 4.4               | 4.4  | 1.34 | 4.5                              | 0.24 | 0.07           | 10.00             | 0.35              | 0.49              | > 0.3 [OK]                    | 95                   | 0.8              | 118.1                | 313             | 0.4  | 0.6  |     |     |
| 9                                                                                  | 3    | 1    | 7              | 7                   | 0.8            |  | 1.99                   | 2.10                | 6.0                 | 18.9                | 2.4                 | 7.7                 | 4.9                 | 4.6                 | 6.8 | 31                    | 1.3                  | 10             | 70             | 70                 | 1.50                | 5.40                | 2.3                    | 2.2                    | 1.3                      | 1.2                      | 6.8               | 6.8  | 1.42 | 4.7                              | 0.24 | 0.07           | 10.00             | 0.35              | 0.40              | > 0.3 [OK]                    | 95                   | 0.8              | 118.1                | 313             | 0.4  | 0.6  |     |     |
| 9.5                                                                                | 3.25 | 1    | 7              | 8                   | 0.8            |  | 2.07                   | 2.15                | 6.7                 | 20.4                | 2.7                 | 8.3                 | 5.5                 | 5.0                 | 7.1 | 36                    | 1.5                  | 10             | 70             | 70                 | 1.63                | 5.70                | 2.4                    | 2.2                    | 1.3                      | 1.2                      | 7.7               | 7.8  | 1.50 | 5.0                              | 0.24 | 0.07           | 10.00             | 0.35              | 0.37              | > 0.3 [OK]                    | 95                   | 0.8              | 118.1                | 313             | 0.4  | 0.6  |     |     |
| 10                                                                                 | 3.25 | 1    | 8              | 8                   | 0.8            |  | 2.15                   | 2.20                | 7.0                 | 22.0                | 2.9                 | 9.0                 | 5.7                 | 5.4                 | 7.5 | 40                    | 1.3                  | 10             | 80             | 80                 | 1.63                | 6.00                | 2.4                    | 2.2                    | 1.3                      | 1.2                      | 8.1               | 8.2  | 1.58 | 5.3                              | 0.24 | 0.08           | 10.00             | 0.40              | 0.39              | > 0.3 [OK]                    | 108                  | 0.8              | 135.0                | 313             | 0.4  | 0.7  |     |     |
| 10.5                                                                               | 3.5  | 1    | 8              | 8                   | 0.8            |  | 2.30                   | 2.25                | 8.1                 | 23.7                | 3.3                 | 9.7                 | 6.6                 | 5.8                 | 7.9 | 46                    | 1.4                  | 10             | 80             | 80                 | 1.75                | 6.30                | 2.5                    | 2.3                    | 1.4                      | 1.2                      | 9.2               | 9.2  | 1.65 | 5.5                              | 0.24 | 0.08           | 10.00             | 0.40              | 0.36              | > 0.3 [OK]                    | 108                  | 0.8              | 135.0                | 313             | 0.4  | 0.7  |     |     |
| 11                                                                                 | 3.75 | 1    | 9              | 9                   | 0.8            |  | 2.45                   | 2.31                | 9.2                 | 25.4                | 3.8                 | 10.4                | 7.5                 | 6.2                 | 8.3 | 51                    | 1.3                  | 10             | 90             | 90                 | 1.88                | 6.60                | 2.6                    | 2.3                    | 1.4                      | 1.2                      | 10.3              | 10.4 | 1.73 | 5.8                              | 0.24 | 0.09           | 10.00             | 0.45              | 0.37              | > 0.3 [OK]                    | 122                  | 0.8              | 151.9                | 313             | 0.5  | 0.8  |     |     |
| 11.5                                                                               | 3.75 | 1    | 9              | 9                   | 0.8            |  | 2.60                   | 2.36                | 9.8                 | 27.2                | 4.0                 | 11.1                | 8.0                 | 6.7                 | 8.6 | 57                    | 1.4                  | 10             | 90             | 90                 | 1.88                | 6.90                | 2.7                    | 2.3                    | 1.5                      | 1.3                      | 10.8              | 10.8 | 1.81 | 6.0                              | 0.24 | 0.09           | 10.00             | 0.45              | 0.36              | > 0.3 [OK]                    | 122                  | 0.8              | 151.9                | 313             | 0.5  | 0.8  |     |     |
| 12                                                                                 | 4    | 1    | 9              | 9                   | 0.8            |  | 2.75                   | 2.42                | 11.0                | 29.0                | 4.5                 | 11.8                | 9.0                 | 7.1                 | 9.0 | 64                    | 1.6                  | 10             | 90             | 90                 | 2.00                | 7.20                | 2.7                    | 2.3                    | 1.5                      | 1.3                      | 12.0              | 12.1 | 1.89 | 6.3                              | 0.24 | 0.09           | 10.00             | 0.45              | 0.34              | > 0.3 [OK]                    | 122                  | 0.8              | 151.9                | 313             | 0.5  | 0.8  |     |     |
| 12.5                                                                               | 4    | 1    | 10             | 10                  | 0.8            |  | 2.96                   | 2.51                | 11.8                | 31.4                | 4.8                 | 12.8                | 9.7                 | 7.7                 | 9.4 | 72                    | 1.4                  | 10             | 100            | 100                | 2.00                | 7.50                | 2.8                    | 2.4                    | 1.5                      | 1.3                      | 12.5              | 12.6 | 1.97 | 6.6                              | 0.24 | 0.10           | 10.00             | 0.50              | 0.35              | > 0.3 [OK]                    | 135                  | 0.8              | 168.8                | 313             | 0.5  | 0.9  |     |     |
| 13                                                                                 | 4    | 1    | 10             | 10                  | 0.8            |  | 3.17                   | 2.61                | 12.7                | 33.9                | 5.2                 | 13.8                | 10.3                | 8.3                 | 9.8 | 81                    | 1.6                  | 10             | 100            | 100                | 2.00                | 7.80                | 2.9                    | 2.4                    | 1.6                      | 1.3                      | 13.0              | 13.1 | 2.05 | 6.8                              | 0.24 | 0.10           | 10.00             | 0.50              | 0.34              | > 0.3 [OK]                    | 135                  | 0.8              | 168.8                | 313             | 0.5  | 0.9  |     |     |
| 13.5                                                                               | 4.25 | 1    | 10             | 11                  | 0.8            |  | 3.38                   | 2.71                | 14.3                | 36.6                | 5.9                 | 14.9                | 11.7                | 9.4                 | 9.9 | 94                    | 1.9                  | 10             | 100            | 100                | 2.13                | 8.10                | 3.0                    | 2.5                    | 1.7                      | 1.4                      | 14.3              | 14.4 | 2.13 | 7.1                              | 0.24 | 0.10           | 10.00             | 0.50              | 0.33              | > 0.3 [OK]                    | 135                  | 0.8              | 168.8                | 313             | 0.5  | 0.9  |     |     |



Project: BI7934 Inter Boat Marinas  
Part: Standard load inputs for fingerpier design  
Date: 01/10/2023  
Author: [REDACTED]

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Pages: 3

Standard load inputs for fingerpier design - and structural optimization potential estimate

| Sailing boats & yachts - Wind, Bollard, Current and Berthing loads on finger piers |       |       |                       |                     |                      |                                                  |                                          |                                                                                  |                                                                          |                                  |                          |                                                  |                                          |                |                                      |                                                           |                |                                                                          |                                              |                                              |                                      |                             |                                    |                                                                                                                          |                                                                                                                  |                   |                |                    |                                               |                          |                                                  |                                                                        |                            |                              |                               |                                                             |                                           |                                                    |                                       |                                                                           |                         |
|------------------------------------------------------------------------------------|-------|-------|-----------------------|---------------------|----------------------|--------------------------------------------------|------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------|--------------------------|--------------------------------------------------|------------------------------------------|----------------|--------------------------------------|-----------------------------------------------------------|----------------|--------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------------------|-----------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------|----------------|--------------------|-----------------------------------------------|--------------------------|--------------------------------------------------|------------------------------------------------------------------------|----------------------------|------------------------------|-------------------------------|-------------------------------------------------------------|-------------------------------------------|----------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|-------------------------|
| Input (Inter Boat Marina Data)                                                     |       |       |                       |                     |                      | Wind and Bollard loads                           |                                          |                                                                                  |                                                                          |                                  |                          |                                                  |                                          |                |                                      | Current (equivalent)                                      |                |                                                                          |                                              | Current (combined)                           |                                      | Berthing (equivalent)       |                                    |                                                                                                                          |                                                                                                                  |                   |                |                    | Structural check - rule of thumb              |                          |                                                  |                                                                        |                            |                              |                               |                                                             |                                           |                                                    |                                       |                                                                           |                         |
| Length [Length Over All]                                                           | Width | Depth | Length of finger pier | Length Finger Pier  | Width of finger pier | Averaged height, for windage area [Head / Stern] | Averaged height, for windage area [Beam] | Net. Windage area [Head / Stern]<br>LOA x H <sub>w,head</sub> x C <sub>A,w</sub> | Net. Windage area [Beam]<br>LOA x H <sub>w,beam</sub> x C <sub>A,w</sub> | Wind load on boat [Head / Stern] | Wind load on boat [Beam] | Wind load to fingerpier - 2 boats [Head / Stern] | Wind load to fingerpier - 2 boats [Beam] | X <sub>m</sub> | M <sub>w,finger</sub> - main walkway | Equivalent distributed wind load along finger pier [Beam] | Bollard load   | Moment at connection due to bollard load [bollard at end of finger pier] | Max. moment due to wind load OR bollard load | Net. area for current loading [Head / Stern] | Net. area for current loading [Beam] | Equivalent current velocity | Equivalent current velocity [Beam] | Combined current velocity combined with 70% of windload [Head / Stern]<br>F <sub>current</sub> = 0.3 x F <sub>wind</sub> | Combined current velocity combined with 70% of windload [Beam]<br>F <sub>current</sub> = 0.3 x F <sub>wind</sub> | Displacement      | Displaced mass | Radius of gyration | Distance between impact point and C.O.G. boat | Eccentricity Coefficient | Estimated allowable displacement at impact point | Equivalent berthing load<br>M <sub>w,berth</sub> = M <sub>w,main</sub> | Equivalent berthing energy | Equivalent berthing velocity | Check with AS6392 requirement | Max. moment due to wind load OR bollard load - Design Value | Internal leverage arm of fingerpier frame | Normal force in the chords of frame - design value | Design normal force capacity of chord | Unity check - Compression (normal force section check only, no stability) | Optimization potential. |
| LOA                                                                                | B     | D     | L <sub>f</sub>        | L <sub>finger</sub> | B <sub>f</sub>       | F <sub>w,head</sub>                              | F <sub>w,beam</sub>                      | A <sub>w,head</sub>                                                              | A <sub>w,beam</sub>                                                      | F <sub>w,head</sub>              | F <sub>w,beam</sub>      | F <sub>w,head</sub>                              | F <sub>w,beam</sub>                      | X <sub>m</sub> | M <sub>w,finger</sub>                | Q <sub>w,equi</sub>                                       | F <sub>b</sub> | M <sub>b</sub>                                                           | M <sub>b,max</sub>                           | A <sub>c,head</sub>                          | A <sub>c,beam</sub>                  | V <sub>c,equi,head</sub>    | V <sub>c,equi,beam</sub>           | V <sub>c,comb,head</sub>                                                                                                 | V <sub>c,comb,beam</sub>                                                                                         | VD                | MD             | K                  | R                                             | CE                       | u <sub>e</sub>                                   | F <sub>berth,equi</sub>                                                | E <sub>berth,equi</sub>    | V <sub>berth,equi</sub>      |                               | M <sub>w,max,d</sub>                                        | Z <sub>int</sub>                          | N <sub>chord,d</sub>                               | N <sub>rd</sub>                       | UCN                                                                       | OPT                     |
| [m]                                                                                | [m]   | [m]   | [m]                   | [m]                 | [m]                  | [kN]                                             | [kN]                                     | [m <sup>2</sup> ]                                                                | [m <sup>2</sup> ]                                                        | [kN]                             | [kN]                     | [kN]                                             | [kN]                                     | [m]            | [kNm]                                | [kN/m]                                                    | [kN]           | [kNm]                                                                    | [kNm]                                        | [m <sup>2</sup> ]                            | [m <sup>2</sup> ]                    | [m/s]                       | [m/s]                              | [m/s]                                                                                                                    | [m/s]                                                                                                            | [m <sup>3</sup> ] | [t]            | [m]                | [m]                                           | [-]                      | [m]                                              | [kN]                                                                   | [kNm]                      | [m/s]                        |                               | [kNm]                                                       | [m]                                       | [kN]                                               | [kN]                                  | [-]                                                                       | [-]                     |
| 4                                                                                  | 2.25  | 0.5   | 3                     | 3                   | 0.6                  | 1.29                                             | 1.13                                     | 2.90                                                                             | 4.50                                                                     | 1.2                              | 1.8                      | 2.4                                              | 1.1                                      | 3.0            | 3                                    | 0.7                                                       | 10             | 30                                                                       | 30                                           | 0.45                                         | 0.80                                 | 3.0                         | 2.0                                | 1.6                                                                                                                      | 1.1                                                                                                              | 0.7               | 0.7            | 0.55               | 2.3                                           | 0.22                     | 0.03                                             | 10.00                                                                  | 0.15                       | 0.86                         | > 0.3 [OK]                    | 41                                                          | 0.6                                       | 67.5                                               | 313                                   | 0.2                                                                       | 0.4                     |
| 4.5                                                                                | 2.25  | 0.5   | 4                     | 4                   | 0.6                  | 1.31                                             | 1.16                                     | 2.94                                                                             | 5.20                                                                     | 1.2                              | 2.1                      | 2.4                                              | 1.3                                      | 3.4            | 4                                    | 0.5                                                       | 10             | 40                                                                       | 40                                           | 0.45                                         | 0.90                                 | 3.0                         | 2.0                                | 1.6                                                                                                                      | 1.1                                                                                                              | 0.8               | 0.8            | 0.62               | 2.5                                           | 0.22                     | 0.04                                             | 10.00                                                                  | 0.20                       | 0.94                         | > 0.3 [OK]                    | 54                                                          | 0.6                                       | 90.0                                               | 313                                   | 0.3                                                                       | 0.5                     |
| 5                                                                                  | 2.5   | 0.5   | 4                     | 4                   | 0.6                  | 1.33                                             | 1.19                                     | 3.32                                                                             | 5.94                                                                     | 1.4                              | 2.4                      | 2.7                                              | 1.5                                      | 3.8            | 5                                    | 0.7                                                       | 10             | 40                                                                       | 40                                           | 0.50                                         | 1.00                                 | 3.0                         | 2.0                                | 1.6                                                                                                                      | 1.1                                                                                                              | 0.9               | 0.9            | 0.69               | 2.8                                           | 0.22                     | 0.04                                             | 10.00                                                                  | 0.20                       | 0.84                         | > 0.3 [OK]                    | 54                                                          | 0.6                                       | 90.0                                               | 313                                   | 0.3                                                                       | 0.5                     |
| 5.5                                                                                | 2.5   | 0.5   | 4                     | 5                   | 0.6                  | 1.35                                             | 1.22                                     | 3.37                                                                             | 6.70                                                                     | 1.4                              | 2.7                      | 2.8                                              | 1.6                                      | 4.1            | 7                                    | 0.8                                                       | 10             | 40                                                                       | 40                                           | 0.50                                         | 1.10                                 | 3.0                         | 2.0                                | 1.7                                                                                                                      | 1.1                                                                                                              | 1.0               | 1.0            | 0.76               | 3.0                                           | 0.22                     | 0.04                                             | 10.00                                                                  | 0.20                       | 0.80                         | > 0.3 [OK]                    | 54                                                          | 0.6                                       | 90.0                                               | 313                                   | 0.3                                                                       | 0.5                     |
| 6                                                                                  | 2.5   | 0.5   | 5                     | 5                   | 0.6                  | 1.37                                             | 1.25                                     | 3.43                                                                             | 7.50                                                                     | 1.4                              | 3.1                      | 2.8                                              | 1.8                                      | 4.5            | 8                                    | 0.7                                                       | 10             | 50                                                                       | 50                                           | 0.50                                         | 1.20                                 | 3.0                         | 2.1                                | 1.7                                                                                                                      | 1.1                                                                                                              | 1.1               | 1.1            | 0.83               | 3.3                                           | 0.22                     | 0.05                                             | 10.00                                                                  | 0.25                       | 0.85                         | > 0.3 [OK]                    | 68                                                          | 0.6                                       | 112.5                                              | 313                                   | 0.4                                                                       | 0.6                     |
| 6.5                                                                                | 2.5   | 1     | 5                     | 5                   | 0.6                  | 1.39                                             | 1.28                                     | 3.48                                                                             | 8.33                                                                     | 1.4                              | 3.4                      | 2.8                                              | 2.0                                      | 4.9            | 10                                   | 0.8                                                       | 10             | 50                                                                       | 50                                           | 1.00                                         | 2.60                                 | 2.2                         | 1.5                                | 1.2                                                                                                                      | 0.8                                                                                                              | 2.4               | 2.4            | 0.90               | 3.5                                           | 0.23                     | 0.05                                             | 10.00                                                                  | 0.25                       | 0.58                         | > 0.3 [OK]                    | 68                                                          | 0.6                                       | 112.5                                              | 313                                   | 0.4                                                                       | 0.6                     |
| 7                                                                                  | 2.5   | 1     | 6                     | 6                   | 0.6                  | 1.41                                             | 1.31                                     | 3.53                                                                             | 9.19                                                                     | 1.4                              | 3.7                      | 2.9                                              | 2.2                                      | 5.3            | 12                                   | 0.7                                                       | 10             | 60                                                                       | 60                                           | 1.00                                         | 2.80                                 | 2.2                         | 1.5                                | 1.2                                                                                                                      | 0.8                                                                                                              | 2.6               | 2.6            | 0.97               | 3.7                                           | 0.23                     | 0.06                                             | 10.00                                                                  | 0.30                       | 0.61                         | > 0.3 [OK]                    | 81                                                          | 0.6                                       | 135.0                                              | 313                                   | 0.4                                                                       | 0.7                     |
| 7.5                                                                                | 2.75  | 1     | 6                     | 6                   | 0.6                  | 1.43                                             | 1.34                                     | 3.94                                                                             | 10.08                                                                    | 1.6                              | 4.1                      | 3.2                                              | 2.5                                      | 5.6            | 14                                   | 0.8                                                       | 10             | 60                                                                       | 60                                           | 1.10                                         | 3.00                                 | 2.2                         | 1.5                                | 1.2                                                                                                                      | 0.8                                                                                                              | 3.1               | 3.1            | 1.04               | 4.0                                           | 0.23                     | 0.06                                             | 10.00                                                                  | 0.30                       | 0.56                         | > 0.3 [OK]                    | 81                                                          | 0.6                                       | 135.0                                              | 313                                   | 0.4                                                                       | 0.7                     |
| 8                                                                                  | 2.75  | 1.25  | 6                     | 6                   | 0.6                  | 1.45                                             | 1.38                                     | 4.00                                                                             | 11.00                                                                    | 1.6                              | 4.5                      | 3.3                                              | 2.7                                      | 6.0            | 16                                   | 0.9                                                       | 10             | 60                                                                       | 60                                           | 1.38                                         | 4.00                                 | 2.0                         | 1.4                                | 1.1                                                                                                                      | 0.7                                                                                                              | 4.1               | 4.1            | 1.11               | 4.2                                           | 0.23                     | 0.06                                             | 10.00                                                                  | 0.30                       | 0.48                         | > 0.3 [OK]                    | 81                                                          | 0.6                                       | 135.0                                              | 313                                   | 0.4                                                                       | 0.7                     |
| 8.5                                                                                | 3     | 1.25  | 7                     | 7                   | 0.8                  | 1.48                                             | 1.41                                     | 4.43                                                                             | 11.95                                                                    | 1.8                              | 4.9                      | 3.6                                              | 2.9                                      | 6.4            | 19                                   | 0.8                                                       | 10             | 70                                                                       | 70                                           | 1.50                                         | 4.25                                 | 2.0                         | 1.4                                | 1.1                                                                                                                      | 0.8                                                                                                              | 4.8               | 4.8            | 1.18               | 4.5                                           | 0.23                     | 0.07                                             | 10.00                                                                  | 0.35                       | 0.48                         | > 0.3 [OK]                    | 95                                                          | 0.8                                       | 118.1                                              | 313                                   | 0.4                                                                       | 0.6                     |
| 9                                                                                  | 3     | 1.25  | 7                     | 7                   | 0.8                  | 1.50                                             | 1.44                                     | 4.49                                                                             | 12.94                                                                    | 1.8                              | 5.3                      | 3.7                                              | 3.2                                      | 6.8            | 21                                   | 0.9                                                       | 10             | 70                                                                       | 70                                           | 1.50                                         | 4.50                                 | 2.0                         | 1.4                                | 1.1                                                                                                                      | 0.8                                                                                                              | 5.1               | 5.1            | 1.25               | 4.7                                           | 0.23                     | 0.07                                             | 10.00                                                                  | 0.35                       | 0.47                         | > 0.3 [OK]                    | 95                                                          | 0.8                                       | 118.1                                              | 313                                   | 0.4                                                                       | 0.6                     |
| 9.5                                                                                | 3     | 1.5   | 7                     | 8                   | 0.8                  | 1.52                                             | 1.47                                     | 4.55                                                                             | 13.95                                                                    | 1.9                              | 5.7                      | 3.7                                              | 3.4                                      | 7.1            | 24                                   | 1.0                                                       | 10             | 70                                                                       | 70                                           | 1.80                                         | 5.70                                 | 1.8                         | 1.3                                | 1.0                                                                                                                      | 0.7                                                                                                              | 6.4               | 6.4            | 1.32               | 5.0                                           | 0.23                     | 0.07                                             | 10.00                                                                  | 0.35                       | 0.42                         | > 0.3 [OK]                    | 95                                                          | 0.8                                       | 118.1                                              | 313                                   | 0.4                                                                       | 0.6                     |
| 10                                                                                 | 3.25  | 1.75  | 8                     | 8                   | 0.8                  | 1.54                                             | 1.50                                     | 5.00                                                                             | 15.00                                                                    | 2.0                              | 6.1                      | 4.1                                              | 3.7                                      | 7.5            | 28                                   | 0.9                                                       | 10             | 80                                                                       | 80                                           | 2.28                                         | 7.00                                 | 1.7                         | 1.2                                | 0.9                                                                                                                      | 0.7                                                                                                              | 8.5               | 8.5            | 1.39               | 5.3                                           | 0.23                     | 0.08                                             | 10.00                                                                  | 0.40                       | 0.38                         | > 0.3 [OK]                    | 108                                                         | 0.8                                       | 135.0                                              | 313                                   | 0.4                                                                       | 0.7                     |
| 10.5                                                                               | 3.25  | 1.75  | 8                     | 8                   | 0.8                  | 1.55                                             | 1.54                                     | 5.05                                                                             | 16.19                                                                    | 2.1                              | 6.6                      | 4.1                                              | 4.0                                      | 7.9            | 31                                   | 1.0                                                       | 10             | 80                                                                       | 80                                           | 2.28                                         | 7.35                                 | 1.7                         | 1.2                                | 0.9                                                                                                                      | 0.7                                                                                                              | 9.0               | 9.0            | 1.45               | 5.5                                           | 0.23                     | 0.08                                             | 10.00                                                                  | 0.40                       | 0.38                         | > 0.3 [OK]                    | 108                                                         | 0.8                                       | 135.0                                              | 313                                   | 0.4                                                                       | 0.7                     |
| 11                                                                                 | 3.5   | 1.75  | 9                     | 9                   | 0.8                  | 1.57                                             | 1.58                                     | 5.49                                                                             | 17.42                                                                    | 2.2                              | 7.1                      | 4.5                                              | 4.3                                      | 8.3            | 35                                   | 0.9                                                       | 10             | 90                                                                       | 90                                           | 2.45                                         | 7.70                                 | 1.7                         | 1.2                                | 1.0                                                                                                                      | 0.7                                                                                                              | 10.1              | 10.2           | 1.52               | 5.8                                           | 0.23                     | 0.09                                             | 10.00                                                                  | 0.45                       | 0.38                         | > 0.3 [OK]                    | 122                                                         | 0.8                                       | 151.9                                              | 313                                   | 0.5                                                                       | 0.8                     |
| 11.5                                                                               | 3.75  | 2     | 9                     | 9                   | 0.8                  | 1.58                                             | 1.63                                     | 5.94                                                                             | 18.69                                                                    | 2.4                              | 7.6                      | 4.8                                              | 4.6                                      | 8.6            | 39                                   | 1.0                                                       | 10             | 90                                                                       | 90                                           | 3.00                                         | 9.20                                 | 1.6                         | 1.2                                | 0.9                                                                                                                      | 0.6                                                                                                              | 12.9              | 13.0           | 1.59               | 6.0                                           | 0.23                     | 0.09                                             | 10.00                                                                  | 0.45                       | 0.34                         | > 0.3 [OK]                    | 122                                                         | 0.8                                       | 151.9                                              | 313                                   | 0.5                                                                       | 0.8                     |
| 12                                                                                 | 3.75  | 2     | 9                     | 9                   | 0.8                  | 1.60                                             | 1.67                                     | 6.00                                                                             | 20.00                                                                    | 2.4                              | 8.2                      | 4.9                                              | 4.9                                      | 9.0            | 44                                   | 1.1                                                       | 10             | 90                                                                       | 90                                           | 3.00                                         | 9.60                                 | 1.6                         | 1.2                                | 0.9                                                                                                                      | 0.7                                                                                                              | 13.5              | 13.6           | 1.66               | 6.3                                           | 0.23                     | 0.09                                             | 10.00                                                                  | 0.45                       | 0.33                         | > 0.3 [OK]                    | 122                                                         | 0.8                                       | 151.9                                              | 313                                   | 0.5                                                                       | 0.8                     |
| 12.5                                                                               | 4     | 2     | 10                    | 10                  | 0.8                  | 1.67                                             | 1.70                                     | 6.67                                                                             | 21.25                                                                    | 2.7                              | 8.7                      | 5.4                                              | 5.2                                      | 9.4            | 49                                   | 1.0                                                       | 10             | 100                                                                      | 100                                          | 3.20                                         | 10.00                                | 1.7                         | 1.2                                | 0.9                                                                                                                      | 0.7                                                                                                              | 15.0              | 15.1           | 1.73               | 6.6                                           | 0.23                     | 0.10                                             | 10.00                                                                  | 0.50                       | 0.33                         | > 0.3 [OK]                    | 135                                                         | 0.8                                       | 168.8                                              | 313                                   | 0.5                                                                       | 0.9                     |
| 13                                                                                 | 4     | 2     | 10                    | 10                  | 0.8                  | 1.73                                             | 1.73                                     | 6.93                                                                             | 22.53                                                                    | 2.8                              | 9.2                      | 5.7                                              | 5.5                                      | 9.8            | 54                                   | 1.1                                                       | 10             | 100                                                                      | 100                                          | 3.20                                         | 10.40                                | 1.7                         | 1.2                                | 0.9                                                                                                                      | 0.7                                                                                                              | 15.6              | 15.7           | 1.80               | 6.8                                           | 0.23                     | 0.10                                             | 10.00                                                                  | 0.50                       | 0.32                         | > 0.3 [OK]                    | 135                                                         | 0.8                                       | 168.8                                              | 313                                   | 0.5                                                                       | 0.9                     |
| 13.5                                                                               | 4     | 2     | 10                    | 11                  | 0.8                  | 1.80                                             | 1.77                                     | 7.20                                                                             | 23.85                                                                    | 2.9                              | 9.7                      | 5.9                                              | 5.8                                      | 10.1           | 59                                   | 1.2                                                       | 10             | 100                                                                      | 100                                          | 3.20                                         | 10.80                                | 1.7                         | 1.2                                | 1.0                                                                                                                      | 0.7                                                                                                              | 16.2              | 16.3           | 1.87               | 7.0                                           | 0.23                     | 0.10                                             | 10.00                                                                  | 0.50                       | 0.32                         | > 0.3 [OK]                    | 135                                                         | 0.8                                       | 168.8                                              | 313                                   | 0.5                                                                       | 0.9                     |

Vertrouwelijk



## A2 SCIA Berekeningsverslag

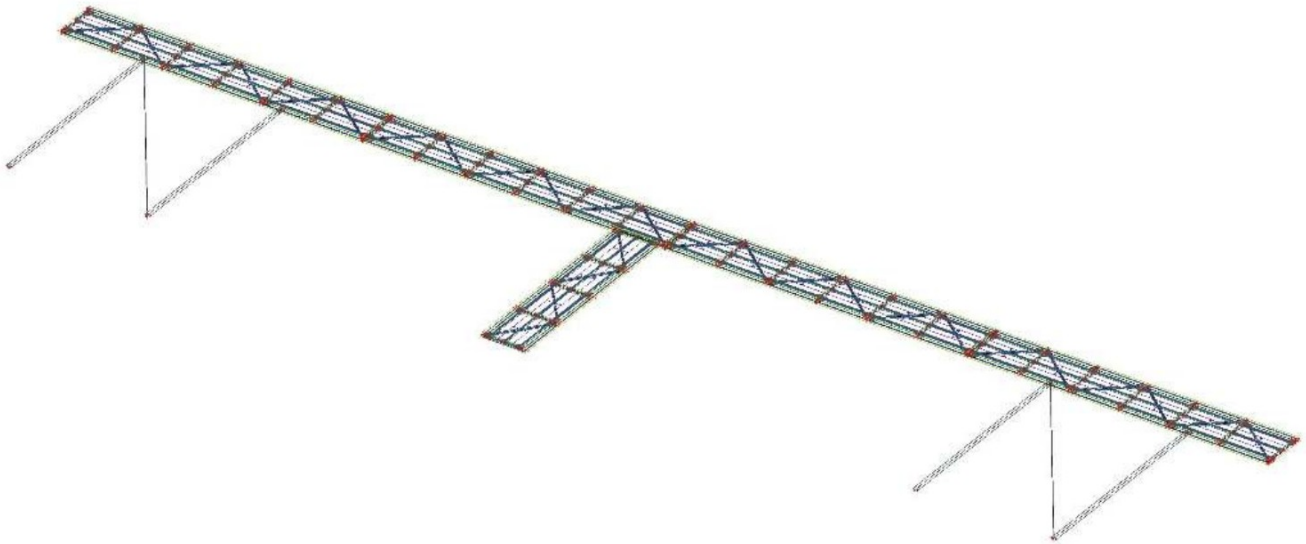


## Bijlage 2 - SCIA Engineering rapport

### **Drijvende oversteek - Schipperskerk**

Klant: Inter Boat Marinas B.V.

## 1. Model overzicht



## 2. Table of contents

|                                              |    |
|----------------------------------------------|----|
| 1. Model overzicht                           | 2  |
| 2. Table of contents                         | 2  |
| 3. Constructie overzicht                     | 5  |
| 3.1. Analyse model (3D aanzicht)             | 5  |
| 3.2. Analyse model (boven aanzicht)          | 5  |
| 3.3. Analyse model (zij aanzicht)            | 6  |
| 3.4. brugdeel                                | 7  |
| 3.5. brugdeel                                | 7  |
| 3.6. brugdeel                                | 8  |
| 3.7. Belasting paneel overspannings richting | 8  |
| 4. Opleggingen                               | 9  |
| 4.1. Overzicht opleggingen                   | 9  |
| 4.2. Nodal supports                          | 9  |
| 4.3. Point supports on member                | 9  |
| 4.4. Opleggingen steigerdeel                 | 12 |
| 4.5. Opleggingen brug deel                   | 13 |
| 4.6. Koppeling                               | 14 |
| 4.7. Schematische koppeling                  | 14 |
| 5. Cross-sections                            | 15 |
| 6. Belastingen                               | 20 |
| 6.1. Load cases                              | 20 |
| 6.2. Belastingen                             | 21 |
| 6.2.1. Dek belastingen                       | 21 |
| 6.2.1.1. Dek belastingen - EG                | 21 |
| 6.2.1.1.1. Belasting overzicht               | 22 |
| 6.2.1.2. Dek belastingen - Perm              | 22 |
| 6.2.1.2.1. Belasting overzicht               | 23 |
| 6.2.1.3. Dek belastingen - Qdek-POS0         | 23 |
| 6.2.1.3.1. Belasting overzicht               | 24 |
| 6.2.1.4. Dek belastingen - Qdek-POS1         | 24 |

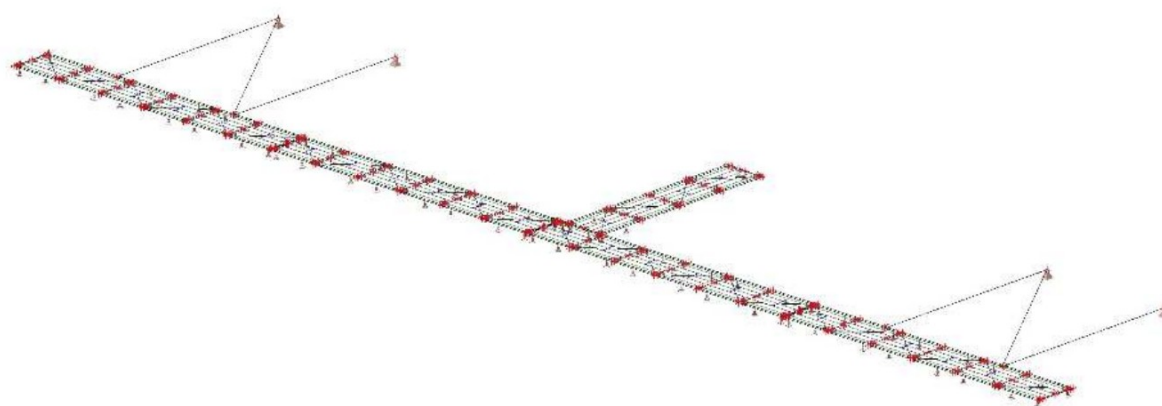
|                                         |    |
|-----------------------------------------|----|
| 6.2.1.4.1. Belasting overzicht          | 25 |
| 6.2.1.5. Dek belastingen - Qdek-POS2    | 25 |
| 6.2.1.5.1. Belasting overzicht          | 26 |
| 6.2.1.6. Dek belastingen - Qdek-POS3    | 26 |
| 6.2.1.6.1. Belasting overzicht          | 27 |
| 6.2.1.7. Dek belastingen - Qdek-POS4    | 27 |
| 6.2.1.7.1. Belasting overzicht          | 28 |
| 6.2.1.8. Dek belastingen - Qdek-POS5    | 28 |
| 6.2.1.8.1. Belasting overzicht          | 29 |
| 6.2.1.9. Dek belastingen - Qdek-POS6    | 29 |
| 6.2.1.9.1. Belasting overzicht          | 30 |
| 6.2.1.10. Dek belastingen - Qdek-POS7   | 30 |
| 6.2.1.10.1. Belasting overzicht         | 31 |
| 6.2.1.11. Dek belastingen - Qdek-POS8   | 31 |
| 6.2.1.11.1. Belasting overzicht         | 32 |
| 6.2.1.12. Dek belastingen - Qdek-POS9   | 32 |
| 6.2.1.12.1. Belasting overzicht         | 33 |
| 6.2.1.13. Dek belastingen - Fdek-POS1   | 33 |
| 6.2.1.13.1. Belasting overzicht         | 34 |
| 6.2.1.14. Dek belastingen - Fdek-POS2   | 34 |
| 6.2.1.14.1. Belasting overzicht         | 35 |
| 6.2.1.15. Dek belastingen - Fdek-POS3   | 35 |
| 6.2.1.15.1. Belasting overzicht         | 36 |
| 6.2.1.16. Dek belastingen - Fdek-POS4   | 36 |
| 6.2.1.16.1. Belasting overzicht         | 37 |
| 6.2.1.17. Dek belastingen - Fdek-POS5   | 37 |
| 6.2.1.17.1. Belasting overzicht         | 38 |
| 6.2.1.18. Dek belastingen - Fdek-POS6   | 38 |
| 6.2.1.18.1. Belasting overzicht         | 39 |
| 6.2.2. Windbelasting                    | 39 |
| 6.2.2.1. Windbelasting - Wind           | 39 |
| 6.2.2.1.1. Belasting overzicht          | 40 |
| 6.2.2.1.2. Belasting detail             | 40 |
| 6.2.2.2. Windbelasting - Wind1          | 41 |
| 6.2.2.2.1. Belasting overzicht          | 41 |
| 6.2.2.2.2. Belasting detail             | 42 |
| 6.3. Load groups                        | 42 |
| 6.4. Combinations                       | 42 |
| 6.5. Result classes                     | 44 |
| 7. Dek                                  | 45 |
| 7.1. Dek met langsliggers               | 45 |
| 7.2. Dek met load pannels               | 45 |
| 7.3. Cross-sections                     | 46 |
| 7.4. Dek eigenschappen                  | 47 |
| 7.4.1. Dek eigenschappen - Langsliggers | 47 |
| 7.4.1.1. Members                        | 47 |
| 7.4.1.2. Hinges                         | 49 |
| 7.4.2. Dek eigenschappen - Dekoutline   | 52 |
| 8. Steigerframe                         | 52 |
| 8.1. Steigerframe                       | 52 |
| 8.2. Layers                             | 52 |
| 8.2.1. Layers - Hoofdliggers            | 52 |
| 8.2.1.1. Staven                         | 53 |
| 8.2.1.2. Cross-sections                 | 53 |
| 8.2.1.3. Members                        | 54 |
| 8.2.1.4. Hinges                         | 55 |
| 8.2.2. Layers - Dwarsliggers            | 55 |
| 8.2.2.1. Staven                         | 55 |
| 8.2.2.2. Cross-sections                 | 55 |
| 8.2.2.3. Members                        | 57 |
| 8.2.2.4. Hinges                         | 58 |
| 8.2.3. Layers - Schoorstaven            | 58 |
| 8.2.3.1. Staven                         | 59 |
| 8.2.3.2. Cross-sections                 | 59 |
| 8.2.3.3. Members                        | 60 |
| 8.2.3.4. Hinges                         | 61 |
| 8.2.4. Layers - Koppelingen             | 61 |
| 8.2.4.1. Staven                         | 62 |
| 8.2.4.2. Cross-sections                 | 62 |
| 8.2.4.3. Members                        | 65 |
| 8.2.4.4. Hinges                         | 65 |
| 9. Resultaten - Reactie Krachten        | 66 |



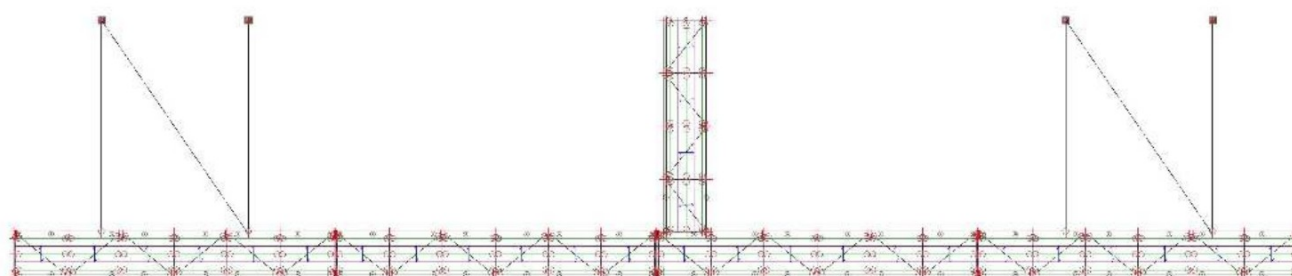
|                                          |           |
|------------------------------------------|-----------|
| 9.1. Reactions; R_x                      | 66        |
| 9.2. Reactions; R_y                      | 66        |
| 9.3. Reactions; R_z                      | 67        |
| 9.4. Reactions; R_z                      | 67        |
| <b>10. Resultaten - Vervormingen</b>     | <b>68</b> |
| 10.1. Load cases                         | 68        |
| 10.1.1. Load cases - EG                  | 68        |
| 10.1.1.1. 3D displacement; U_total       | 68        |
| 10.1.2. Load cases - Perm                | 68        |
| 10.1.2.1. 3D displacement; U_total       | 69        |
| 10.1.3. Load cases - Qdek-POS0           | 69        |
| 10.1.3.1. 3D displacement; U_total       | 70        |
| 10.1.4. Load cases - Qdek-POS7           | 70        |
| 10.1.4.1. 3D displacement; U_total       | 71        |
| 10.1.5. Load cases - Qdek-POS8           | 71        |
| 10.1.5.1. 3D displacement; U_total       | 72        |
| 10.1.6. Load cases - Qdek-POS9           | 72        |
| 10.1.6.1. 3D displacement; U_total       | 73        |
| 10.1.7. Load cases - Wind                | 73        |
| 10.1.7.1. 3D displacement; U_total       | 74        |
| <b>11. Resultaten - Interne Krachten</b> | <b>74</b> |
| 11.1. Interne krachten                   | 74        |
| 11.1.1. Interne krachten - Hoofdliggers  | 74        |
| 11.1.1.1. 1D internal forces             | 74        |
| 11.1.2. Interne krachten - Dwarsliggers  | 75        |
| 11.1.2.1. 1D internal forces             | 75        |
| 11.1.3. Interne krachten - Schoorstaven  | 75        |
| 11.1.3.1. 1D internal forces             | 75        |
| 11.1.4. Interne krachten - Langsliggers  | 76        |
| 11.1.4.1. 1D internal forces             | 76        |
| 11.1.5. Interne krachten - Koppelingen   | 77        |
| 11.1.5.1. 1D internal forces             | 77        |
| 11.1.6. Interne krachten - Dekoutline    | 77        |
| 11.1.6.1. 1D internal forces             | 77        |
| 11.2. 1D internal forces; M_y            | 78        |
| 11.3. 1D internal forces; V_y            | 78        |
| 11.4. 1D internal forces; M_z            | 79        |
| 11.5. 1D internal forces; V_z            | 79        |
| 11.6. 1D internal forces; N              | 80        |
| 11.7. 1D internal forces; M_y            | 81        |
| 11.8. 1D internal forces; V_y            | 81        |
| 11.9. 1D internal forces; M_z            | 82        |
| 11.10. 1D internal forces; V_z           | 82        |
| 11.11. 1D internal forces; N             | 83        |
| 11.12. 1D internal forces; M_y           | 84        |
| 11.13. 1D internal forces; V_y           | 84        |
| 11.14. 1D internal forces; M_z           | 85        |
| 11.15. 1D internal forces; V_z           | 85        |
| 11.16. 1D internal forces; N             | 86        |
| 11.17. 1D internal forces; M_y           | 87        |
| 11.18. 1D internal forces; V_y           | 87        |
| 11.19. 1D internal forces; M_z           | 88        |
| 11.20. 1D internal forces; V_z           | 88        |
| 11.21. 1D internal forces; N             | 89        |
| 11.22. 1D internal forces; M_y           | 90        |
| 11.23. 1D internal forces; V_y           | 90        |
| 11.24. 1D internal forces; M_z           | 91        |
| 11.25. 1D internal forces; V_z           | 91        |
| 11.26. 1D internal forces; N             | 92        |
| 11.27. 1D internal forces; M_y           | 93        |
| 11.28. 1D internal forces; V_y           | 93        |
| 11.29. 1D internal forces; M_z           | 94        |
| 11.30. 1D internal forces; V_z           | 94        |
| 11.31. 1D internal forces; N             | 95        |

### 3. Constructie overzicht

#### 3.1. Analyse model (3D aanzicht)



#### 3.2. Analyse model (boven aanzicht)



### 3.3. Analyse model (zij aanzicht)

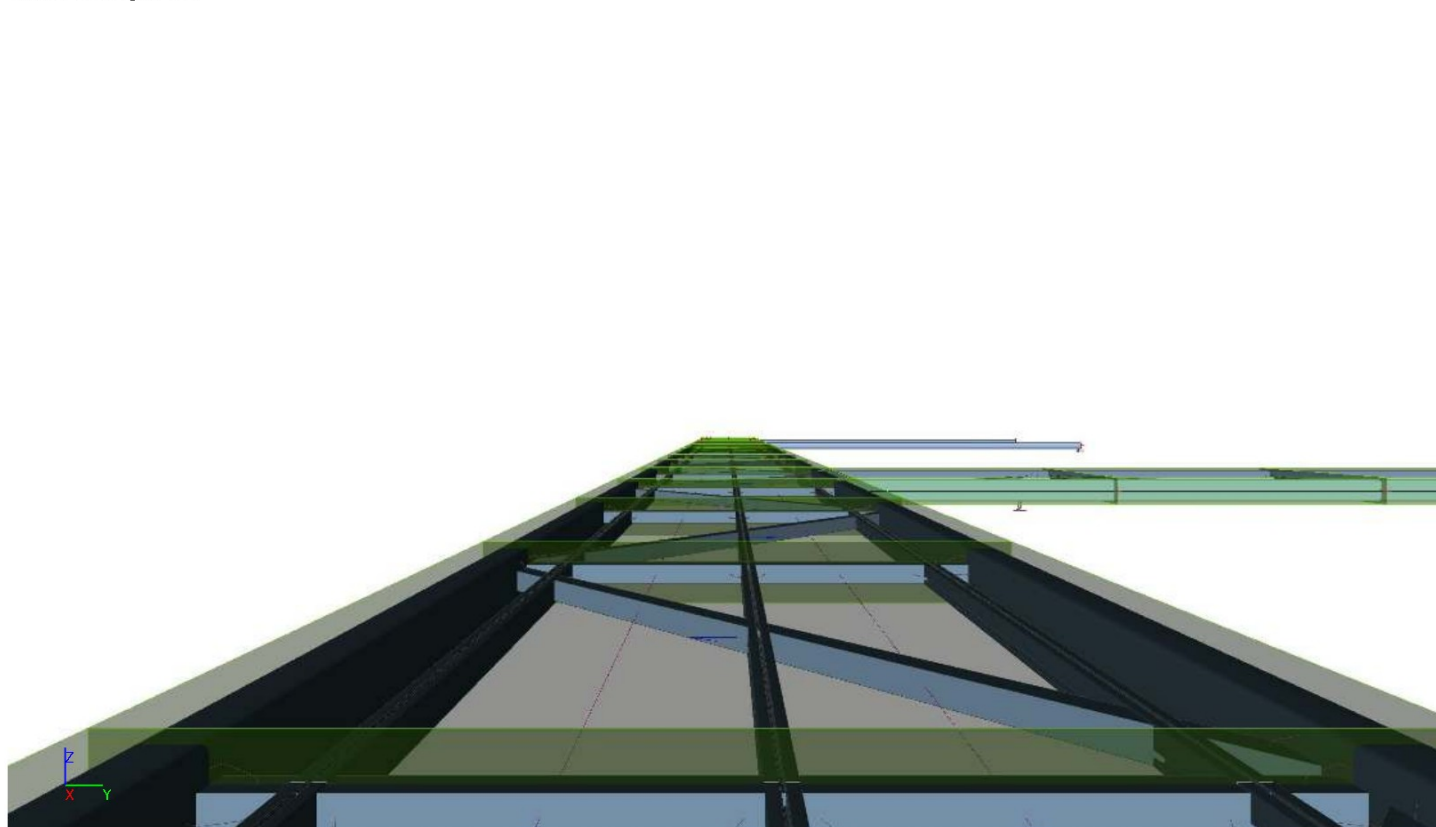




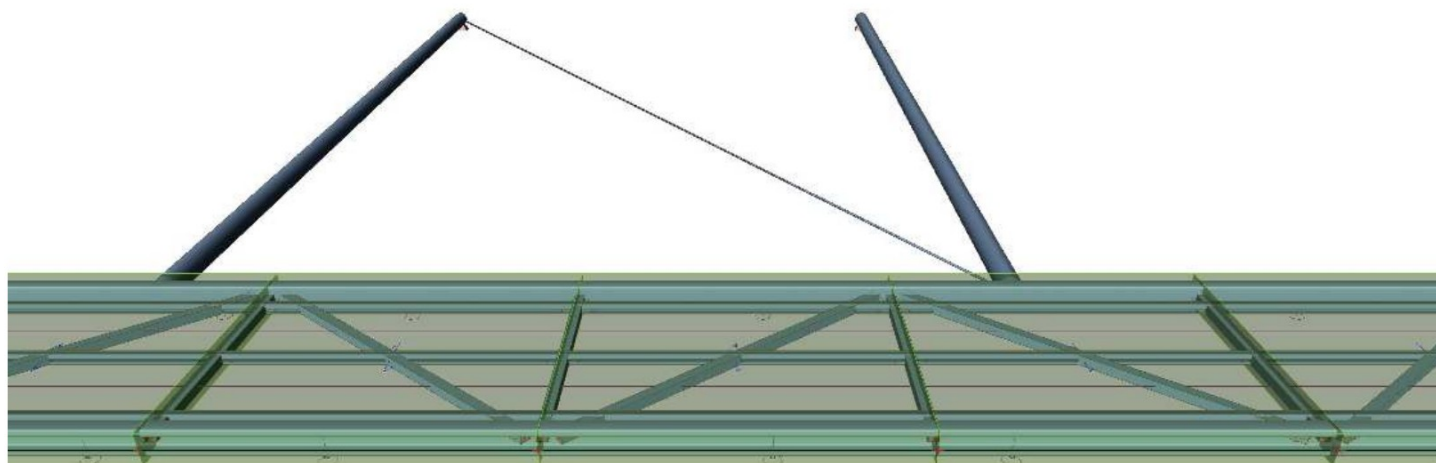
### 3.4. brugdeel



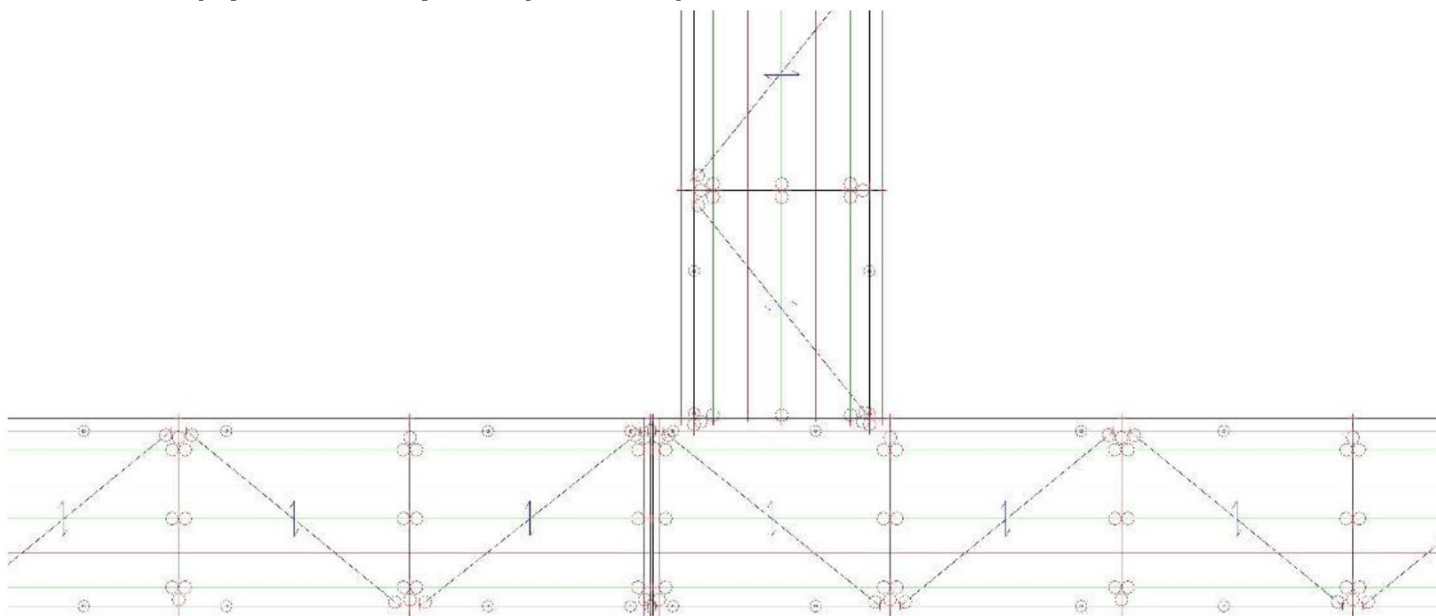
### 3.5. brugdeel



### 3.6. brugdeel

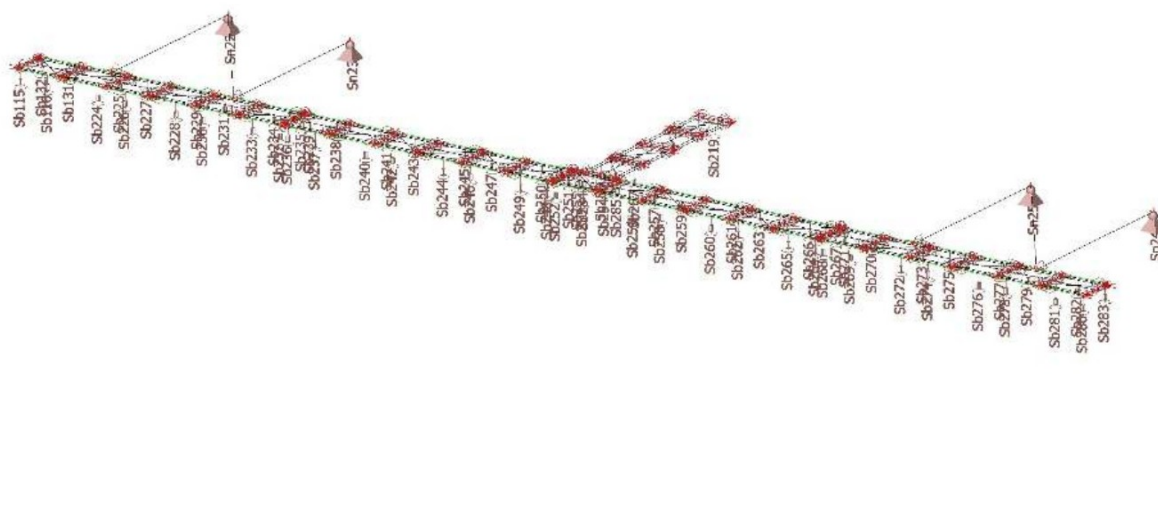


### 3.7. Belasting paneel overspannings richting



## 4. Opleggingen

### 4.1. Overzicht opleggingen



### 4.2. Nodal supports

| Name Node | System User UCS | Type Angle [deg]  | X Stiffness X [MN/m] | Y Stiffness Y [MN/m] | Z Stiffness Z [MN/m] | Rx Stiffness Rx [MNm/rad] | Ry Stiffness Ry [MNm/rad] | Rz Stiffness Rz [MNm/rad] |
|-----------|-----------------|-------------------|----------------------|----------------------|----------------------|---------------------------|---------------------------|---------------------------|
| Sn22 N702 | GCS             | Standard Rz180.00 | Rigid                | Rigid                | Rigid                | Free                      | Free                      | Free                      |
| Sn23 N705 | GCS             | Standard Rz180.00 | Rigid                | Rigid                | Rigid                | Free                      | Free                      | Free                      |
| Sn24 N706 | GCS             | Standard Rz180.00 | Rigid                | Rigid                | Rigid                | Free                      | Free                      | Free                      |
| Sn25 N707 | GCS             | Standard Rz180.00 | Rigid                | Rigid                | Rigid                | Free                      | Free                      | Free                      |

### 4.3. Point supports on member

| Name  | Type     | Coor System | Pos x [m] Orig   | dx [m] Rep (n) | X     | Y     | Z        | Stiffness Z [MN/m] | Rx   | Ry    | Rz   |
|-------|----------|-------------|------------------|----------------|-------|-------|----------|--------------------|------|-------|------|
| Sb115 | Standard | Abso GCS    | 0.150 From start | 1              | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |
| Sb116 | Standard | Abso GCS    | 1.370 From start | 1              | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |
| Sb131 | Standard | Abso GCS    | 1.370 From start | 1              | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |
| Sb132 | Standard | Abso GCS    | 0.150 From start | 1              | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |
| Sb219 | Standard | Rela GCS    | 0.500 From start | 1              | Rigid | Rigid | Rigid    |                    | Free | Rigid | Free |
| Sb224 | Standard | Abso GCS    | 3.643 From start | 1              | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |
| Sb225 | Standard | Abso        | 3.643            |                | Free  | Free  | Flexible | 4.4145e-03         | Free | Free  | Free |

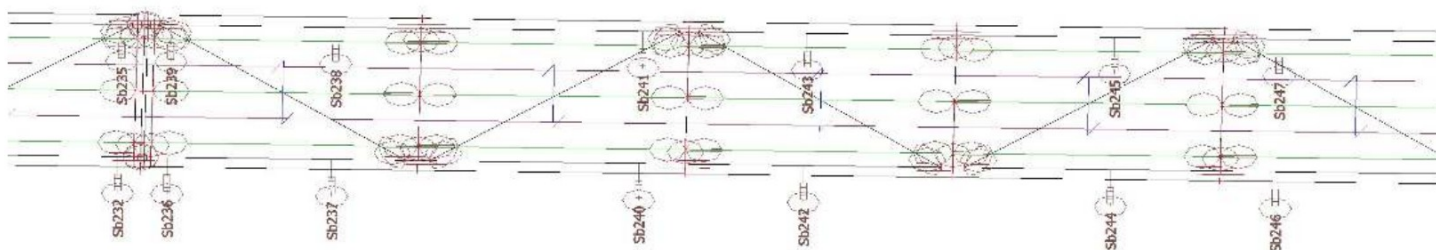


| Name  | Type     | Coor System | Pos x [m] Orig | dx [m] Rep (n) | X    | Y    | Z        | Stiffness Z [MN/m] | Rx   | Ry   | Rz   |
|-------|----------|-------------|----------------|----------------|------|------|----------|--------------------|------|------|------|
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb226 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb227 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb228 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb229 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb230 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb231 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb232 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb233 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb234 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb235 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb236 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb237 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb238 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb239 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb240 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb241 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb242 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb243 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb244 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb245 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb246 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb247 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb248 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb249 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb250 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb251 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb252 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb253 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb254 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb255 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |

| Name  | Type     | Coor System | Pos x [m] Orig | dx [m] Rep (n) | X    | Y    | Z        | Stiffness Z [MN/m] | Rx   | Ry   | Rz   |
|-------|----------|-------------|----------------|----------------|------|------|----------|--------------------|------|------|------|
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb256 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb257 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb258 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb259 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb260 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb261 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb262 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb263 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb264 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb265 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb266 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb267 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb268 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb269 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb270 | Standard | Abso        | 1.370          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb271 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb272 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb273 | Standard | Abso        | 3.643          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb274 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb275 | Standard | Abso        | 4.863          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb276 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb277 | Standard | Abso        | 7.136          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb278 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb279 | Standard | Abso        | 8.356          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb280 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb281 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb282 | Standard | Abso        | 10.595         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb283 | Standard | Abso        | 11.815         |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb284 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |
|       |          | GCS         | From start     | 1              |      |      |          |                    |      |      |      |
| Sb285 | Standard | Abso        | 0.150          |                | Free | Free | Flexible | 4.4145e-03         | Free | Free | Free |

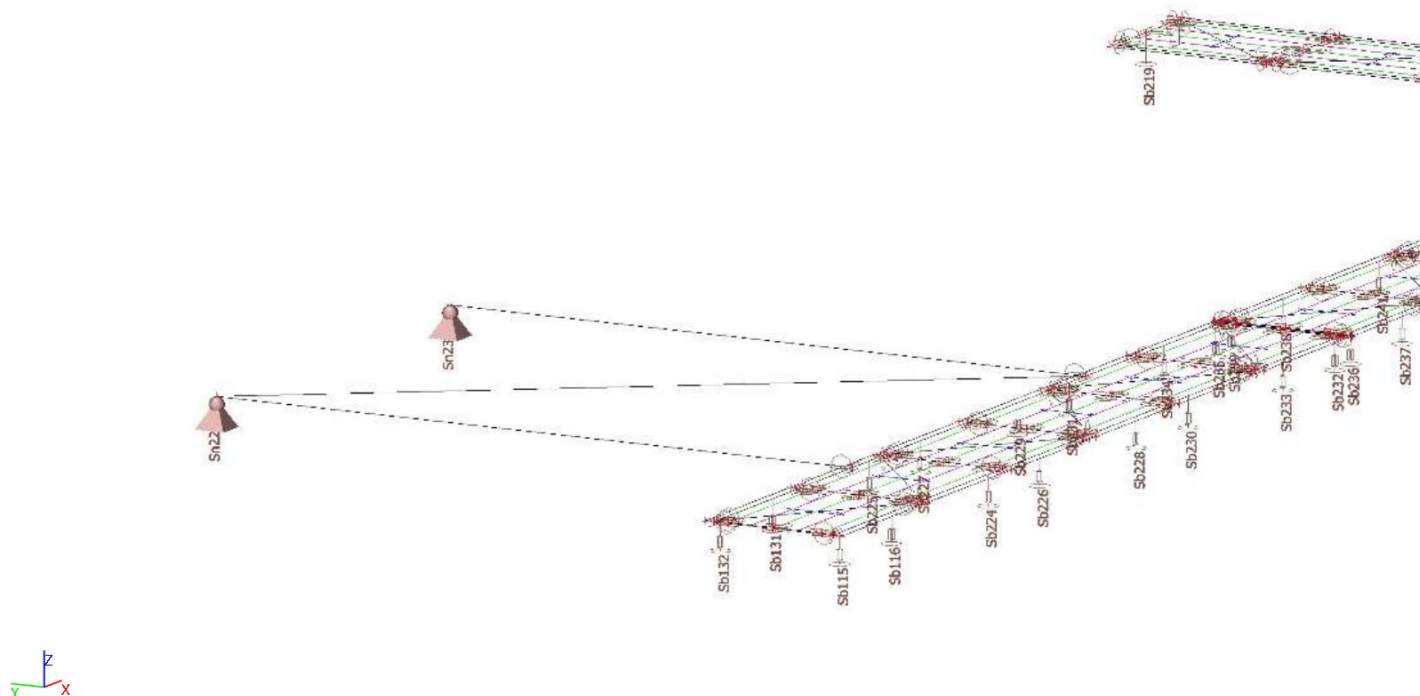
| Name  | Type     | Coor<br>System | Pos x<br>[m]<br>Orig | dx<br>[m]<br>Rep (n) | X    | Y    | Z        | Stiffness Z<br>[MN/m] | Rx   | Ry   | Rz   |
|-------|----------|----------------|----------------------|----------------------|------|------|----------|-----------------------|------|------|------|
|       |          | GCS            | From start           | 1                    |      |      |          |                       |      |      |      |
| Sb286 | Standard | Abso           | 1.370                |                      | Free | Free | Flexible | 4.4145e-03            | Free | Free | Free |
|       |          | GCS            | From start           | 1                    |      |      |          |                       |      |      |      |
| Sb287 | Standard | Abso           | 1.370                |                      | Free | Free | Flexible | 4.4145e-03            | Free | Free | Free |
|       |          | GCS            | From start           | 1                    |      |      |          |                       |      |      |      |

#### 4.4. Opleggingen steigerdeel

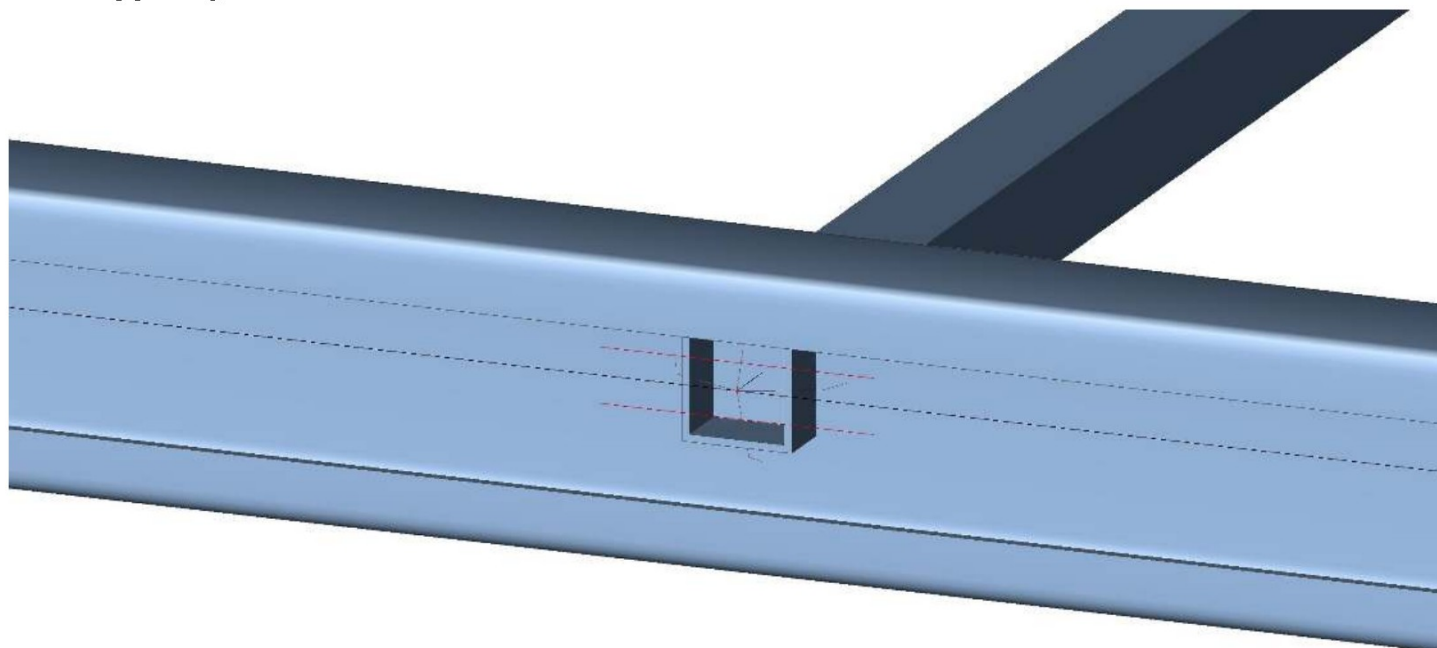




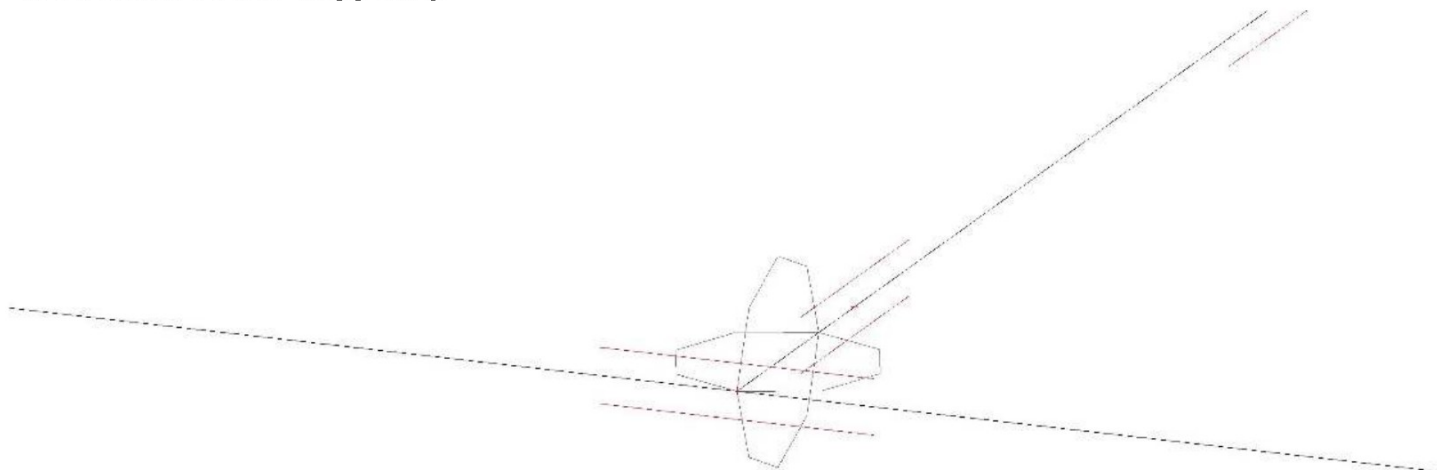
## 4.5. Opleggingen brug deel



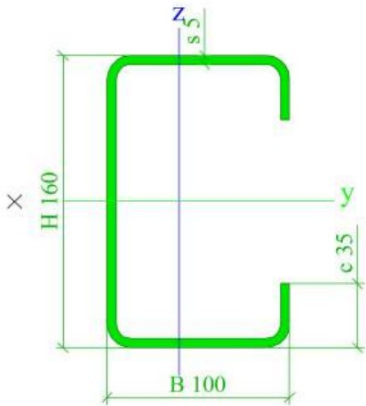
## 4.6. Koppeling



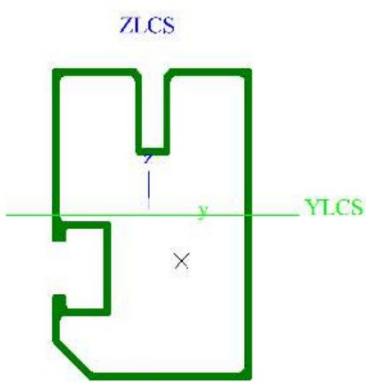
## 4.7. Schematische koppeling



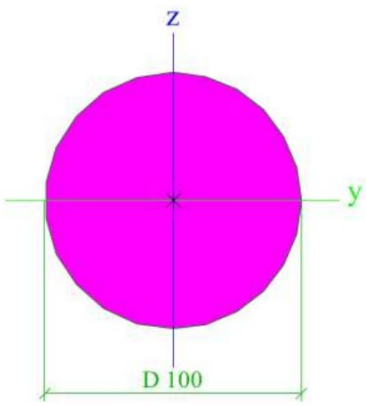
## 5. Cross-sections

| CS3                                                                        |                                                                                     |            |            |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|------------|
| Type                                                                       | Cold formed C section                                                               |            |            |
| Detailed                                                                   | 160; 100; 5; 8; 35                                                                  |            |            |
| Formcode                                                                   | 114 - Cold formed C section                                                         |            |            |
| Shape type                                                                 | Thin-walled                                                                         |            |            |
| Item material                                                              | S 355                                                                               |            |            |
| Fabrication                                                                | cold formed                                                                         |            |            |
| Colour                                                                     |    |            |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                            | b                                                                                   |            | b          |
| A [m <sup>2</sup> ]                                                        |                                                                                     | 1.9582e-03 |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]         |                                                                                     | 9.7518e-04 | 9.1909e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]     |                                                                                     | 7.9378e-01 | 7.9378e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                           |                                                                                     | 39         | 80         |
| α [deg]                                                                    |                                                                                     | 0.00       |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]         |                                                                                     | 7.9386e-06 | 2.7476e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                   |                                                                                     | 64         | 37         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]   |                                                                                     | 9.9232e-05 | 4.5105e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]   |                                                                                     | 1.1633e-04 | 6.5275e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                         |                                                                                     | 41298.45   | 41298.45   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                         |                                                                                     | 23172.74   | 23172.74   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                   |                                                                                     | -89        | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]         |                                                                                     | 1.7083e-08 | 1.9857e-08 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                   |                                                                                     | 0          | 221        |
| Picture                                                                    |  |            |            |
| CS4-AluProfiel                                                             |                                                                                     |            |            |
| Type                                                                       | General cross-section                                                               |            |            |
| Shape type                                                                 | Thick-walled                                                                        |            |            |
| Item material                                                              | EN-AW 6063 (EP,ET,ER/B) T66 (0-10)                                                  |            |            |
| Fabrication                                                                | general                                                                             |            |            |
| Colour                                                                     |  |            |            |
| A [m <sup>2</sup> ]                                                        |                                                                                     | 4.3592e-04 |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]         |                                                                                     | 6.8043e-05 | 1.4545e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]     |                                                                                     | 2.9149e-01 | 5.5765e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                           |                                                                                     | -1         | 2          |
| I <sub>y,LCS</sub> [m <sup>4</sup> ], I <sub>z,LCS</sub> [m <sup>4</sup> ] |                                                                                     | 2.5981e-07 | 1.2152e-07 |
| I <sub>yz,LCS</sub> [m <sup>4</sup> ]                                      |                                                                                     | 3.8972e-10 |            |
| α [deg]                                                                    |                                                                                     | -0.16      |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]         |                                                                                     | 2.5981e-07 | 1.2152e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                   |                                                                                     | 24         | 17         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]   |                                                                                     | 7.0227e-06 | 5.1533e-06 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]   |                                                                                     | 9.4597e-06 | 6.4255e-06 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                         |                                                                                     | 1891.93    | 1891.93    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                         |                                                                                     | 1285.10    | 1285.10    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                   |                                                                                     | 8          | -10        |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]         |                                                                                     | 1.5561e-07 | 1.2905e-11 |



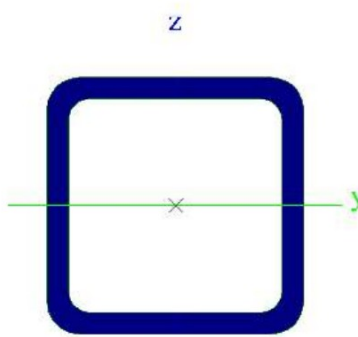
|                                |                                                                                   |    |
|--------------------------------|-----------------------------------------------------------------------------------|----|
| $\beta_y$ [mm], $\beta_z$ [mm] | 17                                                                                | -9 |
| Picture                        |  |    |

### Dummy

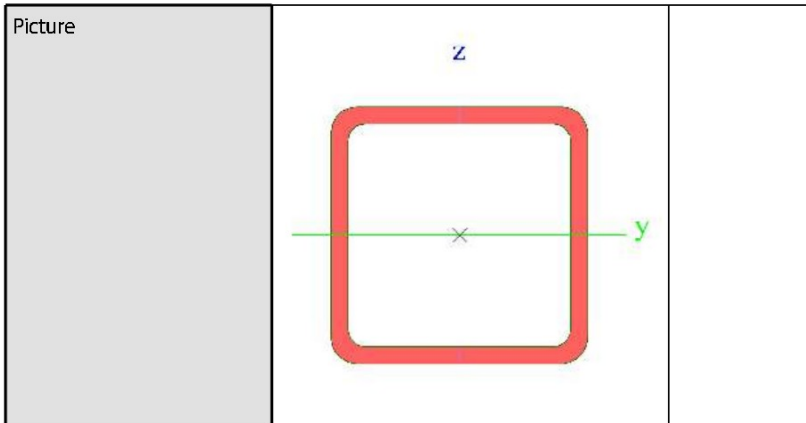
|                                                                          |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | Full circle                                                                         |            |
| Detailed                                                                 | 100                                                                                 |            |
| Formcode                                                                 | 11 - Full circular section                                                          |            |
| Shape type                                                               | Thick-walled                                                                        |            |
| Item material                                                            | Dummy Koppeling                                                                     |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |    |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | c                                                                                   | c          |
| A [m <sup>2</sup> ]                                                      | 7.8540e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 6.7325e-03                                                                          | 6.7325e-03 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 3.1414e-01                                                                          | 3.1414e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 50                                                                                  | 50         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 4.9087e-06                                                                          | 4.9087e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 25                                                                                  | 25         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 9.8175e-05                                                                          | 9.8175e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.6667e-04                                                                          | 1.6667e-04 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 23326.23                                                                            | 23326.23   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 23326.23                                                                            | 23326.23   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 9.8109e-06                                                                          | 0.0000e+00 |
| $\beta_y$ [mm], $\beta_z$ [mm]                                           | 0                                                                                   | 0          |
| Picture                                                                  |  |            |

### CS5

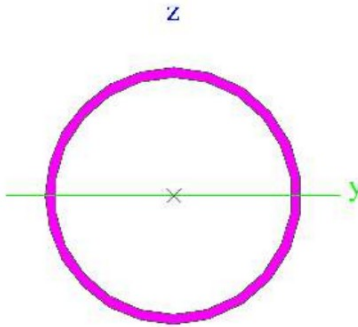
|               |                                |  |
|---------------|--------------------------------|--|
| Type          | SHS60/60/5.0                   |  |
| Formcode      | 2 - Rectangular hollow section |  |
| Shape type    | Thin-walled                    |  |
| Item material | S 235                          |  |

|                                                                          |                                                                                    |            |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------|
| Fabrication                                                              | rolled                                                                             |            |
| Colour                                                                   |   |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | a                                                                                  | a          |
| A [m <sup>2</sup> ]                                                      | 1.0700e-03                                                                         |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 5.3634e-04                                                                         | 5.3634e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 2.2700e-01                                                                         | 4.1844e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 30                                                                                 | 30         |
| α [deg]                                                                  | 0.00                                                                               |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 5.3300e-07                                                                         | 5.3300e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 22                                                                                 | 22         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.7800e-05                                                                         | 1.7800e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 2.1900e-05                                                                         | 2.1900e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 5141.72                                                                            | 5141.72    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 5141.72                                                                            | 5141.72    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                  | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 8.6400e-07                                                                         | 3.2400e-10 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                  | 0          |
| Picture                                                                  |  |            |

|                                                                          |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| CS6                                                                      |                                                                                     |            |
| Type                                                                     | SHS60/60/4.0                                                                        |            |
| Formcode                                                                 | 2 - Rectangular hollow section                                                      |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | S 235                                                                               |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | a                                                                                   | a          |
| A [m <sup>2</sup> ]                                                      | 8.7900e-04                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 3.9281e-04                                                                          | 3.9281e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 2.3000e-01                                                                          | 4.3075e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 30                                                                                  | 30         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 4.5400e-07                                                                          | 4.5400e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 23                                                                                  | 23         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.5100e-05                                                                          | 1.5100e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.8300e-05                                                                          | 1.8300e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 4299.91                                                                             | 4299.91    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 4299.91                                                                             | 4299.91    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 7.4149e-07                                                                          | 6.5397e-13 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |



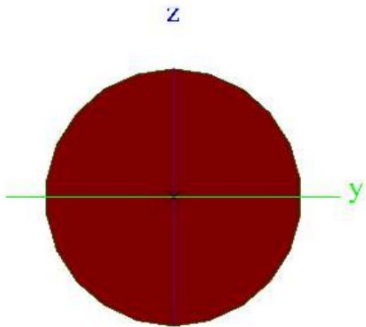
#### CS8

|                                                                          |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | CFCBS159X6                                                                          |            |
| Formcode                                                                 | 3 - Circular hollow section                                                         |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | EN-AW 6063 (EP,ET,ER/B) T66 (0-10)                                                  |            |
| Fabrication                                                              | cold formed                                                                         |            |
| Colour                                                                   |    |            |
| A [m <sup>2</sup> ]                                                      | 2.8840e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 1.4457e-03                                                                          | 1.4457e-03 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 5.0000e-01                                                                          | 9.6128e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 80                                                                                  | 80         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 8.4519e-06                                                                          | 8.4519e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 54                                                                                  | 54         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.0631e-04                                                                          | 1.0631e-04 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.4053e-04                                                                          | 1.4053e-04 |
| M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]                         | 28096.64                                                                            | 28096.64   |
| M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]                         | 28096.64                                                                            | 28096.64   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 1.6904e-05                                                                          | 0.0000e+00 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| Picture                                                                  |  |            |

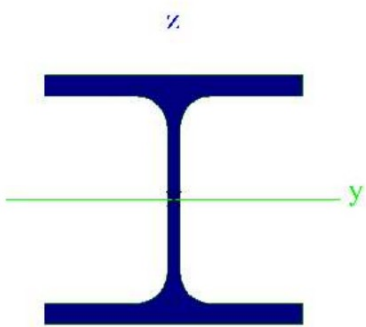
#### CS9

|                                                                        |                                                                                     |            |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                   | RD16                                                                                |            |
| Formcode                                                               | 11 - Full circular section                                                          |            |
| Shape type                                                             | Thick-walled                                                                        |            |
| Item material                                                          | S 235                                                                               |            |
| Fabrication                                                            | rolled                                                                              |            |
| Colour                                                                 |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                        | c                                                                                   | c          |
| A [m <sup>2</sup> ]                                                    | 2.0096e-04                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]     | 1.7226e-04                                                                          | 1.7226e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m] | 5.0133e-02                                                                          | 5.0263e-02 |



|                                                                          |                                                                                   |            |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------|
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 8                                                                                 | 8          |
| α [deg]                                                                  | 0.00                                                                              |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 3.1496e-09                                                                        | 3.1496e-09 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 4                                                                                 | 4          |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 3.9370e-07                                                                        | 3.9370e-07 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 6.7190e-07                                                                        | 6.7190e-07 |
| M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]                         | 160.38                                                                            | 160.38     |
| M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]                         | 160.38                                                                            | 160.38     |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                 | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 6.4299e-09                                                                        | 0.0000e+00 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                 | 0          |
| Picture                                                                  |  |            |

#### CS14

|                                                                          |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | HEA100                                                                              |            |
| Formcode                                                                 | 1 - I section                                                                       |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | S 235                                                                               |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | b                                                                                   | c          |
| A [m <sup>2</sup> ]                                                      | 2.1200e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 1.4881e-03                                                                          | 4.7795e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 5.6100e-01                                                                          | 5.6130e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 50                                                                                  | 48         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 3.4900e-06                                                                          | 1.3400e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 41                                                                                  | 25         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 7.2800e-05                                                                          | 2.6800e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 8.2917e-05                                                                          | 4.1125e-05 |
| M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]                         | 19527.28                                                                            | 19527.28   |
| M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]                         | 9671.68                                                                             | 9671.68    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 5.2084e-08                                                                          | 2.4750e-09 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| Picture                                                                  |  |            |

| Explanations of symbols |                                                                                |
|-------------------------|--------------------------------------------------------------------------------|
| Formcode                | s - Thickness<br>r - Inner radius<br>b - Flange width<br>h - Height<br>c - Lip |
| A                       | Area                                                                           |
| $A_y$                   | Shear Area in principal y-direction                                            |
| $A_z$                   | Shear Area in principal z-direction                                            |
| $A_L$                   | Circumference per unit length                                                  |
| $A_D$                   | Drying surface per unit length                                                 |
| $C_{Y,UCS}$             | Centroid coordinate in Y-direction of Input axis system                        |
| $C_{Z,UCS}$             | Centroid coordinate in Z-direction of Input axis system                        |
| $I_{Y,LCS}$             | Second moment of area about the YLCS axis                                      |
| $I_{Z,LCS}$             | Second moment of area about the ZLCS axis                                      |
| $I_{YZ,LCS}$            | Product moment of area in the LCS system                                       |
| $\alpha$                | Rotation angle of the principal axis system                                    |
| $I_y$                   | Second moment of area about the principal y-axis                               |
| $I_z$                   | Second moment of area about the principal z-axis                               |
| $i_y$                   | Radius of gyration about the principal y-axis                                  |

| Explanations of symbols |                                                                             |
|-------------------------|-----------------------------------------------------------------------------|
| $i_z$                   | Radius of gyration about the principal z-axis                               |
| $W_{el,y}$              | Elastic section modulus about the principal y-axis                          |
| $W_{el,z}$              | Elastic section modulus about the principal z-axis                          |
| $W_{pl,y}$              | Plastic section modulus about the principal y-axis                          |
| $W_{pl,z}$              | Plastic section modulus about the principal z-axis                          |
| $M_{pl,y,+}$            | Plastic moment about the principal y-axis for a positive $M_y$ moment       |
| $M_{pl,y,-}$            | Plastic moment about the principal y-axis for a negative $M_y$ moment       |
| $M_{pl,z,+}$            | Plastic moment about the principal z-axis for a positive $M_z$ moment       |
| $M_{pl,z,-}$            | Plastic moment about the principal z-axis for a negative $M_z$ moment       |
| $d_y$                   | Shear center coordinate in principal y-direction measured from the centroid |
| $d_z$                   | Shear center coordinate in principal z-direction measured from the centroid |
| $I_t$                   | Torsional constant                                                          |
| $I_w$                   | Warping constant                                                            |
| $\beta_y$               | Mono-symmetry constant about the principal y-axis                           |
| $\beta_z$               | Mono-symmetry constant about the principal z-axis                           |

## 6. Belastingen

### 6.1. Load cases

| Name      | Description<br>Spec           | Action type<br>Load type | Load group | Direction | Duration | Master load case |
|-----------|-------------------------------|--------------------------|------------|-----------|----------|------------------|
| EG        | Self Weight                   | Permanent<br>Self weight | LG1        | -Z        |          |                  |
| Perm      | Eigengewicht dek en bekleding | Permanent<br>Standard    | LG1        |           |          |                  |
| Qdek-POS0 | Q-Dek overall<br>Standard     | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS1 | Q-Dek positie 1<br>Standard   | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS2 | Q-Dek positie 2<br>Standard   | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS3 | Q-Dek positie 3<br>Standard   | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS4 | Q-Dek positie 4<br>Standard   | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS5 | Q-Dek positie 5<br>Standard   | Variable<br>Static       | LG2 - Dek  |           | Short    | None             |
| Qdek-POS6 | Q-Dek positie 6               | Variable                 | LG2 - Dek  |           | Short    | None             |

| Name      | Description<br>Spec            | Action type<br>Load type | Load group | Direction | Duration | Master load case |
|-----------|--------------------------------|--------------------------|------------|-----------|----------|------------------|
|           | Standard                       | Static                   |            |           |          |                  |
| Qdek-POS7 | Q-Dek-Schaakbord               | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Qdek-POS8 | Q-Dek-Schaakbord               | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Qdek-POS9 | Q-Dek-Schaakbord               | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS1 | F-Dek positie 1                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS2 | F-Dek positie 2                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS3 | F-Dek positie 3                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS4 | F-Dek positie 4                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS5 | F-Dek positie 5                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Fdek-POS6 | F-Dek positie 6                | Variable                 | LG2 - Dek  |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Wind      | Wind belasting haaks           | Variable                 | LG3 - Wind |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Wind1     | Wind belasting<br>evenwijdig   | Variable                 | LG3 - Wind |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |
| Wind2     | Wind belasting<br>evenwijdig-2 | Variable                 | LG3 - Wind |           | Short    | None             |
|           | Standard                       | Static                   |            |           |          |                  |

## 6.2. Belastingen

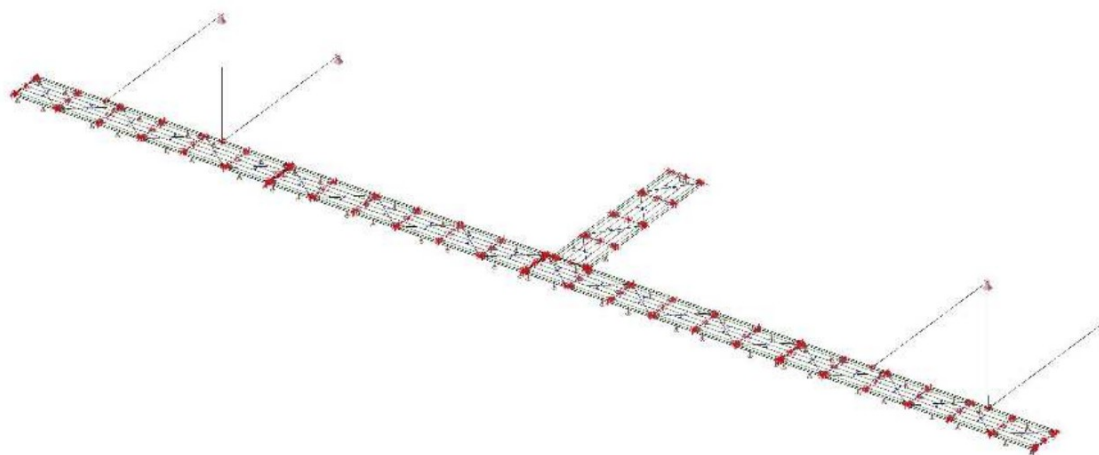
### 6.2.1. Dek belastingen

#### 6.2.1.1. Dek belastingen - EG

| Name | Description<br>Spec | Action type<br>Load type | Load group | Direction |
|------|---------------------|--------------------------|------------|-----------|
| EG   | Self Weight         | Permanent                | LG1        | -Z        |
|      |                     | Self weight              |            |           |



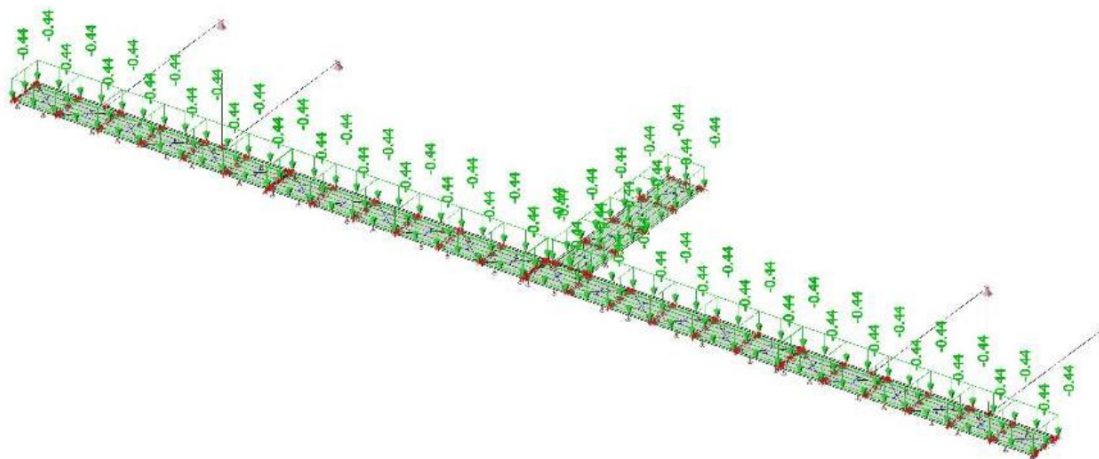
#### 6.2.1.1.1. Belasting overzicht



#### 6.2.1.2. Dek belastingen - Perm

| Name | Description<br>Spec           | Action type<br>Load type | Load group |
|------|-------------------------------|--------------------------|------------|
| Perm | Eigengewicht dek en bekleding | Permanent                | LG1        |
|      |                               | Standard                 |            |

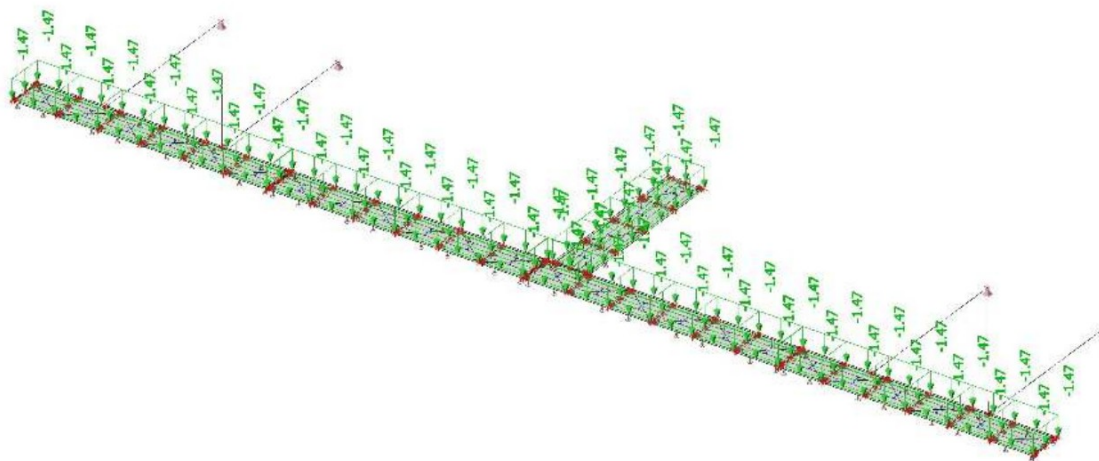
#### 6.2.1.2.1. Belasting overzicht



#### 6.2.1.3. Dek belastingen - Qdek-POS0

| Name      | Description   | Action type | Load group | Duration | Master load case |
|-----------|---------------|-------------|------------|----------|------------------|
|           | Spec          | Load type   |            |          |                  |
| Qdek-POS0 | Q-Dek overall | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard      | Static      |            |          |                  |

#### 6.2.1.3.1. Belasting overzicht

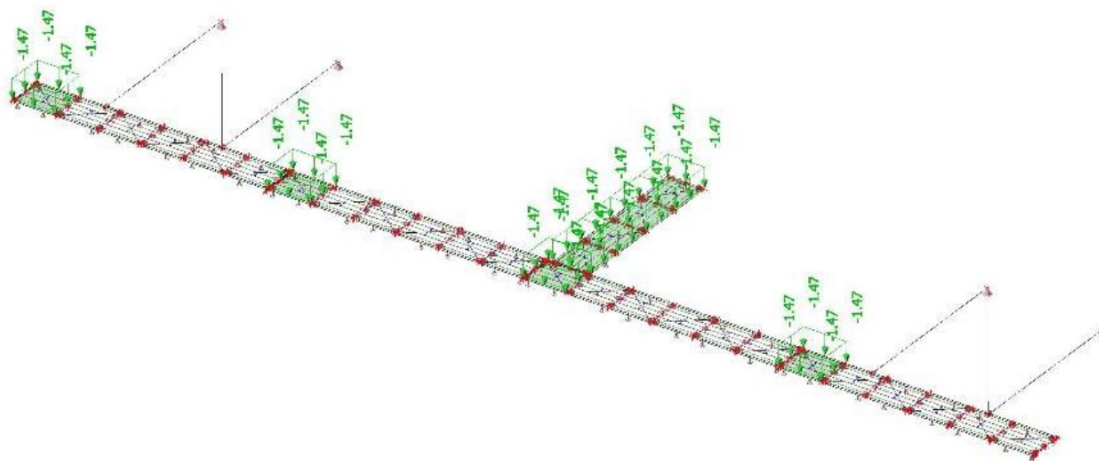


#### 6.2.1.4. Dek belastingen - Qdek-POS1

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS1 | Q-Dek positie 1 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |



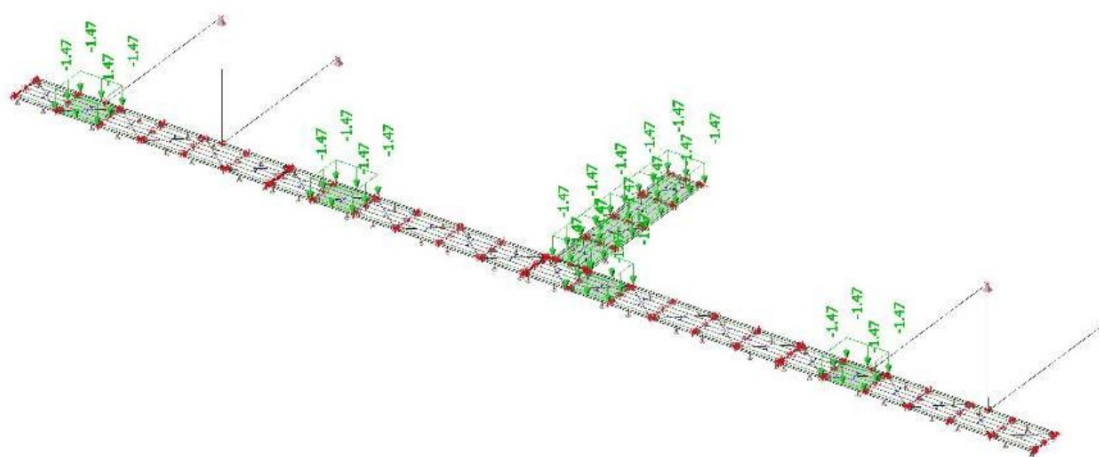
#### 6.2.1.4.1. Belasting overzicht



#### 6.2.1.5. Dek belastingen - Qdek-POS2

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS2 | Q-Dek positie 2 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

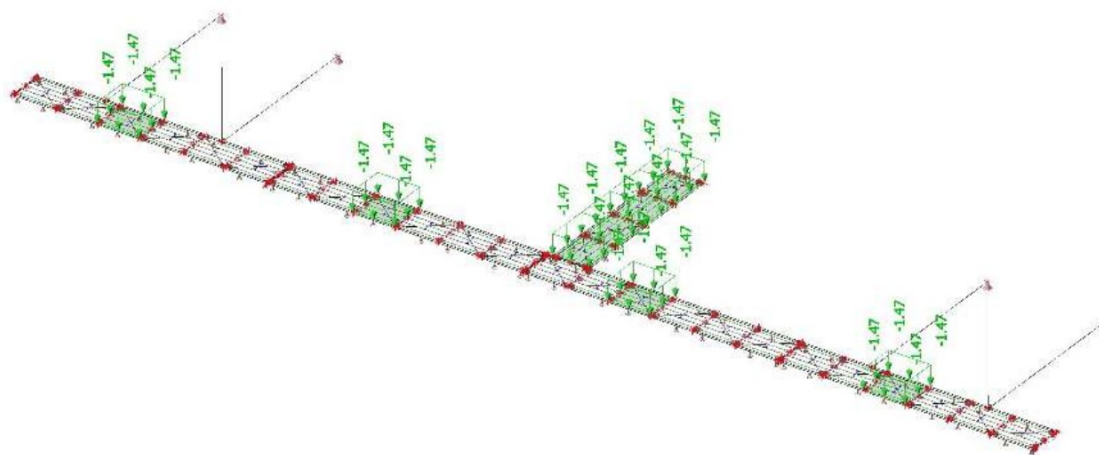
#### 6.2.1.5.1. Belasting overzicht



#### 6.2.1.6. Dek belastingen - Qdek-POS3

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS3 | Q-Dek positie 3 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

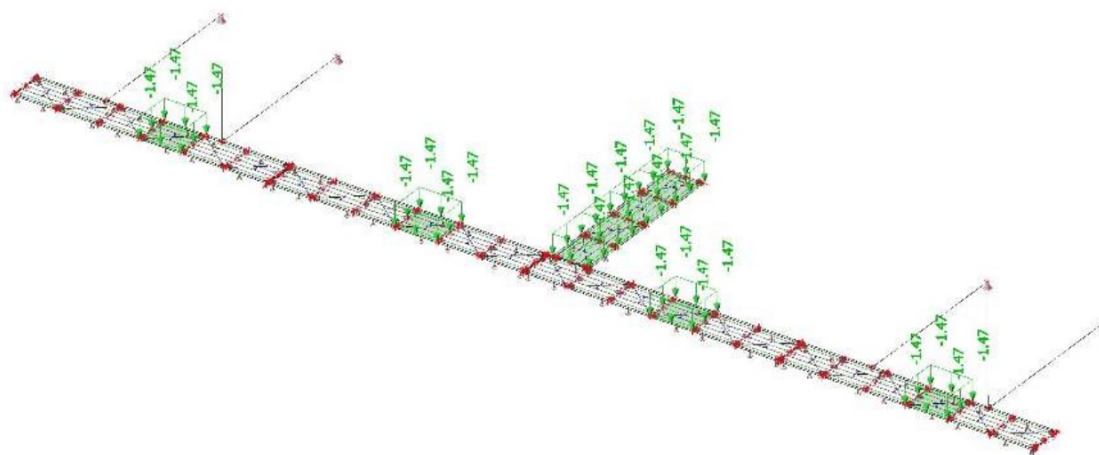
#### 6.2.1.6.1. Belasting overzicht



#### 6.2.1.7. Dek belastingen - Qdek-POS4

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS4 | Q-Dek positie 4 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

#### 6.2.1.7.1. Belasting overzicht

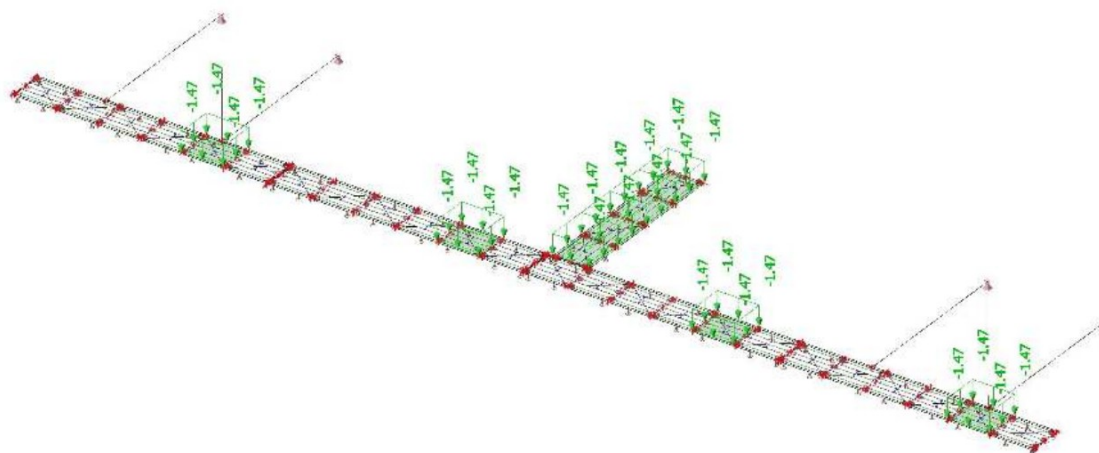


#### 6.2.1.8. Dek belastingen - Qdek-POS5

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS5 | Q-Dek positie 5 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |



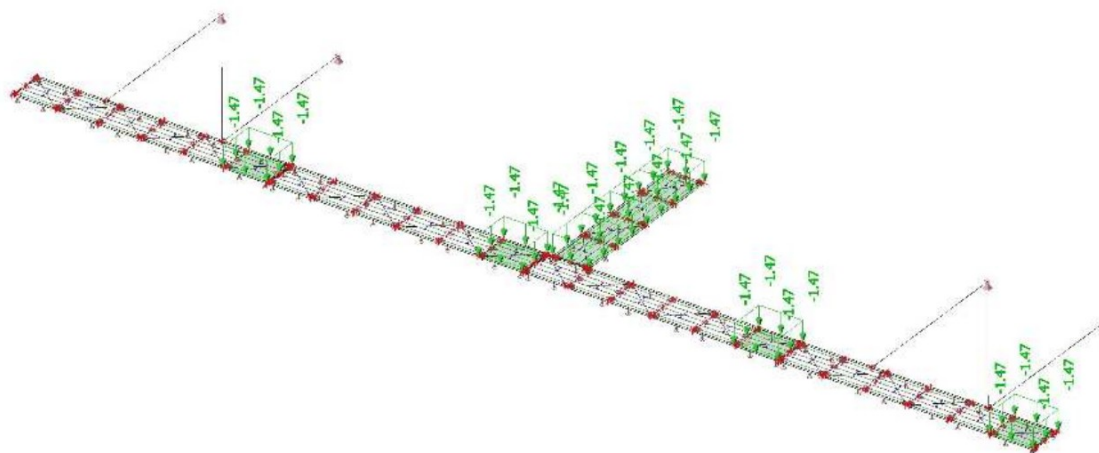
#### 6.2.1.8.1. Belasting overzicht



#### 6.2.1.9. Dek belastingen - Qdek-POS6

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Qdek-POS6 | Q-Dek positie 6 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

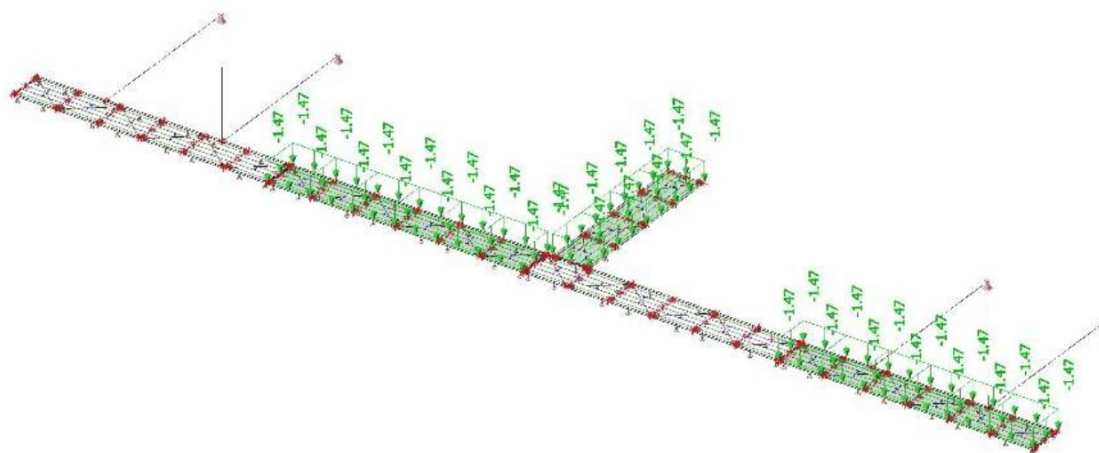
#### 6.2.1.9.1. Belasting overzicht



#### 6.2.1.10. Dek belastingen - Qdek-POS7

| Name      | Description      | Action type | Load group | Duration | Master load case |
|-----------|------------------|-------------|------------|----------|------------------|
|           | Spec             | Load type   |            |          |                  |
| Qdek-POS7 | Q-Dek-Schaakbord | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard         | Static      |            |          |                  |

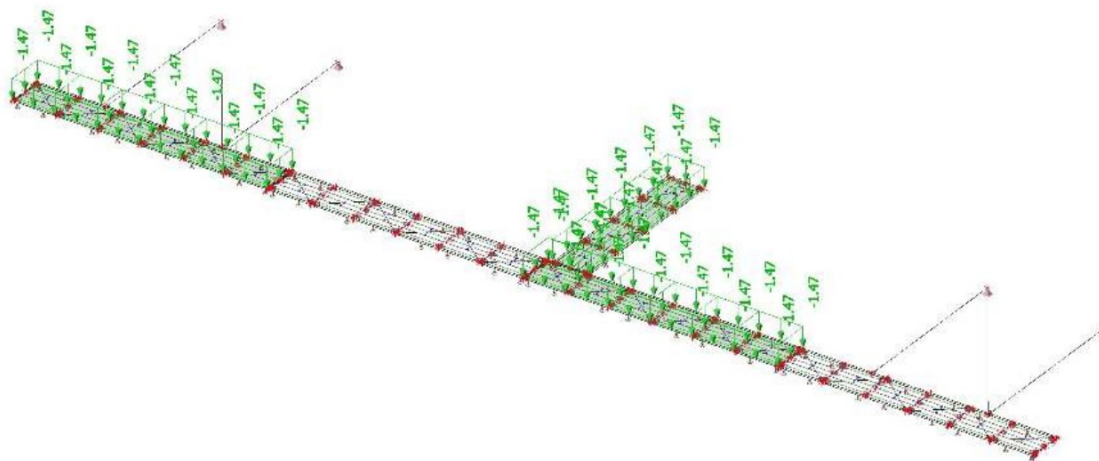
#### 6.2.1.10.1. Belasting overzicht



#### 6.2.1.11. Dek belastingen - Qdek-POS8

| Name      | Description<br>Spec | Action type<br>Load type | Load group | Duration | Master load case |
|-----------|---------------------|--------------------------|------------|----------|------------------|
| Qdek-POS8 | Q-Dek-Schaakbord    | Variable                 | LG2 - Dek  | Short    | None             |
|           | Standard            | Static                   |            |          |                  |

#### 6.2.1.11.1. Belasting overzicht

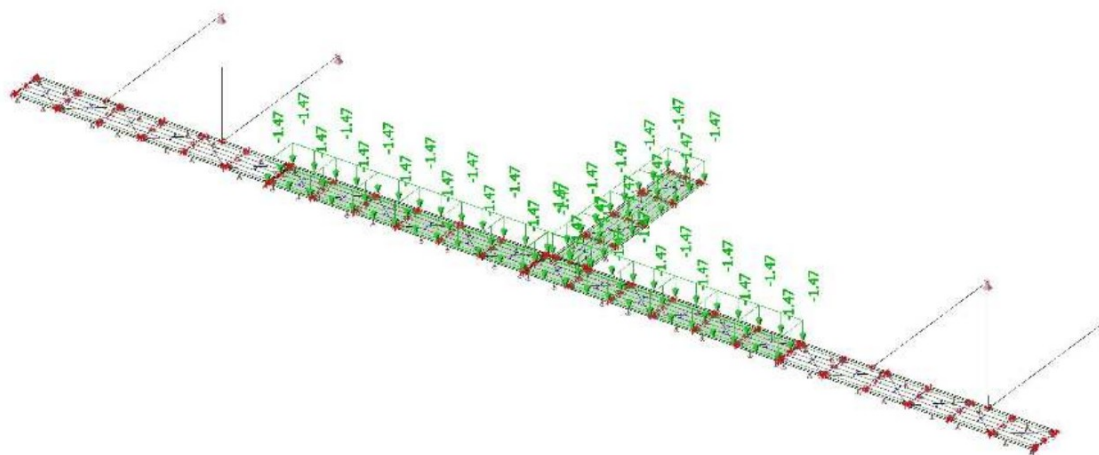


#### 6.2.1.12. Dek belastingen - Qdek-POS9

| Name      | Description      | Action type | Load group | Duration | Master load case |
|-----------|------------------|-------------|------------|----------|------------------|
|           | Spec             | Load type   |            |          |                  |
| Qdek-POS9 | Q-Dek-Schaakbord | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard         | Static      |            |          |                  |



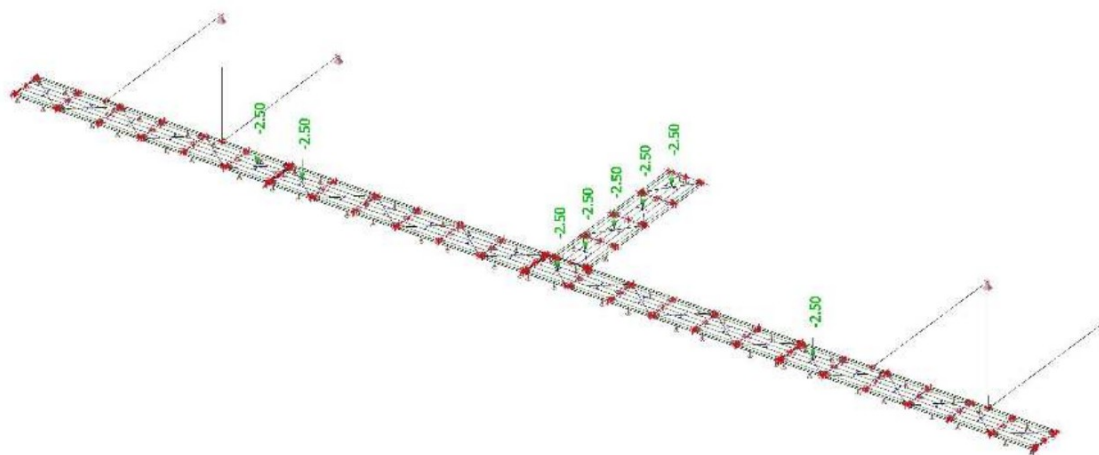
#### 6.2.1.12.1. Belasting overzicht



#### 6.2.1.13. Dek belastingen - Fdek-POS1

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS1 | F-Dek positie 1 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

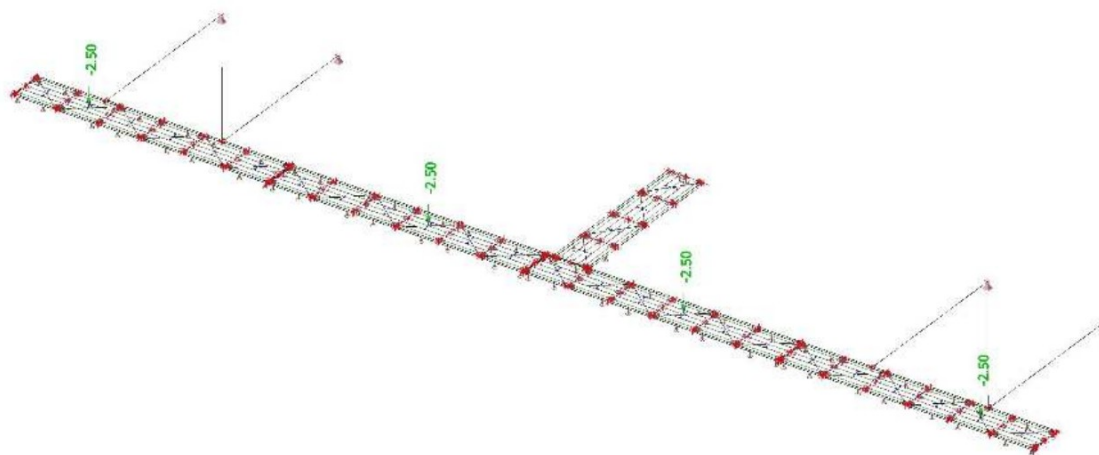
#### 6.2.1.13.1. Belasting overzicht



#### 6.2.1.14. Dek belastingen - Fdek-POS2

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS2 | F-Dek positie 2 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

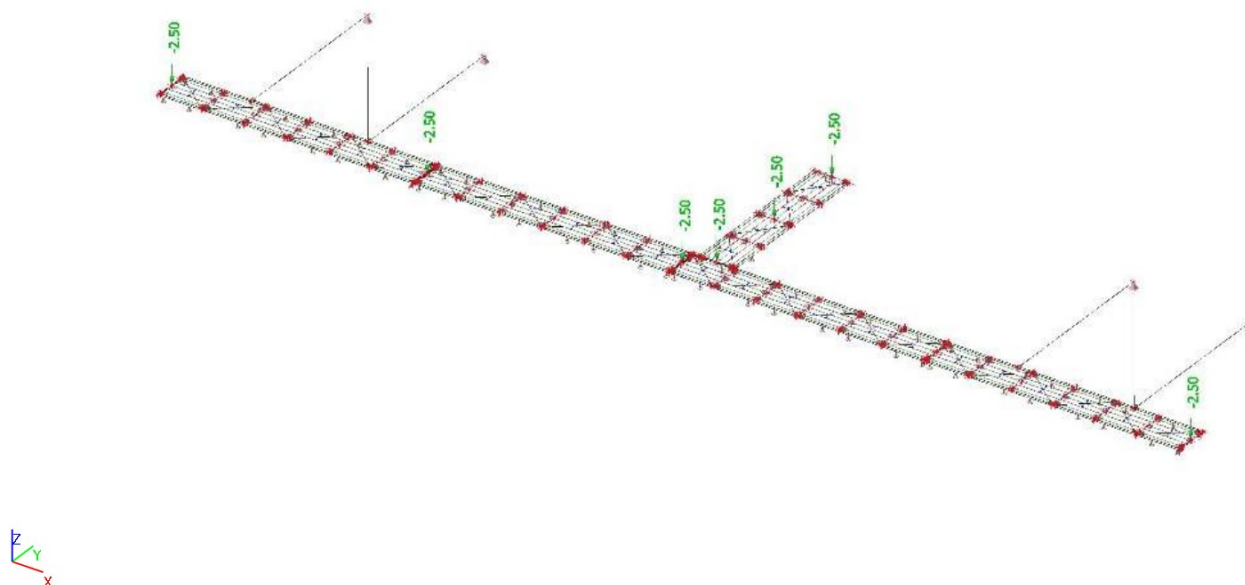
#### 6.2.1.14.1. Belasting overzicht



#### 6.2.1.15. Dek belastingen - Fdek-POS3

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS3 | F-Dek positie 3 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

#### 6.2.1.15.1. Belasting overzicht

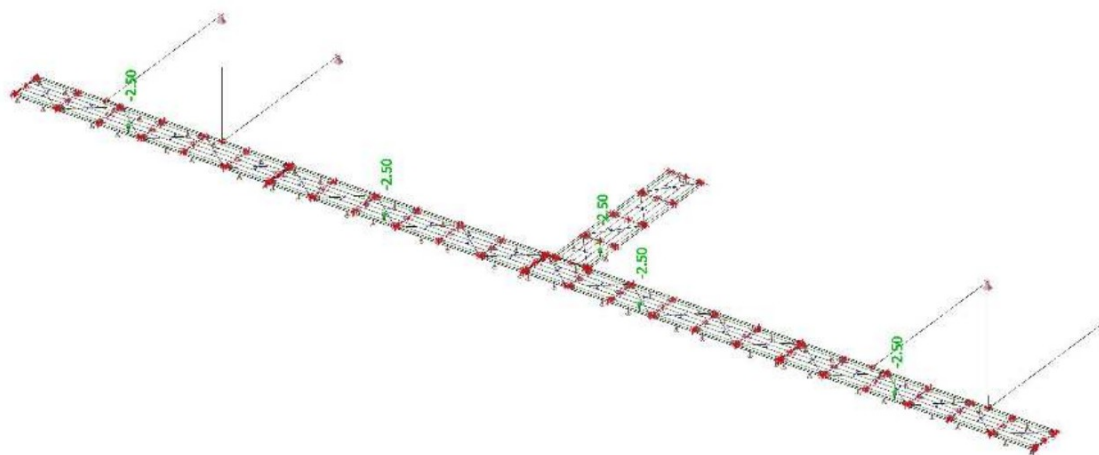


#### 6.2.1.16. Dek belastingen - Fdek-POS4

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS4 | F-Dek positie 4 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |



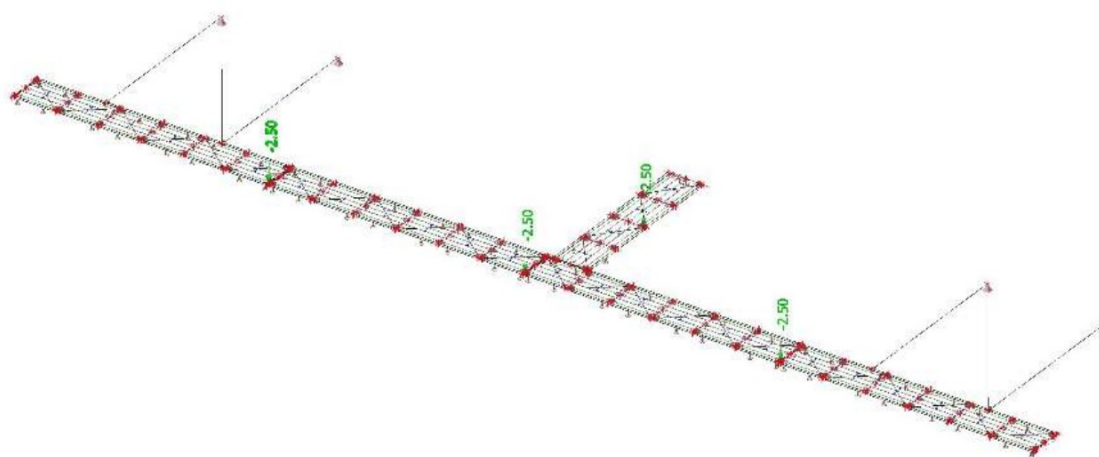
#### 6.2.1.16.1. Belasting overzicht



#### 6.2.1.17. Dek belastingen - Fdek-POS5

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS5 | F-Dek positie 5 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

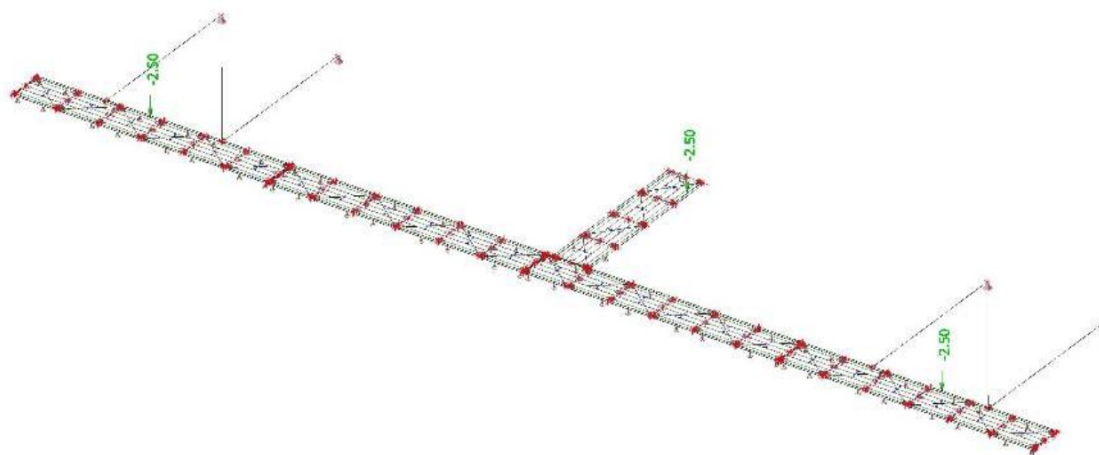
#### 6.2.1.17.1. Belasting overzicht



#### 6.2.1.18. Dek belastingen - Fdek-POS6

| Name      | Description     | Action type | Load group | Duration | Master load case |
|-----------|-----------------|-------------|------------|----------|------------------|
|           | Spec            | Load type   |            |          |                  |
| Fdek-POS6 | F-Dek positie 6 | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard        | Static      |            |          |                  |

### 6.2.1.18.1. Belasting overzicht

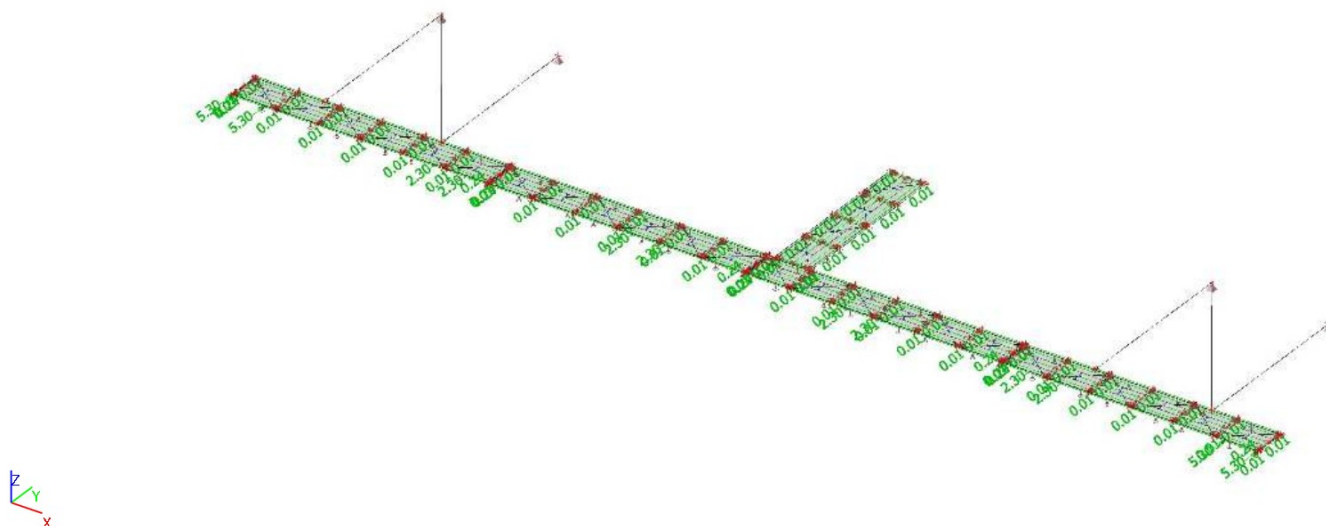


## 6.2.2. Windbelasting

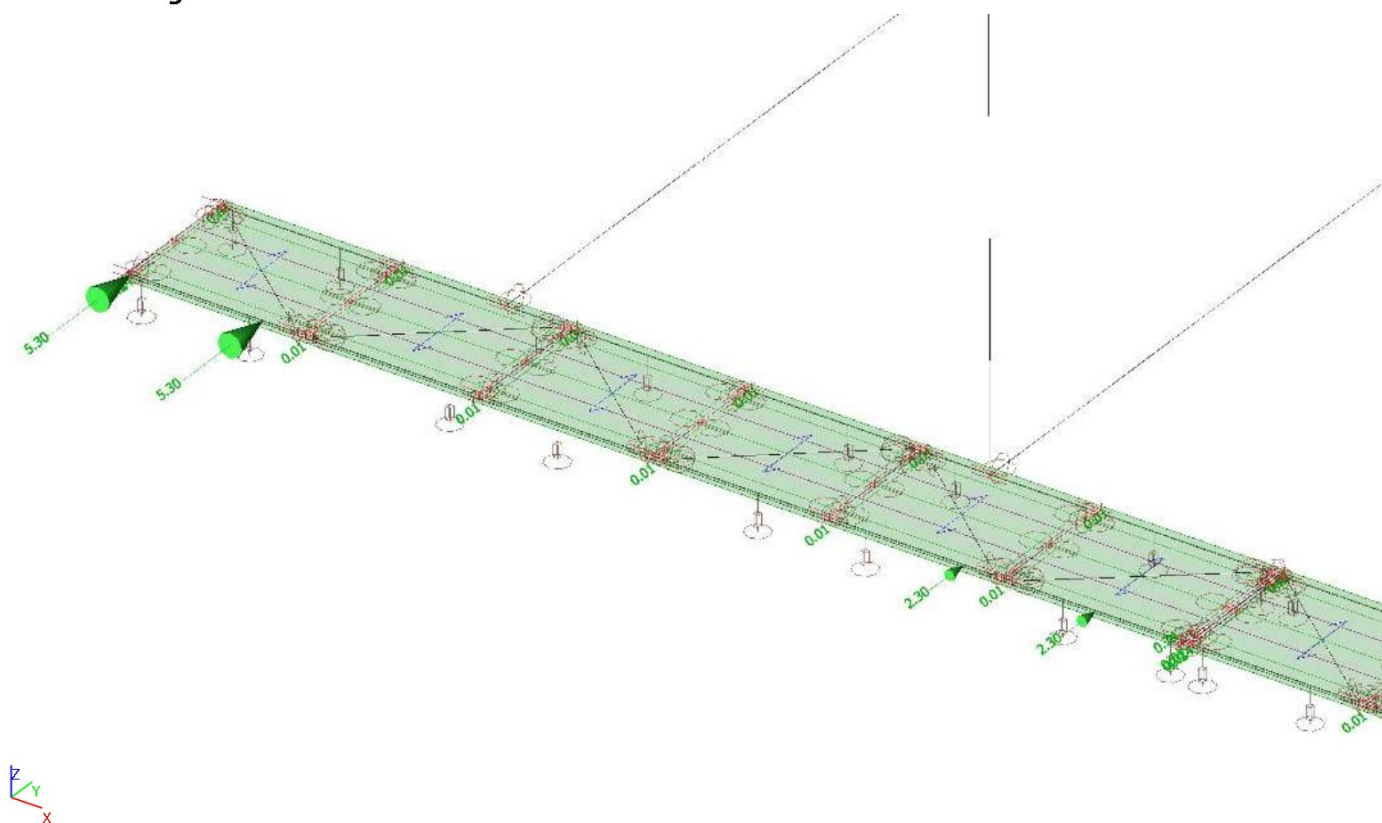
### 6.2.2.1. Windbelasting - Wind

| Name | Description<br>Spec  | Action type<br>Load type | Load group | Duration | Master load case |
|------|----------------------|--------------------------|------------|----------|------------------|
| Wind | Wind belasting haaks | Variable                 | LG3 - Wind | Short    | None             |
|      | Standard             | Static                   |            |          |                  |

### 6.2.2.1.1. Belasting overzicht



### 6.2.2.1.2. Belasting detail

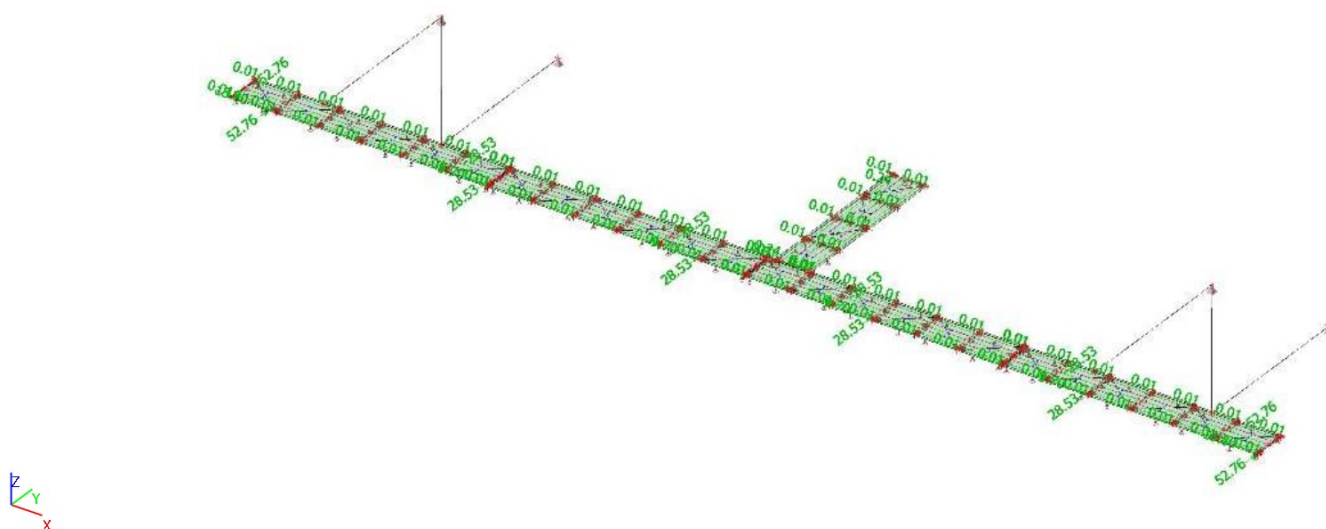




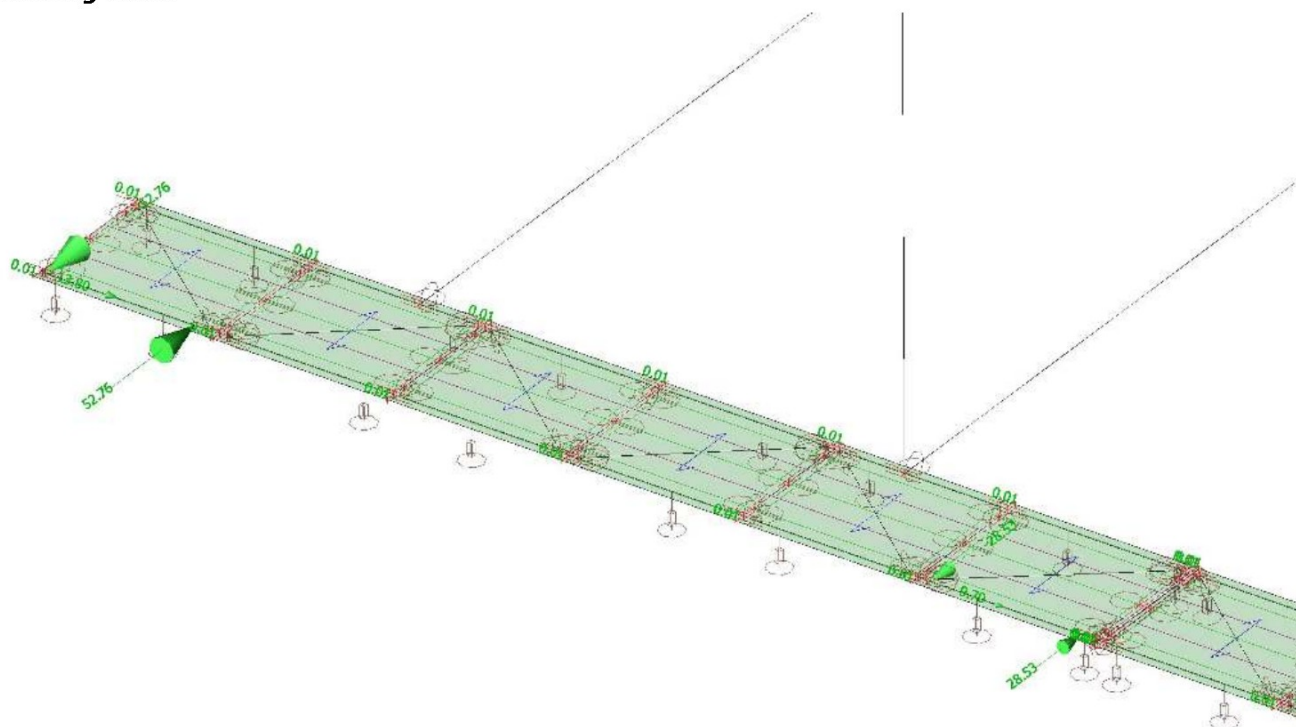
#### 6.2.2.2. Windbelasting - Wind1

| Name  | Description                  | Action type | Load group | Duration | Master load case |
|-------|------------------------------|-------------|------------|----------|------------------|
|       | Spec                         | Load type   |            |          |                  |
| Wind1 | Wind belasting<br>evenwijdig | Variable    | LG3 - Wind | Short    | None             |
|       | Standard                     | Static      |            |          |                  |

##### 6.2.2.2.1. Belasting overzicht



#### 6.2.2.2. Belasting detail



### 6.3. Load groups

| Name       | Load      | Relation  | Type             |
|------------|-----------|-----------|------------------|
| LG1        | Permanent |           |                  |
| LG2 - Dek  | Variable  | Exclusive | Cat A : Domestic |
| LG3 - Wind | Variable  | Exclusive | Cat A : Domestic |
| LG4 - Wave | Variable  | Exclusive | Cat A : Domestic |

### 6.4. Combinations

| Name | Description               | Type                      | Load cases                           | Coeff. [-] |
|------|---------------------------|---------------------------|--------------------------------------|------------|
| C01  | SLS - DEK - automatisch   | Envelope - serviceability | EG - Self Weight                     | 1.000      |
|      |                           |                           | Perm - Eigengewicht dek en bekleding | 1.000      |
|      |                           |                           | Qdek-POS0 - Q-Dek overall            | 1.000      |
|      |                           |                           | Qdek-POS1 - Q-Dek positie 1          | 1.000      |
|      |                           |                           | Qdek-POS2 - Q-Dek positie 2          | 1.000      |
|      |                           |                           | Qdek-POS3 - Q-Dek positie 3          | 1.000      |
|      |                           |                           | Qdek-POS4 - Q-Dek positie 4          | 1.000      |
|      |                           |                           | Qdek-POS5 - Q-Dek positie 5          | 1.000      |
|      |                           |                           | Qdek-POS6 - Q-Dek positie 6          | 1.000      |
|      |                           |                           | Fdek-POS1 - F-Dek positie 1          | 1.000      |
|      |                           |                           | Fdek-POS2 - F-Dek positie 2          | 1.000      |
|      |                           |                           | Fdek-POS3 - F-Dek positie 3          | 1.000      |
|      |                           |                           | Fdek-POS4 - F-Dek positie 4          | 1.000      |
|      |                           |                           | Fdek-POS5 - F-Dek positie 5          | 1.000      |
|      |                           |                           | Fdek-POS6 - F-Dek positie 6          | 1.000      |
|      |                           |                           | Wind - Wind belasting haaks          | 0.300      |
| C02  | SLS - STORM - automatisch | Envelope - serviceability | EG - Self Weight                     | 1.000      |
|      |                           |                           | Perm - Eigengewicht dek en           | 1.000      |

| Name | Description                          | Type                      | Load cases                           | Coeff. [-] |
|------|--------------------------------------|---------------------------|--------------------------------------|------------|
|      |                                      |                           | bekleding                            |            |
|      |                                      |                           | Qdek-POS0 - Q-Dek overall            | 0.800      |
|      |                                      |                           | Qdek-POS1 - Q-Dek positie 1          | 0.800      |
|      |                                      |                           | Qdek-POS2 - Q-Dek positie 2          | 0.800      |
|      |                                      |                           | Qdek-POS3 - Q-Dek positie 3          | 0.800      |
|      |                                      |                           | Qdek-POS4 - Q-Dek positie 4          | 0.800      |
|      |                                      |                           | Qdek-POS5 - Q-Dek positie 5          | 0.800      |
|      |                                      |                           | Qdek-POS6 - Q-Dek positie 6          | 0.800      |
|      |                                      |                           | Fdek-POS1 - F-Dek positie 1          | 0.800      |
|      |                                      |                           | Fdek-POS2 - F-Dek positie 2          | 0.800      |
|      |                                      |                           | Fdek-POS3 - F-Dek positie 3          | 0.800      |
|      |                                      |                           | Fdek-POS4 - F-Dek positie 4          | 0.800      |
|      |                                      |                           | Fdek-POS5 - F-Dek positie 5          | 0.800      |
|      |                                      |                           | Fdek-POS6 - F-Dek positie 6          | 0.800      |
|      |                                      |                           | Wind - Wind belasting haaks          | 1.000      |
| C03  | ULS - DEK - automatisch              | Envelope - ultimate       | EG - Self Weight                     | 1.100      |
|      |                                      |                           | Perm - Eigengewicht dek en bekleding | 1.100      |
|      |                                      |                           | Qdek-POS0 - Q-Dek overall            | 1.200      |
|      |                                      |                           | Qdek-POS1 - Q-Dek positie 1          | 1.200      |
|      |                                      |                           | Qdek-POS2 - Q-Dek positie 2          | 1.200      |
|      |                                      |                           | Qdek-POS3 - Q-Dek positie 3          | 1.200      |
|      |                                      |                           | Qdek-POS4 - Q-Dek positie 4          | 1.200      |
|      |                                      |                           | Qdek-POS5 - Q-Dek positie 5          | 1.200      |
|      |                                      |                           | Qdek-POS6 - Q-Dek positie 6          | 1.200      |
|      |                                      |                           | Fdek-POS1 - F-Dek positie 1          | 1.200      |
|      |                                      |                           | Fdek-POS2 - F-Dek positie 2          | 1.200      |
|      |                                      |                           | Fdek-POS3 - F-Dek positie 3          | 1.200      |
|      |                                      |                           | Fdek-POS4 - F-Dek positie 4          | 1.200      |
|      |                                      |                           | Fdek-POS5 - F-Dek positie 5          | 1.200      |
|      |                                      |                           | Fdek-POS6 - F-Dek positie 6          | 1.200      |
|      |                                      |                           | Wind - Wind belasting haaks          | 0.405      |
|      |                                      |                           | Wind1 - Wind belasting evenwijdig    | 0.405      |
| C04  | ULS - STORM - automatisch            | Envelope - ultimate       | EG - Self Weight                     | 1.100      |
|      |                                      |                           | Perm - Eigengewicht dek en bekleding | 1.100      |
|      |                                      |                           | Qdek-POS0 - Q-Dek overall            | 0.960      |
|      |                                      |                           | Qdek-POS1 - Q-Dek positie 1          | 0.960      |
|      |                                      |                           | Qdek-POS2 - Q-Dek positie 2          | 0.960      |
|      |                                      |                           | Qdek-POS3 - Q-Dek positie 3          | 0.960      |
|      |                                      |                           | Qdek-POS4 - Q-Dek positie 4          | 0.960      |
|      |                                      |                           | Qdek-POS5 - Q-Dek positie 5          | 0.960      |
|      |                                      |                           | Qdek-POS6 - Q-Dek positie 6          | 0.960      |
|      |                                      |                           | Fdek-POS1 - F-Dek positie 1          | 0.960      |
|      |                                      |                           | Fdek-POS2 - F-Dek positie 2          | 0.960      |
|      |                                      |                           | Fdek-POS3 - F-Dek positie 3          | 0.960      |
|      |                                      |                           | Fdek-POS4 - F-Dek positie 4          | 0.960      |
|      |                                      |                           | Fdek-POS5 - F-Dek positie 5          | 0.960      |
|      |                                      |                           | Fdek-POS6 - F-Dek positie 6          | 0.960      |
|      |                                      |                           | Wind - Wind belasting haaks          | 1.350      |
|      |                                      |                           | Wind1 - Wind belasting evenwijdig    | 1.350      |
| C05  | SLS - DEK - automatisch - schaakbord | Envelope - serviceability | EG - Self Weight                     | 1.000      |
|      |                                      |                           | Perm - Eigengewicht dek en bekleding | 1.000      |
|      |                                      |                           | Qdek-POS7 - Q-Dek-Schaakbord         | 1.000      |
|      |                                      |                           | Qdek-POS8 - Q-Dek-Schaakbord         | 1.000      |
|      |                                      |                           | Qdek-POS9 - Q-Dek-Schaakbord         | 1.000      |
|      |                                      |                           | Wind - Wind belasting haaks          | 0.300      |

| Name | Description                            | Type                      | Load cases                           | Coeff. [-] |
|------|----------------------------------------|---------------------------|--------------------------------------|------------|
| C06  | SLS - STORM - automatisch - Schaakbord | Envelope - serviceability | EG - Self Weight                     | 1.000      |
|      |                                        |                           | Perm - Eigengewicht dek en bekleding | 1.000      |
|      |                                        |                           | Qdek-POS7 - Q-Dek-Schaakbord         | 0.800      |
|      |                                        |                           | Qdek-POS8 - Q-Dek-Schaakbord         | 0.800      |
|      |                                        |                           | Qdek-POS9 - Q-Dek-Schaakbord         | 0.800      |
|      |                                        |                           | Wind - Wind belasting haaks          | 1.000      |
| C07  | ULS - DEK - automatisch-Schaakbord     | Envelope - ultimate       | EG - Self Weight                     | 1.100      |
|      |                                        |                           | Perm - Eigengewicht dek en bekleding | 1.100      |
|      |                                        |                           | Qdek-POS7 - Q-Dek-Schaakbord         | 1.200      |
|      |                                        |                           | Qdek-POS8 - Q-Dek-Schaakbord         | 1.200      |
|      |                                        |                           | Qdek-POS9 - Q-Dek-Schaakbord         | 1.200      |
|      |                                        |                           | Wind - Wind belasting haaks          | 0.405      |
|      |                                        |                           | Wind1 - Wind belasting evenwijdig    | 0.405      |
| C08  | ULS - STORM - automatisch-schaakbord   | Envelope - ultimate       | EG - Self Weight                     | 1.100      |
|      |                                        |                           | Perm - Eigengewicht dek en bekleding | 1.100      |
|      |                                        |                           | Qdek-POS7 - Q-Dek-Schaakbord         | 0.960      |
|      |                                        |                           | Qdek-POS8 - Q-Dek-Schaakbord         | 0.960      |
|      |                                        |                           | Qdek-POS9 - Q-Dek-Schaakbord         | 0.960      |
|      |                                        |                           | Wind - Wind belasting haaks          | 1.350      |
|      |                                        |                           | Wind1 - Wind belasting evenwijdig    | 1.350      |

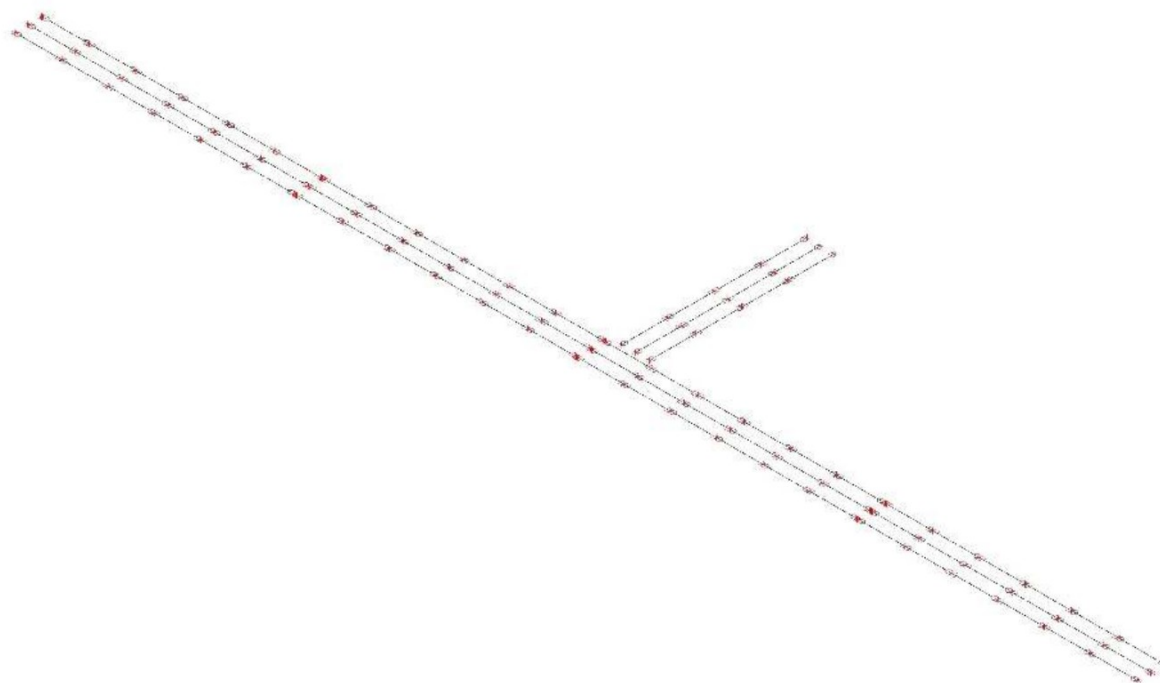
## 6.5. Result classes

| Name        | List                                                                                                                                                                                                                                                         |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All ULS     | C03 - Envelope - ultimate<br>C04 - Envelope - ultimate<br>C07 - Envelope - ultimate<br>C08 - Envelope - ultimate                                                                                                                                             |
| All SLS     | C01 - Envelope - serviceability<br>C02 - Envelope - serviceability<br>C05 - Envelope - serviceability<br>C06 - Envelope - serviceability                                                                                                                     |
| All ULS+SLS | C03 - Envelope - ultimate<br>C04 - Envelope - ultimate<br>C07 - Envelope - ultimate<br>C08 - Envelope - ultimate<br>C01 - Envelope - serviceability<br>C02 - Envelope - serviceability<br>C05 - Envelope - serviceability<br>C06 - Envelope - serviceability |

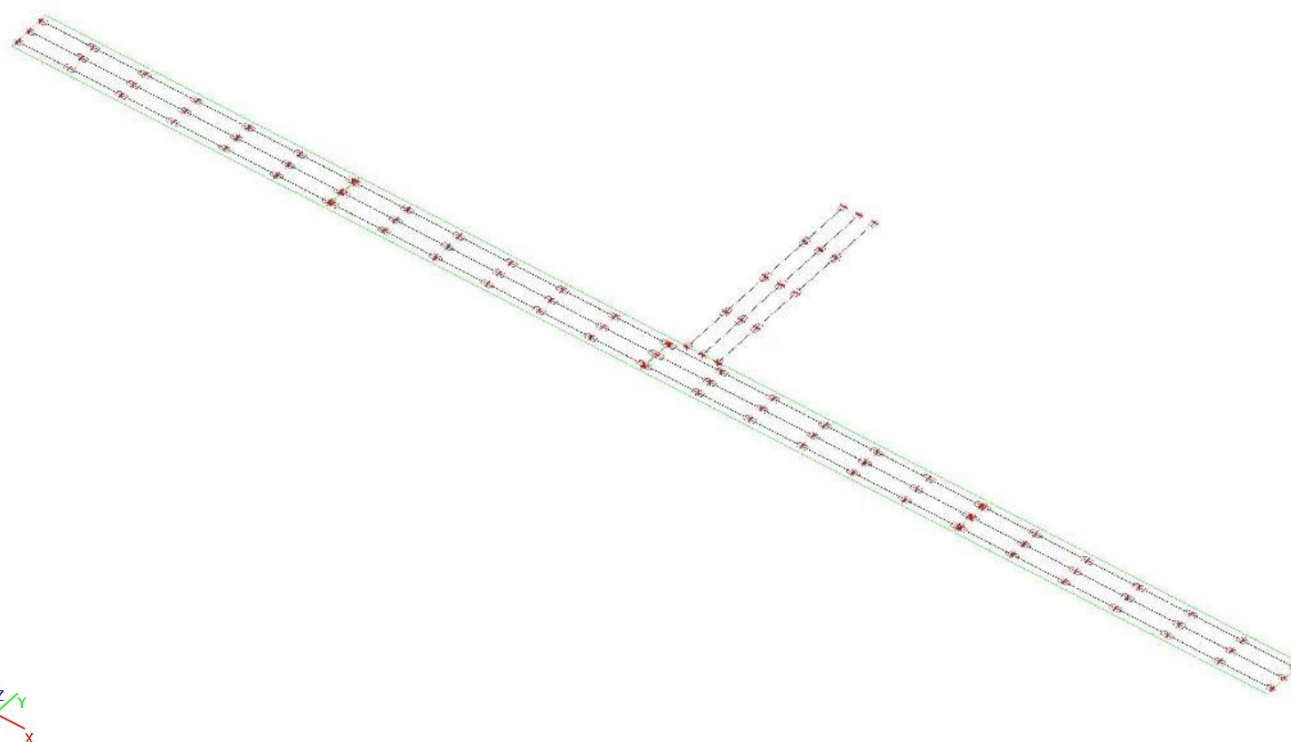


## 7. Dek

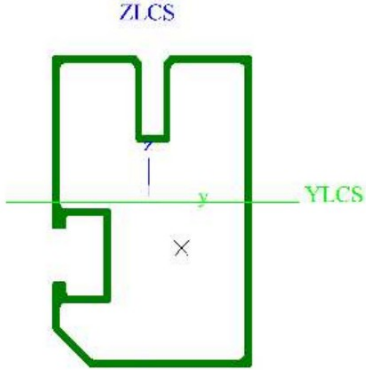
### 7.1. Dek met langsliggers



### 7.2. Dek met load pannels



### 7.3. Cross-sections

| CS4-AluProfiel                                                             |                                                                                    |            |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------|
| Type                                                                       | General cross-section                                                              |            |
| Shape type                                                                 | Thick-walled                                                                       |            |
| Item material                                                              | EN-AW 6063 (EP,ET,ER/B) T66 (0-10)                                                 |            |
| Fabrication                                                                | general                                                                            |            |
| Colour                                                                     |   |            |
| A [m <sup>2</sup> ]                                                        | 4.3592e-04                                                                         |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]         | 6.8043e-05                                                                         | 1.4545e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]     | 2.9149e-01                                                                         | 5.5765e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                           | -1                                                                                 | 2          |
| I <sub>y,LCS</sub> [m <sup>4</sup> ], I <sub>z,LCS</sub> [m <sup>4</sup> ] | 2.5981e-07                                                                         | 1.2152e-07 |
| I <sub>yz,LCS</sub> [m <sup>4</sup> ]                                      | 3.8972e-10                                                                         |            |
| α [deg]                                                                    | -0.16                                                                              |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]         | 2.5981e-07                                                                         | 1.2152e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                   | 24                                                                                 | 17         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]   | 7.0227e-06                                                                         | 5.1533e-06 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]   | 9.4597e-06                                                                         | 6.4255e-06 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                         | 1891.93                                                                            | 1891.93    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                         | 1285.10                                                                            | 1285.10    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                   | 8                                                                                  | -10        |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]         | 1.5561e-07                                                                         | 1.2905e-11 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                   | 17                                                                                 | -9         |
| Picture                                                                    |  |            |

#### Explanations of symbols

|                     |                                                                     |
|---------------------|---------------------------------------------------------------------|
| A                   | Area                                                                |
| A <sub>y</sub>      | Shear Area in principal y-direction - Calculated by 2D FEM analysis |
| A <sub>z</sub>      | Shear Area in principal z-direction - Calculated by 2D FEM analysis |
| A <sub>L</sub>      | Circumference per unit length                                       |
| A <sub>D</sub>      | Drying surface per unit length                                      |
| c <sub>y,UCS</sub>  | Centroid coordinate in Y-direction of Input axis system             |
| c <sub>z,UCS</sub>  | Centroid coordinate in Z-direction of Input axis system             |
| I <sub>y,LCS</sub>  | Second moment of area about the YLCS axis                           |
| I <sub>z,LCS</sub>  | Second moment of area about the ZLCS axis                           |
| I <sub>yz,LCS</sub> | Product moment of area in the LCS system                            |

#### Explanations of symbols

|                   |                                                    |
|-------------------|----------------------------------------------------|
| α                 | Rotation angle of the principal axis system        |
| I <sub>y</sub>    | Second moment of area about the principal y-axis   |
| I <sub>z</sub>    | Second moment of area about the principal z-axis   |
| i <sub>y</sub>    | Radius of gyration about the principal y-axis      |
| i <sub>z</sub>    | Radius of gyration about the principal z-axis      |
| W <sub>el,y</sub> | Elastic section modulus about the principal y-axis |
| W <sub>el,z</sub> | Elastic section modulus about the principal z-axis |
| W <sub>pl,y</sub> | Plastic section modulus about the principal y-axis |
| W <sub>pl,z</sub> | Plastic section modulus about the principal z-axis |

| Explanations of symbols |                                                                                                             |
|-------------------------|-------------------------------------------------------------------------------------------------------------|
| $M_{pl.y.+}$            | Plastic moment about the principal y-axis for a positive $M_y$ moment                                       |
| $M_{pl.y.-}$            | Plastic moment about the principal y-axis for a negative $M_y$ moment                                       |
| $M_{pl.z.+}$            | Plastic moment about the principal z-axis for a positive $M_z$ moment                                       |
| $M_{pl.z.-}$            | Plastic moment about the principal z-axis for a negative $M_z$ moment                                       |
| $d_y$                   | Shear center coordinate in principal y-direction measured from the centroid - Calculated by 2D FEM analysis |

| Explanations of symbols |                                                                                                             |
|-------------------------|-------------------------------------------------------------------------------------------------------------|
| $d_z$                   | Shear center coordinate in principal z-direction measured from the centroid - Calculated by 2D FEM analysis |
| $I_t$                   | Torsional constant - Calculated by 2D FEM analysis                                                          |
| $I_w$                   | Warping constant - Calculated by 2D FEM analysis                                                            |
| $\beta_y$               | Mono-symmetry constant about the principal y-axis                                                           |
| $\beta_z$               | Mono-symmetry constant about the principal z-axis                                                           |

## 7.4. Dek eigenschappen

### 7.4.1. Dek eigenschappen - Langsliggers

| Name         | Structural model only | Colour |
|--------------|-----------------------|--------|
| Langsliggers | *                     | ■      |

#### 7.4.1.1. Members

| Name | Cross-section                          | Material                           | Length [m] | Beg. node | End node | Type      |
|------|----------------------------------------|------------------------------------|------------|-----------|----------|-----------|
| B3   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N5        | N552     | beam (80) |
| B4   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N5        | N7       | beam (80) |
| B5   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N7        | N8       | beam (80) |
| B6   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N8        | N9       | beam (80) |
| B7   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N9        | N10      | beam (80) |
| B8   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N10       | N11      | beam (80) |
| B9   | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N12       | N13      | beam (80) |
| B10  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N12       | N14      | beam (80) |
| B11  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N14       | N15      | beam (80) |
| B12  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N15       | N16      | beam (80) |
| B13  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N16       | N17      | beam (80) |
| B14  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N17       | N18      | beam (80) |
| B15  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N19       | N20      | beam (80) |
| B16  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N19       | N21      | beam (80) |
| B17  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N21       | N22      | beam (80) |
| B18  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N22       | N23      | beam (80) |
| B19  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N23       | N24      | beam (80) |
| B20  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N24       | N25      | beam (80) |
| B96  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N11       | N144     | beam (80) |
| B97  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N18       | N145     | beam (80) |
| B98  | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N25       | N146     | beam (80) |
| B101 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N552      | N153     | beam (80) |
| B102 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N13       | N149     | beam (80) |
| B103 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N20       | N150     | beam (80) |
| B169 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N275      | N276     | beam (80) |
| B170 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N275      | N277     | beam (80) |
| B171 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N277      | N278     | beam (80) |
| B172 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N278      | N279     | beam (80) |
| B173 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N279      | N280     | beam (80) |
| B174 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N280      | N281     | beam (80) |
| B175 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N282      | N283     | beam (80) |
| B176 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N282      | N284     | beam (80) |
| B177 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N284      | N285     | beam (80) |
| B178 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N285      | N286     | beam (80) |



Project Drijvende oversteek - Oudega  
Part Bijlage 2 SCIA reken model  
Author &   
Current date 20.07.2023  
Project filename schipperskerk.esa

| Name | Cross-section                          | Material                           | Length [m] | Beg. node | End node | Type      |
|------|----------------------------------------|------------------------------------|------------|-----------|----------|-----------|
| B179 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N286      | N287     | beam (80) |
| B180 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N287      | N288     | beam (80) |
| B181 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N289      | N290     | beam (80) |
| B182 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N289      | N291     | beam (80) |
| B183 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N291      | N292     | beam (80) |
| B184 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N292      | N293     | beam (80) |
| B185 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N293      | N294     | beam (80) |
| B186 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N294      | N295     | beam (80) |
| B212 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N281      | N344     | beam (80) |
| B213 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N288      | N345     | beam (80) |
| B214 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N295      | N346     | beam (80) |
| B217 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N276      | N353     | beam (80) |
| B218 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N283      | N349     | beam (80) |
| B219 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N290      | N350     | beam (80) |
| B226 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N366      | N367     | beam (80) |
| B227 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N366      | N368     | beam (80) |
| B228 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N368      | N369     | beam (80) |
| B229 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N369      | N370     | beam (80) |
| B230 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N370      | N371     | beam (80) |
| B231 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N371      | N372     | beam (80) |
| B232 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N373      | N374     | beam (80) |
| B233 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N373      | N375     | beam (80) |
| B234 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N375      | N376     | beam (80) |
| B235 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N376      | N377     | beam (80) |
| B236 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N377      | N378     | beam (80) |
| B237 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N378      | N379     | beam (80) |
| B238 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N380      | N381     | beam (80) |
| B239 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N380      | N382     | beam (80) |
| B240 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N382      | N383     | beam (80) |
| B241 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N383      | N384     | beam (80) |
| B242 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N384      | N385     | beam (80) |
| B243 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N385      | N386     | beam (80) |
| B269 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N372      | N435     | beam (80) |
| B270 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N379      | N436     | beam (80) |
| B271 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N386      | N437     | beam (80) |
| B274 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N367      | N444     | beam (80) |
| B275 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N374      | N440     | beam (80) |
| B276 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N381      | N441     | beam (80) |
| B374 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N629      | N687     | beam (80) |
| B375 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N629      | N630     | beam (80) |
| B376 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N630      | N631     | beam (80) |
| B377 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N631      | N632     | beam (80) |
| B378 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N632      | N633     | beam (80) |
| B379 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N633      | N634     | beam (80) |
| B380 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N635      | N688     | beam (80) |
| B381 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N635      | N636     | beam (80) |
| B382 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N636      | N637     | beam (80) |
| B383 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N637      | N638     | beam (80) |
| B384 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N638      | N639     | beam (80) |
| B385 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N639      | N640     | beam (80) |
| B386 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.977      | N641      | N689     | beam (80) |
| B387 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N641      | N642     | beam (80) |
| B388 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N642      | N643     | beam (80) |
| B389 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N643      | N644     | beam (80) |
| B390 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N644      | N645     | beam (80) |
| B391 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 2.008      | N645      | N646     | beam (80) |
| B404 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N634      | N681     | beam (80) |
| B405 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N640      | N682     | beam (80) |



| Name | Cross-section                          | Material                           | Length [m] | Beg. node | End node | Type      |
|------|----------------------------------------|------------------------------------|------------|-----------|----------|-----------|
| B406 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N646      | N683     | beam (80) |
| B410 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N687      | N693     | beam (80) |
| B411 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N688      | N694     | beam (80) |
| B412 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 0.050      | N689      | N695     | beam (80) |
| B419 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N710      | N711     | beam (80) |
| B420 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N712      | N713     | beam (80) |
| B422 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N716      | N717     | beam (80) |
| B425 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N710      | N722     | beam (80) |
| B426 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N712      | N723     | beam (80) |
| B428 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N716      | N726     | beam (80) |
| B431 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N729      | N735     | beam (80) |
| B432 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N730      | N736     | beam (80) |
| B434 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N732      | N739     | beam (80) |
| B436 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N729      | N722     | beam (80) |
| B437 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N730      | N723     | beam (80) |
| B439 | CS4-AluProfiel - General cross-section | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 1.980      | N732      | N726     | beam (80) |

#### 7.4.1.2. Hinges

| Name | Member | Position | ux    | uy    | uz    | fix   | f1y   | f1z  |
|------|--------|----------|-------|-------|-------|-------|-------|------|
| H15  | B3     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H16  | B4     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H17  | B5     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H18  | B6     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H19  | B7     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H20  | B8     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H21  | B9     | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H22  | B10    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H23  | B11    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H24  | B12    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H25  | B13    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H26  | B14    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H27  | B15    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H28  | B16    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H29  | B17    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H30  | B18    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H31  | B19    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H32  | B20    | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H44  | B14    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H45  | B3     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H46  | B4     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H47  | B5     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H48  | B6     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H49  | B7     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H50  | B8     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H51  | B9     | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H52  | B10    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H53  | B11    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H54  | B12    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H55  | B13    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H56  | B15    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H57  | B16    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H58  | B17    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H59  | B18    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H60  | B19    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H61  | B20    | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H226 | B169   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H227 | B169   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |

Project Drijvende oversteek - Oudega  
 Part Bijlage 2 SCIA reken model  
 Author [REDACTED] & [REDACTED]  
 Current date 20.07.2023  
 Project filename schipperskerk.esa

| Name | Member | Position | ux    | uy    | uz    | fix   | fiy   | fiz  |
|------|--------|----------|-------|-------|-------|-------|-------|------|
| H228 | B170   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H229 | B170   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H230 | B171   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H231 | B171   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H232 | B172   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H233 | B172   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H234 | B173   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H235 | B173   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H236 | B174   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H237 | B174   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H238 | B175   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H239 | B175   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H240 | B176   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H241 | B176   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H242 | B177   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H243 | B177   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H244 | B178   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H245 | B178   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H246 | B179   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H247 | B179   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H248 | B180   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H249 | B180   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H250 | B181   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H251 | B181   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H252 | B182   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H253 | B182   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H254 | B183   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H255 | B183   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H256 | B184   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H257 | B184   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H258 | B185   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H259 | B185   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H260 | B186   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H261 | B186   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H301 | B226   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H302 | B226   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H303 | B227   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H304 | B227   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H305 | B228   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H306 | B228   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H307 | B229   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H308 | B229   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H309 | B230   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H310 | B230   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H311 | B231   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H312 | B231   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H313 | B232   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H314 | B232   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H315 | B233   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H316 | B233   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H317 | B234   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H318 | B234   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H319 | B235   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H320 | B235   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H321 | B236   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H322 | B236   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H323 | B237   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H324 | B237   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H325 | B238   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |

Project Drijvende oversteek - Oudega  
 Part Bijlage 2 SCIA reken model  
 Author [REDACTED] & [REDACTED]  
 Current date 20.07.2023  
 Project filename schipperskerk.esa

| Name | Member | Position | ux    | uy    | uz    | fix   | fiy   | fiz  |
|------|--------|----------|-------|-------|-------|-------|-------|------|
| H326 | B238   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H327 | B239   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H328 | B239   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H329 | B240   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H330 | B240   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H331 | B241   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H332 | B241   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H333 | B242   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H334 | B242   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H335 | B243   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H336 | B243   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H493 | B374   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H494 | B374   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H495 | B375   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H496 | B375   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H497 | B376   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H498 | B376   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H499 | B377   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H500 | B377   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H501 | B378   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H502 | B378   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H503 | B379   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H504 | B379   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H505 | B380   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H506 | B380   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H507 | B381   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H508 | B381   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H509 | B382   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H510 | B382   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H511 | B383   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H512 | B383   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H513 | B384   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H514 | B384   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H515 | B385   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H516 | B385   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H517 | B386   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H518 | B386   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H519 | B387   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H520 | B387   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H521 | B388   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H522 | B388   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H523 | B389   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H524 | B389   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H525 | B390   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H526 | B390   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H527 | B391   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H528 | B391   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H550 | B419   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H551 | B419   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H552 | B420   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H553 | B420   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H555 | B422   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H556 | B422   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H559 | B425   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H560 | B425   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H561 | B426   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H562 | B426   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H564 | B428   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H565 | B428   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |

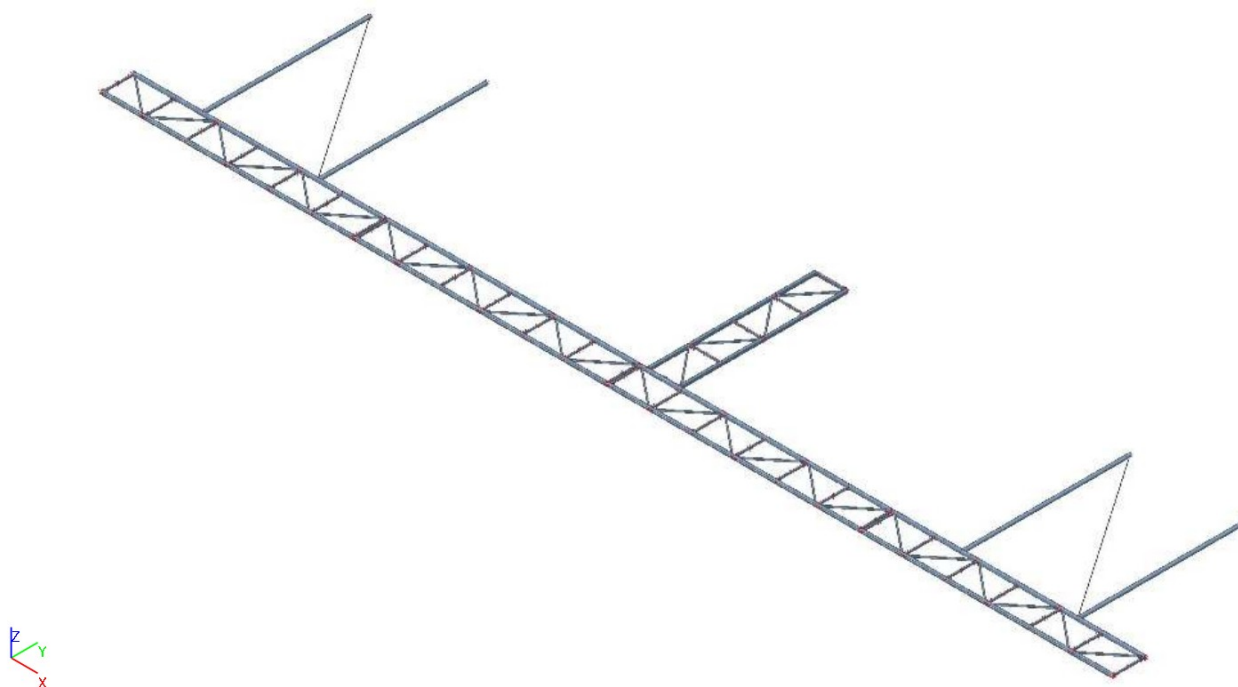
| Name | Member | Position | ux    | uy    | uz    | fix   | fiy   | fiz  |
|------|--------|----------|-------|-------|-------|-------|-------|------|
| H568 | B431   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H569 | B431   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H570 | B432   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H571 | B432   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H573 | B434   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H574 | B434   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H576 | B436   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H577 | B436   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H578 | B437   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H579 | B437   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H581 | B439   | Begin    | Free  | Rigid | Rigid | Rigid | Rigid | Free |
| H582 | B439   | End      | Rigid | Rigid | Rigid | Rigid | Rigid | Free |

#### 7.4.2. Dek eigenschappen - Dekoutline

| Name       | Structural model only | Colour |
|------------|-----------------------|--------|
| Dekoutline | x                     | ■      |

## 8. Steigerframe

### 8.1. Steigerframe



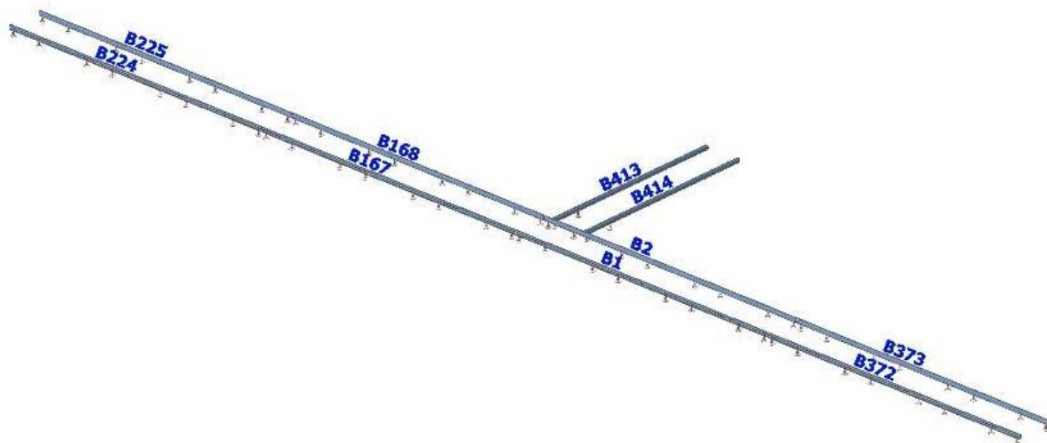
### 8.2. Layers

#### 8.2.1. Layers - Hoofdliggers

| Name         | Structural model only | Colour |
|--------------|-----------------------|--------|
| Hoofdliggers | x                     | ■      |

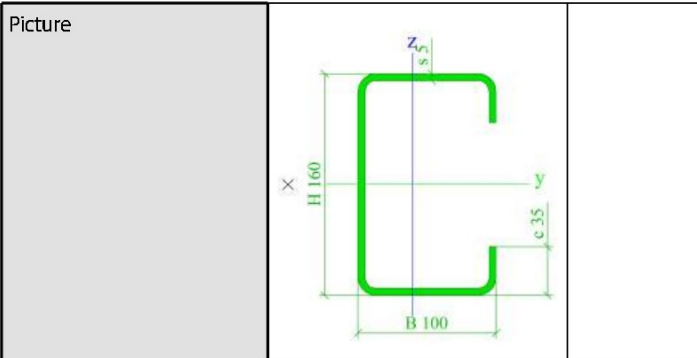


### 8.2.1.1. Staven



### 8.2.1.2. Cross-sections

| CS3                                                                      |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | Cold formed C section                                                               |            |
| Detailed                                                                 | 160; 100; 5; 8; 35                                                                  |            |
| Formcode                                                                 | 114 - Cold formed C section                                                         |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | S 355                                                                               |            |
| Fabrication                                                              | cold formed                                                                         |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | b                                                                                   | b          |
| A [m <sup>2</sup> ]                                                      | 1.9582e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 9.7518e-04                                                                          | 9.1909e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 7.9378e-01                                                                          | 7.9378e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 39                                                                                  | 80         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 7.9386e-06                                                                          | 2.7476e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 64                                                                                  | 37         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 9.9232e-05                                                                          | 4.5105e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.1633e-04                                                                          | 6.5275e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 41298.45                                                                            | 41298.45   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 23172.74                                                                            | 23172.74   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | -89                                                                                 | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 1.7083e-08                                                                          | 1.9857e-08 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 221        |



| Explanations of symbols |                                                                                |
|-------------------------|--------------------------------------------------------------------------------|
| Formcode                | s - Thickness<br>r - Inner radius<br>b - Flange width<br>h - Height<br>c - Lip |
| A                       | Area                                                                           |
| $A_y$                   | Shear Area in principal y-direction                                            |
| $A_z$                   | Shear Area in principal z-direction                                            |
| $A_L$                   | Circumference per unit length                                                  |
| $A_D$                   | Drying surface per unit length                                                 |
| $C_{Y,UCS}$             | Centroid coordinate in Y-direction of Input axis system                        |
| $C_{Z,UCS}$             | Centroid coordinate in Z-direction of Input axis system                        |
| $I_{Y,LCS}$             | Second moment of area about the YLCS axis                                      |
| $I_{Z,LCS}$             | Second moment of area about the ZLCS axis                                      |
| $I_{YZ,LCS}$            | Product moment of area in the LCS system                                       |
| $\alpha$                | Rotation angle of the principal axis system                                    |
| $I_y$                   | Second moment of area about the principal y-axis                               |
| $I_z$                   | Second moment of area about the principal z-axis                               |
| $i_y$                   | Radius of gyration about the principal y-axis                                  |

| Explanations of symbols |                                                                             |
|-------------------------|-----------------------------------------------------------------------------|
| $i_z$                   | Radius of gyration about the principal z-axis                               |
| $W_{el,y}$              | Elastic section modulus about the principal y-axis                          |
| $W_{el,z}$              | Elastic section modulus about the principal z-axis                          |
| $W_{pl,y}$              | Plastic section modulus about the principal y-axis                          |
| $W_{pl,z}$              | Plastic section modulus about the principal z-axis                          |
| $M_{pl,y,+}$            | Plastic moment about the principal y-axis for a positive $M_y$ moment       |
| $M_{pl,y,-}$            | Plastic moment about the principal y-axis for a negative $M_y$ moment       |
| $M_{pl,z,+}$            | Plastic moment about the principal z-axis for a positive $M_z$ moment       |
| $M_{pl,z,-}$            | Plastic moment about the principal z-axis for a negative $M_z$ moment       |
| $d_y$                   | Shear center coordinate in principal y-direction measured from the centroid |
| $d_z$                   | Shear center coordinate in principal z-direction measured from the centroid |
| $I_t$                   | Torsional constant                                                          |
| $I_w$                   | Warping constant                                                            |
| $\beta_y$               | Mono-symmetry constant about the principal y-axis                           |
| $\beta_z$               | Mono-symmetry constant about the principal z-axis                           |

### 8.2.1.3. Members

| Name | Cross-section                                    | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------------------------------------|----------|------------|-----------|----------|-------------|
| B1   | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N155      | N558     | general (0) |
| B2   | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N551      | N557     | general (0) |
| B167 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N355      | N554     | general (0) |
| B168 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N354      | N553     | general (0) |
| B224 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N446      | N549     | general (0) |
| B225 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N545      | N548     | general (0) |
| B372 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N80       | N686     | general (0) |

| Name | Cross-section                                    | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------------------------------------|----------|------------|-----------|----------|-------------|
| B373 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 11.965     | N556      | N685     | general (0) |
| B413 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 8.000      | N699      | N698     | general (0) |
| B414 | CS3 - Cold formed C section (160; 100; 5; 8; 35) | S 355    | 8.000      | N700      | N701     | general (0) |

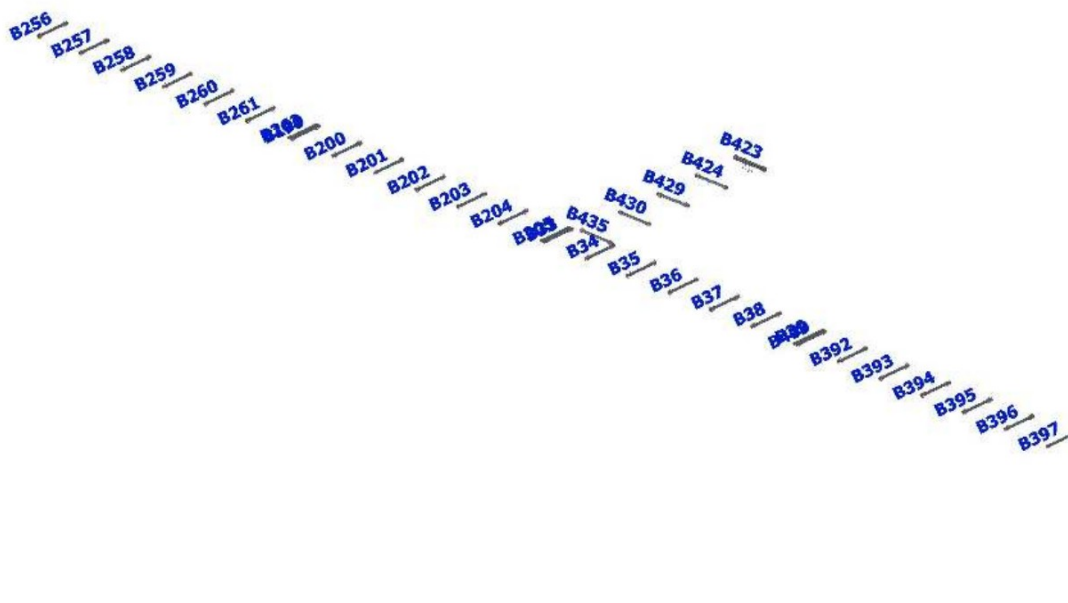
#### 8.2.1.4. Hinges

| Name | Member | Position | ux    | uy    | uz    | fix   | fiy  | fiz  |
|------|--------|----------|-------|-------|-------|-------|------|------|
| H544 | B413   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H545 | B414   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |

### 8.2.2. Layers - Dwarsliggers

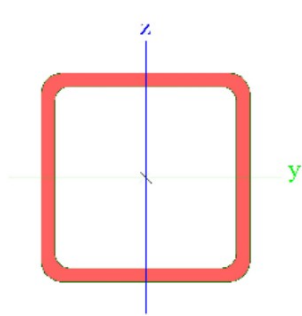
| Name         | Structural model only | Colour                                                                            |
|--------------|-----------------------|-----------------------------------------------------------------------------------|
| Dwarsliggers | x                     |  |

#### 8.2.2.1. Staven

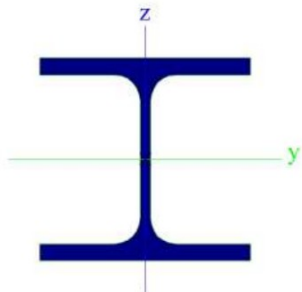


#### 8.2.2.2. Cross-sections

| CS6                                          |                                                                                     |  |            |
|----------------------------------------------|-------------------------------------------------------------------------------------|--|------------|
| Type                                         | SHS60/60/4.0                                                                        |  |            |
| Formcode                                     | 2 - Rectangular hollow section                                                      |  |            |
| Shape type                                   | Thin-walled                                                                         |  |            |
| Item material                                | S 235                                                                               |  |            |
| Fabrication                                  | rolled                                                                              |  |            |
| Colour                                       |  |  |            |
| Flexural buckling y-y,                       | a                                                                                   |  | a          |
| Flexural buckling z-z                        |                                                                                     |  |            |
| A [m²]                                       | 8.7900e-04                                                                          |  |            |
| A <sub>y</sub> [m²], A <sub>z</sub> [m²]     | 3.9281e-04                                                                          |  | 3.9281e-04 |
| A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m] | 2.3000e-01                                                                          |  | 4.3075e-01 |

|                                                            |                                                                                   |            |
|------------------------------------------------------------|-----------------------------------------------------------------------------------|------------|
| $c_{y,UCS}$ [mm], $c_{z,UCS}$ [mm]                         | 30                                                                                | 30         |
| $\alpha$ [deg]                                             | 0.00                                                                              |            |
| $I_y$ [m <sup>4</sup> ], $I_z$ [m <sup>4</sup> ]           | 4.5400e-07                                                                        | 4.5400e-07 |
| $i_y$ [mm], $i_z$ [mm]                                     | 23                                                                                | 23         |
| $W_{el,y}$ [m <sup>3</sup> ], $W_{el,z}$ [m <sup>3</sup> ] | 1.5100e-05                                                                        | 1.5100e-05 |
| $W_{pl,y}$ [m <sup>3</sup> ], $W_{pl,z}$ [m <sup>3</sup> ] | 1.8300e-05                                                                        | 1.8300e-05 |
| $M_{pl,y,+}$ [Nm], $M_{pl,y,-}$ [Nm]                       | 4299.91                                                                           | 4299.91    |
| $M_{pl,z,+}$ [Nm], $M_{pl,z,-}$ [Nm]                       | 4299.91                                                                           | 4299.91    |
| $d_y$ [mm], $d_z$ [mm]                                     | 0                                                                                 | 0          |
| $I_t$ [m <sup>4</sup> ], $I_w$ [m <sup>6</sup> ]           | 7.4149e-07                                                                        | 6.5397e-13 |
| $\beta_y$ [mm], $\beta_z$ [mm]                             | 0                                                                                 | 0          |
| Picture                                                    |  |            |

#### CS14

|                                                            |                                                                                     |            |
|------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                       | HEA100                                                                              |            |
| Formcode                                                   | 1 - I section                                                                       |            |
| Shape type                                                 | Thin-walled                                                                         |            |
| Item material                                              | S 235                                                                               |            |
| Fabrication                                                | rolled                                                                              |            |
| Colour                                                     |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z            | b                                                                                   | c          |
| $A$ [m <sup>2</sup> ]                                      | 2.1200e-03                                                                          |            |
| $A_y$ [m <sup>2</sup> ], $A_z$ [m <sup>2</sup> ]           | 1.4881e-03                                                                          | 4.7795e-04 |
| $A_L$ [m <sup>2</sup> /m], $A_D$ [m <sup>2</sup> /m]       | 5.6100e-01                                                                          | 5.6130e-01 |
| $c_{y,UCS}$ [mm], $c_{z,UCS}$ [mm]                         | 50                                                                                  | 48         |
| $\alpha$ [deg]                                             | 0.00                                                                                |            |
| $I_y$ [m <sup>4</sup> ], $I_z$ [m <sup>4</sup> ]           | 3.4900e-06                                                                          | 1.3400e-06 |
| $i_y$ [mm], $i_z$ [mm]                                     | 41                                                                                  | 25         |
| $W_{el,y}$ [m <sup>3</sup> ], $W_{el,z}$ [m <sup>3</sup> ] | 7.2800e-05                                                                          | 2.6800e-05 |
| $W_{pl,y}$ [m <sup>3</sup> ], $W_{pl,z}$ [m <sup>3</sup> ] | 8.2917e-05                                                                          | 4.1125e-05 |
| $M_{pl,y,+}$ [Nm], $M_{pl,y,-}$ [Nm]                       | 19527.28                                                                            | 19527.28   |
| $M_{pl,z,+}$ [Nm], $M_{pl,z,-}$ [Nm]                       | 9671.68                                                                             | 9671.68    |
| $d_y$ [mm], $d_z$ [mm]                                     | 0                                                                                   | 0          |
| $I_t$ [m <sup>4</sup> ], $I_w$ [m <sup>6</sup> ]           | 5.2084e-08                                                                          | 2.4750e-09 |
| $\beta_y$ [mm], $\beta_z$ [mm]                             | 0                                                                                   | 0          |
| Picture                                                    |  |            |

#### Explanations of symbols

|          |                                                              |
|----------|--------------------------------------------------------------|
| Formcode | h - Height<br>b - Width<br>s - Thickness<br>r - Outer radius |
|----------|--------------------------------------------------------------|

#### Explanations of symbols

|       |                                       |
|-------|---------------------------------------|
|       | r1 - Inner radius                     |
| A     | Area                                  |
| $A_y$ | Shear Area in principal y-direction - |



| Explanations of symbols |                                                                     |
|-------------------------|---------------------------------------------------------------------|
|                         | Calculated by 2D FEM analysis                                       |
| $A_z$                   | Shear Area in principal z-direction - Calculated by 2D FEM analysis |
| $A_L$                   | Circumference per unit length                                       |
| $A_D$                   | Drying surface per unit length                                      |
| $C_{Y,UCS}$             | Centroid coordinate in Y-direction of Input axis system             |
| $C_{Z,UCS}$             | Centroid coordinate in Z-direction of Input axis system             |
| $I_{Y,LCS}$             | Second moment of area about the YLCS axis                           |
| $I_{Z,LCS}$             | Second moment of area about the ZLCS axis                           |
| $I_{YZ,LCS}$            | Product moment of area in the LCS system                            |
| $\alpha$                | Rotation angle of the principal axis system                         |
| $I_y$                   | Second moment of area about the principal y-axis                    |
| $I_z$                   | Second moment of area about the principal z-axis                    |
| $i_y$                   | Radius of gyration about the principal y-axis                       |
| $i_z$                   | Radius of gyration about the principal z-axis                       |
| $W_{el,y}$              | Elastic section modulus about the principal y-axis                  |

| Explanations of symbols |                                                                                                             |
|-------------------------|-------------------------------------------------------------------------------------------------------------|
| $W_{el,z}$              | Elastic section modulus about the principal z-axis                                                          |
| $W_{pl,y}$              | Plastic section modulus about the principal y-axis                                                          |
| $W_{pl,z}$              | Plastic section modulus about the principal z-axis                                                          |
| $M_{pl,y,+}$            | Plastic moment about the principal y-axis for a positive $M_y$ moment                                       |
| $M_{pl,y,-}$            | Plastic moment about the principal y-axis for a negative $M_y$ moment                                       |
| $M_{pl,z,+}$            | Plastic moment about the principal z-axis for a positive $M_z$ moment                                       |
| $M_{pl,z,-}$            | Plastic moment about the principal z-axis for a negative $M_z$ moment                                       |
| $d_y$                   | Shear center coordinate in principal y-direction measured from the centroid - Calculated by 2D FEM analysis |
| $d_z$                   | Shear center coordinate in principal z-direction measured from the centroid - Calculated by 2D FEM analysis |
| $I_t$                   | Torsional constant - Calculated by 2D FEM analysis                                                          |
| $I_w$                   | Warping constant - Calculated by 2D FEM analysis                                                            |
| $\beta_y$               | Mono-symmetry constant about the principal y-axis                                                           |
| $\beta_z$               | Mono-symmetry constant about the principal z-axis                                                           |

### 8.2.2.3. Members

| Name | Cross-section      | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------|----------|------------|-----------|----------|-------------|
| B33  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N3        | N1       | general (0) |
| B34  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N40       | N41      | general (0) |
| B35  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N42       | N43      | general (0) |
| B36  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N44       | N45      | general (0) |
| B37  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N46       | N47      | general (0) |
| B38  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N48       | N49      | general (0) |
| B39  | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N4        | N2       | general (0) |
| B199 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N273      | N271     | general (0) |
| B200 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N310      | N311     | general (0) |
| B201 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N312      | N313     | general (0) |
| B202 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N314      | N315     | general (0) |
| B203 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N316      | N317     | general (0) |
| B204 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N318      | N319     | general (0) |
| B205 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N274      | N272     | general (0) |
| B256 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N364      | N362     | general (0) |
| B257 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N401      | N402     | general (0) |
| B258 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N403      | N404     | general (0) |
| B259 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N405      | N406     | general (0) |
| B260 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N407      | N408     | general (0) |
| B261 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N409      | N410     | general (0) |

| Name | Cross-section      | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------|----------|------------|-----------|----------|-------------|
| B262 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N365      | N363     | general (0) |
| B392 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N647      | N648     | general (0) |
| B393 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N649      | N650     | general (0) |
| B394 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N651      | N652     | general (0) |
| B395 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N653      | N654     | general (0) |
| B396 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N655      | N656     | general (0) |
| B397 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N628      | N627     | general (0) |
| B409 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N691      | N692     | general (0) |
| B423 | CS14 - HEA100      | S 235    | 1.500      | N701      | N698     | general (0) |
| B424 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N720      | N721     | general (0) |
| B429 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N727      | N728     | general (0) |
| B430 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N733      | N734     | general (0) |
| B435 | CS6 - SHS60/60/4.0 | S 235    | 1.500      | N740      | N741     | general (0) |

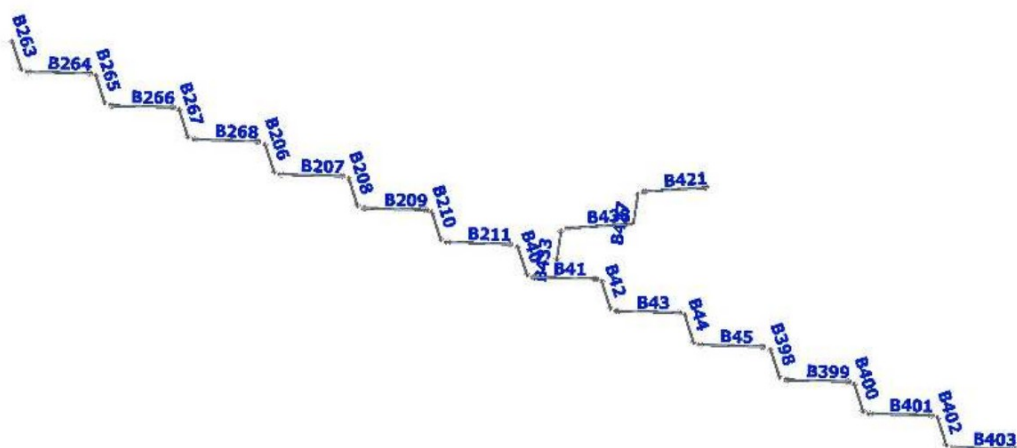
#### 8.2.2.4. Hinges

| Name | Member | Position | ux    | uy    | uz    | fix   | fiy   | fiz  |
|------|--------|----------|-------|-------|-------|-------|-------|------|
| H7   | B38    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H8   | B33    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H9   | B34    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H10  | B35    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H11  | B36    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H12  | B37    | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H13  | B39    | Both     | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H286 | B199   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H287 | B200   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H288 | B201   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H289 | B202   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H290 | B203   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H291 | B204   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H292 | B205   | Both     | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H361 | B256   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H362 | B257   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H363 | B258   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H364 | B259   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H365 | B260   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H366 | B261   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H367 | B262   | Both     | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H529 | B392   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H530 | B393   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H531 | B394   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H532 | B395   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H533 | B396   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H534 | B397   | Both     | Rigid | Rigid | Rigid | Rigid | Rigid | Free |
| H543 | B409   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H557 | B423   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H558 | B424   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H566 | B429   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H567 | B430   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |
| H575 | B435   | Both     | Rigid | Rigid | Rigid | Rigid | Free  | Free |

#### 8.2.3. Layers - Schoorstaven

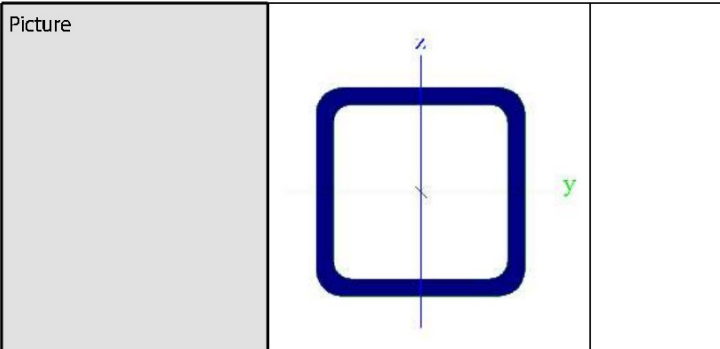
| Name         | Structural model only | Colour |
|--------------|-----------------------|--------|
| Schoorstaven | x                     | ■      |

### 8.2.3.1. Staven



### 8.2.3.2. Cross-sections

| CS5                                                                      |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | SHS60/60/5.0                                                                        |            |
| Formcode                                                                 | 2 - Rectangular hollow section                                                      |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | S 235                                                                               |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | a                                                                                   | a          |
| A [m <sup>2</sup> ]                                                      | 1.0700e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 5.3634e-04                                                                          | 5.3634e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 2.2700e-01                                                                          | 4.1844e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 30                                                                                  | 30         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 5.3300e-07                                                                          | 5.3300e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 22                                                                                  | 22         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.7800e-05                                                                          | 1.7800e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 2.1900e-05                                                                          | 2.1900e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 5141.72                                                                             | 5141.72    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 5141.72                                                                             | 5141.72    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 8.6400e-07                                                                          | 3.2400e-10 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |



| Explanations of symbols |                                                                                   |
|-------------------------|-----------------------------------------------------------------------------------|
| Formcode                | h - Height<br>b - Width<br>s - Thickness<br>r - Outer radius<br>r1 - Inner radius |
| A                       | Area                                                                              |
| A <sub>y</sub>          | Shear Area in principal y-direction                                               |
| A <sub>z</sub>          | Shear Area in principal z-direction                                               |
| A <sub>L</sub>          | Circumference per unit length                                                     |
| A <sub>D</sub>          | Drying surface per unit length                                                    |
| C <sub>y,UCS</sub>      | Centroid coordinate in Y-direction of Input axis system                           |
| C <sub>z,UCS</sub>      | Centroid coordinate in Z-direction of Input axis system                           |
| I <sub>y,LCS</sub>      | Second moment of area about the YLCS axis                                         |
| I <sub>z,LCS</sub>      | Second moment of area about the ZLCS axis                                         |
| I <sub>yz,LCS</sub>     | Product moment of area in the LCS system                                          |
| α                       | Rotation angle of the principal axis system                                       |
| I <sub>y</sub>          | Second moment of area about the principal y-axis                                  |
| I <sub>z</sub>          | Second moment of area about the principal z-axis                                  |
| i <sub>y</sub>          | Radius of gyration about the principal y-axis                                     |

| Explanations of symbols |                                                                                |
|-------------------------|--------------------------------------------------------------------------------|
| i <sub>z</sub>          | Radius of gyration about the principal z-axis                                  |
| W <sub>el,y</sub>       | Elastic section modulus about the principal y-axis                             |
| W <sub>el,z</sub>       | Elastic section modulus about the principal z-axis                             |
| W <sub>pl,y</sub>       | Plastic section modulus about the principal y-axis                             |
| W <sub>pl,z</sub>       | Plastic section modulus about the principal z-axis                             |
| M <sub>pl,y,+</sub>     | Plastic moment about the principal y-axis for a positive M <sub>y</sub> moment |
| M <sub>pl,y,-</sub>     | Plastic moment about the principal y-axis for a negative M <sub>y</sub> moment |
| M <sub>pl,z,+</sub>     | Plastic moment about the principal z-axis for a positive M <sub>z</sub> moment |
| M <sub>pl,z,-</sub>     | Plastic moment about the principal z-axis for a negative M <sub>z</sub> moment |
| d <sub>y</sub>          | Shear center coordinate in principal y-direction measured from the centroid    |
| d <sub>z</sub>          | Shear center coordinate in principal z-direction measured from the centroid    |
| I <sub>t</sub>          | Torsional constant                                                             |
| I <sub>w</sub>          | Warping constant                                                               |
| β <sub>y</sub>          | Mono-symmetry constant about the principal y-axis                              |
| β <sub>z</sub>          | Mono-symmetry constant about the principal z-axis                              |

### 8.2.3.3. Members

| Name | Cross-section      | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------|----------|------------|-----------|----------|-------------|
| B40  | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N50       | N51      | general (0) |
| B41  | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N52       | N53      | general (0) |
| B42  | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N54       | N55      | general (0) |
| B43  | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N56       | N57      | general (0) |
| B44  | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N58       | N59      | general (0) |
| B45  | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N60       | N61      | general (0) |
| B206 | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N320      | N321     | general (0) |



| Name | Cross-section      | Material | Length [m] | Beg. node | End node | Type        |
|------|--------------------|----------|------------|-----------|----------|-------------|
| B207 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N322      | N323     | general (0) |
| B208 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N324      | N325     | general (0) |
| B209 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N326      | N327     | general (0) |
| B210 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N328      | N329     | general (0) |
| B211 | CS5 - SHS60/60/5.0 | S 235    | 2.411      | N330      | N331     | general (0) |
| B263 | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N411      | N412     | general (0) |
| B264 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N413      | N414     | general (0) |
| B265 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N415      | N416     | general (0) |
| B266 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N417      | N418     | general (0) |
| B267 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N419      | N420     | general (0) |
| B268 | CS5 - SHS60/60/5.0 | S 235    | 2.411      | N421      | N422     | general (0) |
| B398 | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N657      | N690     | general (0) |
| B399 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N658      | N659     | general (0) |
| B400 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N660      | N661     | general (0) |
| B401 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N662      | N663     | general (0) |
| B402 | CS5 - SHS60/60/5.0 | S 235    | 2.364      | N664      | N665     | general (0) |
| B403 | CS5 - SHS60/60/5.0 | S 235    | 2.388      | N666      | N667     | general (0) |
| B421 | CS5 - SHS60/60/5.0 | S 235    | 2.390      | N714      | N715     | general (0) |
| B427 | CS5 - SHS60/60/5.0 | S 235    | 2.389      | N724      | N725     | general (0) |
| B433 | CS5 - SHS60/60/5.0 | S 235    | 2.389      | N737      | N738     | general (0) |
| B438 | CS5 - SHS60/60/5.0 | S 235    | 2.389      | N731      | N742     | general (0) |

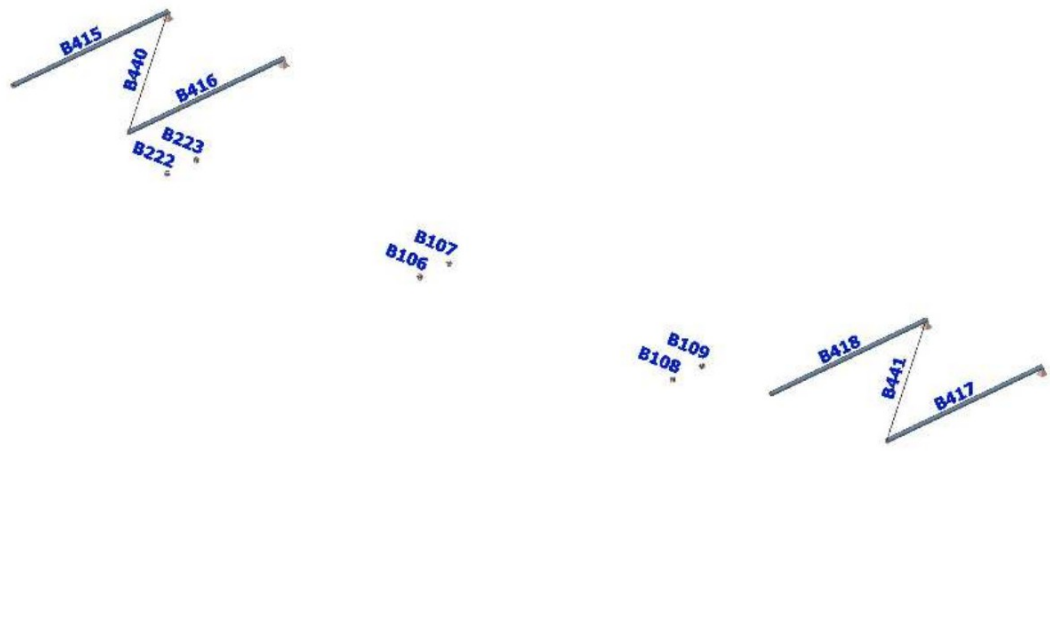
#### 8.2.3.4. Hinges

| Name | Member | Position | ux    | uy    | uz    | fix   | fy   | fz   |
|------|--------|----------|-------|-------|-------|-------|------|------|
| H1   | B42    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H2   | B40    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H3   | B41    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H4   | B43    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H5   | B44    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H6   | B45    | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H293 | B206   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H294 | B207   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H295 | B208   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H296 | B209   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H297 | B210   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H298 | B211   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H368 | B263   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H369 | B264   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H370 | B265   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H371 | B266   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H372 | B267   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H373 | B268   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H535 | B398   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H536 | B399   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H537 | B400   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H538 | B401   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H539 | B402   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H540 | B403   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H554 | B421   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H563 | B427   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H572 | B433   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H580 | B438   | Both     | Rigid | Rigid | Rigid | Rigid | Free | Free |

#### 8.2.4. Layers - Koppelingen

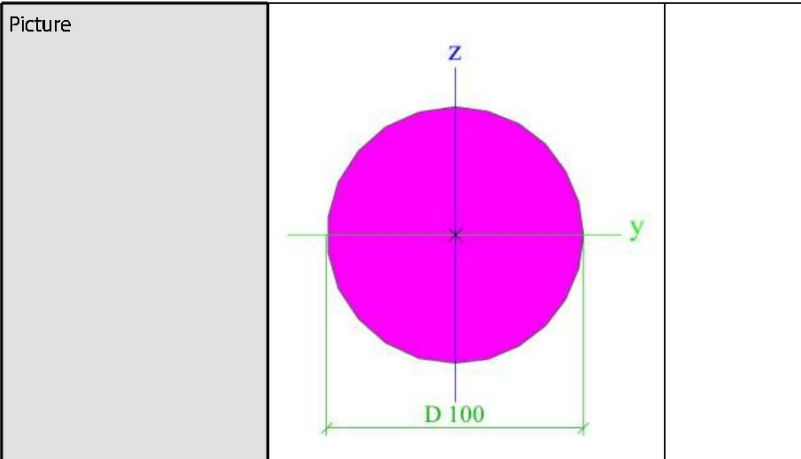
| Name        | Structural model only | Colour |
|-------------|-----------------------|--------|
| Koppelingen | x                     | ■      |

#### 8.2.4.1. Staven



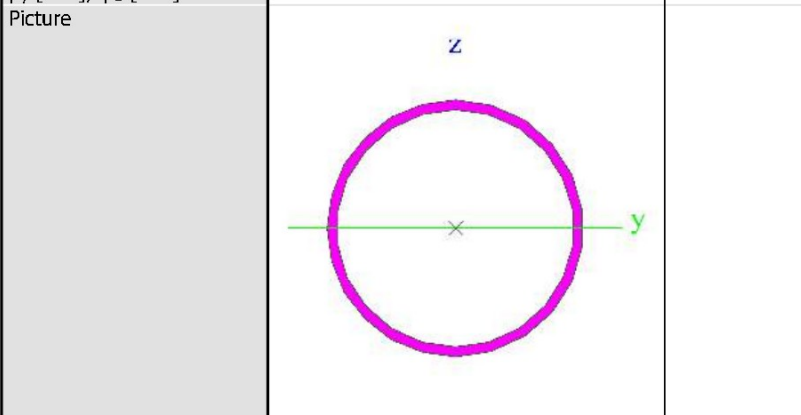
#### 8.2.4.2. Cross-sections

| Dummy                                                                    |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | Full circle                                                                         |            |
| Detailed                                                                 | 100                                                                                 |            |
| Formcode                                                                 | 11 - Full circular section                                                          |            |
| Shape type                                                               | Thick-walled                                                                        |            |
| Item material                                                            | Dummy Koppeling                                                                     |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                          | c                                                                                   | c          |
| A [m <sup>2</sup> ]                                                      | 7.8540e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 6.7325e-03                                                                          | 6.7325e-03 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 3.1414e-01                                                                          | 3.1414e-01 |
| c <sub>y,ucs</sub> [mm], c <sub>z,ucs</sub> [mm]                         | 50                                                                                  | 50         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 4.9087e-06                                                                          | 4.9087e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 25                                                                                  | 25         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 9.8175e-05                                                                          | 9.8175e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.6667e-04                                                                          | 1.6667e-04 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 23326.23                                                                            | 23326.23   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 23326.23                                                                            | 23326.23   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 9.8109e-06                                                                          | 0.0000e+00 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |



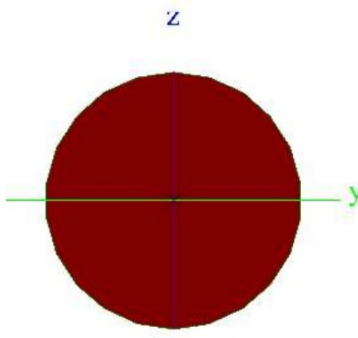
#### CS8

|                                                                          |                                                                                   |            |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------|
| Type                                                                     | CFCHS159X6                                                                        |            |
| Formcode                                                                 | 3 - Circular hollow section                                                       |            |
| Shape type                                                               | Thin-walled                                                                       |            |
| Item material                                                            | EN-AW 6063 (EP,ET,ER/B) T66 (0-10)                                                |            |
| Fabrication                                                              | cold formed                                                                       |            |
| Colour                                                                   |  |            |
| A [m <sup>2</sup> ]                                                      | 2.8840e-03                                                                        |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 1.4457e-03                                                                        | 1.4457e-03 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 5.0000e-01                                                                        | 9.6128e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 80                                                                                | 80         |
| α [deg]                                                                  | 0.00                                                                              |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 8.4519e-06                                                                        | 8.4519e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 54                                                                                | 54         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.0631e-04                                                                        | 1.0631e-04 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 1.4053e-04                                                                        | 1.4053e-04 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 28096.64                                                                          | 28096.64   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 28096.64                                                                          | 28096.64   |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                 | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 1.6904e-05                                                                        | 0.0000e+00 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                 | 0          |



#### CS9

|                                                                    |                                                                                     |            |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                               | RD16                                                                                |            |
| Formcode                                                           | 11 - Full circular section                                                          |            |
| Shape type                                                         | Thick-walled                                                                        |            |
| Item material                                                      | S 235                                                                               |            |
| Fabrication                                                        | rolled                                                                              |            |
| Colour                                                             |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z                    | c                                                                                   | c          |
| A [m <sup>2</sup> ]                                                | 2.0096e-04                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ] | 1.7226e-04                                                                          | 1.7226e-04 |

|                                                            |                                                                                   |            |
|------------------------------------------------------------|-----------------------------------------------------------------------------------|------------|
| $A_L$ [m <sup>2</sup> /m], $A_D$ [m <sup>2</sup> /m]       | 5.0133e-02                                                                        | 5.0263e-02 |
| $c_{y,UCS}$ [mm], $c_{z,UCS}$ [mm]                         | 8                                                                                 | 8          |
| $\alpha$ [deg]                                             | 0.00                                                                              |            |
| $I_y$ [m <sup>4</sup> ], $I_z$ [m <sup>4</sup> ]           | 3.1496e-09                                                                        | 3.1496e-09 |
| $i_y$ [mm], $i_z$ [mm]                                     | 4                                                                                 | 4          |
| $W_{el,y}$ [m <sup>3</sup> ], $W_{el,z}$ [m <sup>3</sup> ] | 3.9370e-07                                                                        | 3.9370e-07 |
| $W_{pl,y}$ [m <sup>3</sup> ], $W_{pl,z}$ [m <sup>3</sup> ] | 6.7190e-07                                                                        | 6.7190e-07 |
| $M_{pl,y,+}$ [Nm], $M_{pl,y,-}$ [Nm]                       | 160.38                                                                            | 160.38     |
| $M_{pl,z,+}$ [Nm], $M_{pl,z,-}$ [Nm]                       | 160.38                                                                            | 160.38     |
| $d_y$ [mm], $d_z$ [mm]                                     | 0                                                                                 | 0          |
| $I_t$ [m <sup>4</sup> ], $I_w$ [m <sup>6</sup> ]           | 6.4299e-09                                                                        | 0.0000e+00 |
| $\beta_y$ [mm], $\beta_z$ [mm]                             | 0                                                                                 | 0          |
| Picture                                                    |  |            |

| Explanations of symbols |                                                                     |
|-------------------------|---------------------------------------------------------------------|
| Formcode                | d - Diameter                                                        |
| A                       | Area                                                                |
| $A_y$                   | Shear Area in principal y-direction - Calculated by 2D FEM analysis |
| $A_z$                   | Shear Area in principal z-direction - Calculated by 2D FEM analysis |
| $A_L$                   | Circumference per unit length                                       |
| $A_D$                   | Drying surface per unit length                                      |
| $c_{y,UCS}$             | Centroid coordinate in Y-direction of Input axis system             |
| $c_{z,UCS}$             | Centroid coordinate in Z-direction of Input axis system             |
| $I_{y,LCS}$             | Second moment of area about the YLCS axis                           |
| $I_{z,LCS}$             | Second moment of area about the ZLCS axis                           |
| $I_{yz,LCS}$            | Product moment of area in the LCS system                            |
| $\alpha$                | Rotation angle of the principal axis system                         |
| $I_y$                   | Second moment of area about the principal y-axis                    |
| $I_z$                   | Second moment of area about the principal z-axis                    |
| $i_y$                   | Radius of gyration about the principal y-axis                       |

| Explanations of symbols |                                                                                                             |
|-------------------------|-------------------------------------------------------------------------------------------------------------|
| $i_z$                   | Radius of gyration about the principal z-axis                                                               |
| $W_{el,y}$              | Elastic section modulus about the principal y-axis                                                          |
| $W_{el,z}$              | Elastic section modulus about the principal z-axis                                                          |
| $W_{pl,y}$              | Plastic section modulus about the principal y-axis                                                          |
| $W_{pl,z}$              | Plastic section modulus about the principal z-axis                                                          |
| $M_{pl,y,+}$            | Plastic moment about the principal y-axis for a positive $M_y$ moment                                       |
| $M_{pl,y,-}$            | Plastic moment about the principal y-axis for a negative $M_y$ moment                                       |
| $M_{pl,z,+}$            | Plastic moment about the principal z-axis for a positive $M_z$ moment                                       |
| $M_{pl,z,-}$            | Plastic moment about the principal z-axis for a negative $M_z$ moment                                       |
| $d_y$                   | Shear center coordinate in principal y-direction measured from the centroid - Calculated by 2D FEM analysis |
| $d_z$                   | Shear center coordinate in principal z-direction measured from the centroid - Calculated by 2D FEM analysis |
| $I_t$                   | Torsional constant - Calculated by 2D FEM analysis                                                          |
| $I_w$                   | Warping constant - Calculated by 2D                                                                         |



| Explanations of symbols |                                                   |
|-------------------------|---------------------------------------------------|
|                         | FEM analysis                                      |
| $\beta_y$               | Mono-symmetry constant about the principal y-axis |
| $\beta_z$               | Mono-symmetry constant about the principal z-axis |

### 8.2.4.3. Members

| Name | Cross-section             | Material                           | Length [m] | Beg. node | End node | Type        |
|------|---------------------------|------------------------------------|------------|-----------|----------|-------------|
| B106 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N155      | N554     | general (0) |
| B107 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N551      | N553     | general (0) |
| B108 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N80       | N558     | general (0) |
| B109 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N556      | N557     | general (0) |
| B222 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N355      | N549     | general (0) |
| B223 | Dummy - Full circle (100) | Dummy Koppeling                    | 0.065      | N547      | N548     | general (0) |
| B415 | CS8 - CFCHS159X6          | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 8.000      | N703      | N702     | general (0) |
| B416 | CS8 - CFCHS159X6          | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 8.000      | N704      | N705     | general (0) |
| B417 | CS8 - CFCHS159X6          | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 8.000      | N708      | N706     | general (0) |
| B418 | CS8 - CFCHS159X6          | EN-AW 6063 (EP,ET,ER/B) T66 (0-10) | 8.000      | N709      | N707     | general (0) |
| B440 | CS9 - RD16                | S 235                              | 9.708      | N702      | N704     | general (0) |
| B441 | CS9 - RD16                | S 235                              | 9.708      | N707      | N708     | general (0) |

### 8.2.4.4. Hinges

| Name | Member | Position | ux    | uy    | uz    | fix   | fiy  | fiz  |
|------|--------|----------|-------|-------|-------|-------|------|------|
| H147 | B106   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H148 | B107   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H149 | B108   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H150 | B109   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H299 | B222   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H300 | B223   | End      | Rigid | Rigid | Rigid | Free  | Free | Free |
| H546 | B415   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H547 | B416   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H548 | B417   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |
| H549 | B418   | Begin    | Rigid | Rigid | Rigid | Rigid | Free | Free |

## 9. Resultaten - Reactie Krachten

### 9.1. Reactions; $R_x$

Values:  $R_x$

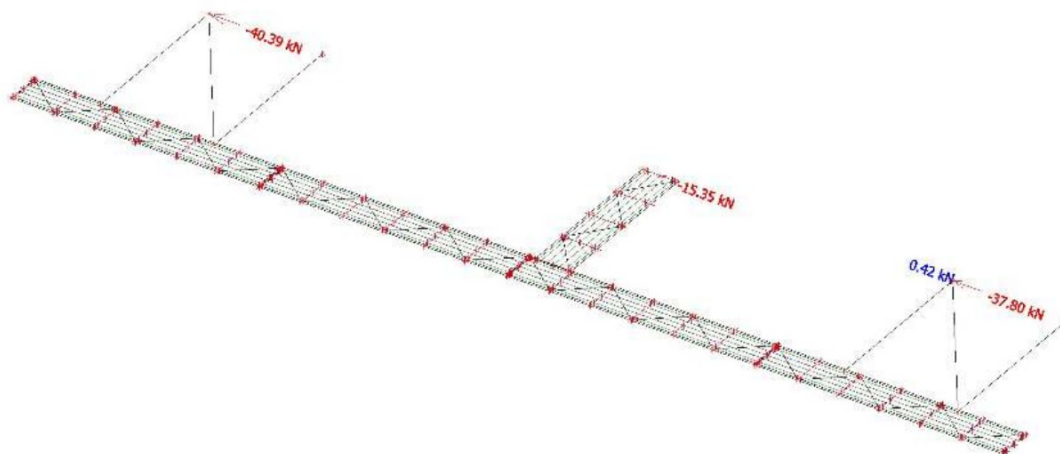
Linear calculation

Class: All ULS

System: Global

Extreme: Member

Selection: All



### 9.2. Reactions; $R_y$

Values:  $R_y$

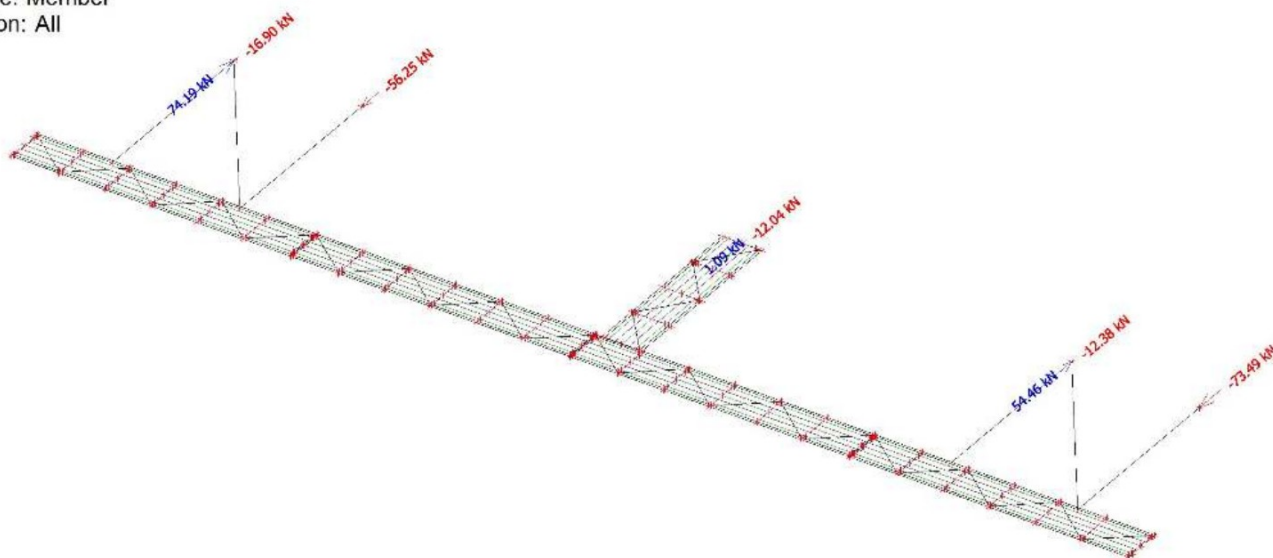
Linear calculation

Class: All ULS

System: Global

Extreme: Member

Selection: All



### 9.3. Reactions; $R_z$

Values:  $R_z$

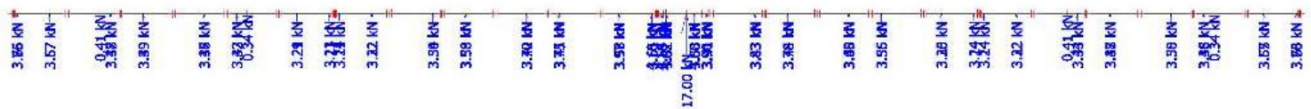
Linear calculation

Class: All ULS

System: Global

Extreme: Member

Selection: All



### 9.4. Reactions; $R_z$

Values:  $R_z$

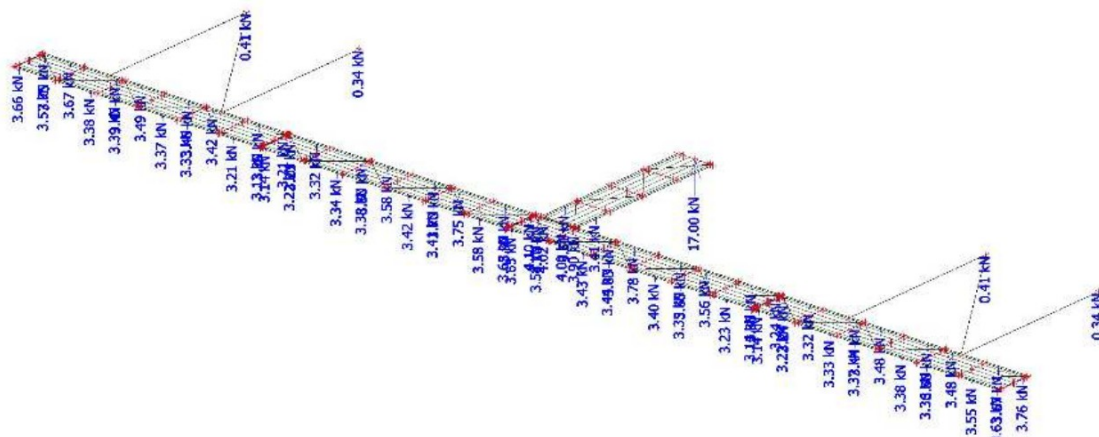
Linear calculation

Class: All ULS

System: Global

Extreme: Member

Selection: All



## 10. Resultaten - Vervormingen

### 10.1. Load cases

#### 10.1.1. Load cases - EG

| Name | Description<br>Spec | Action type<br>Load type | Load group | Direction |
|------|---------------------|--------------------------|------------|-----------|
| EG   | Self Weight         | Permanent<br>Self weight | LG1        | -Z        |

##### 10.1.1.1. 3D displacement; $U_{total}$

Values:  $U_{total}$

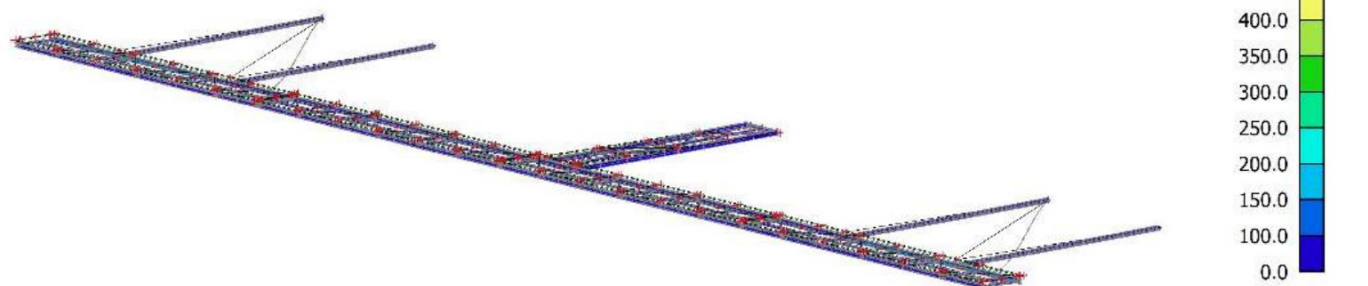
Linear calculation

Load case: EG

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 10.1.2. Load cases - Perm

| Name | Description<br>Spec           | Action type<br>Load type | Load group |
|------|-------------------------------|--------------------------|------------|
| Perm | Eigengewicht dek en bekleding | Permanent                | LG1        |
|      |                               | Standard                 |            |



### 10.1.2.1. 3D displacement; $U_{total}$

Values:  $U_{total}$

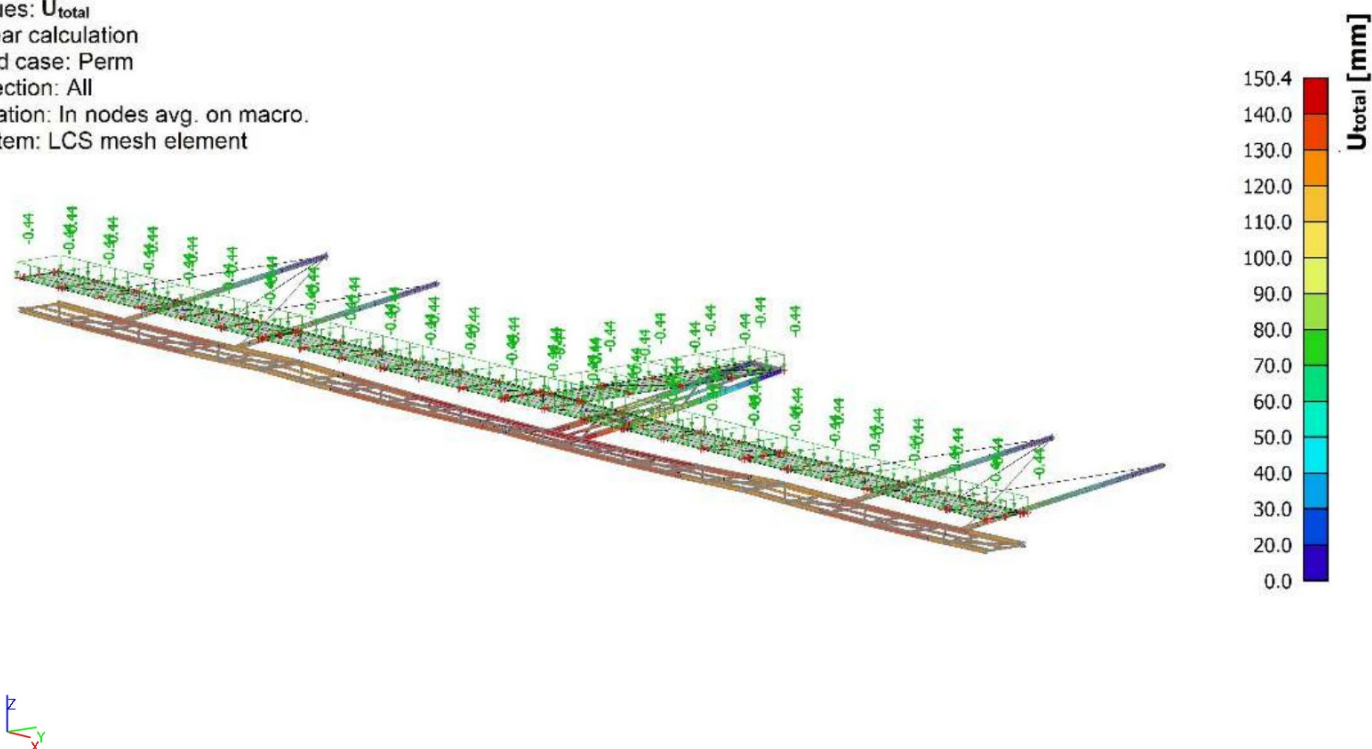
Linear calculation

Load case: Perm

Selection: All

Location: In nodes avg. on macro

System: LCS mesh element



### 10.1.3. Load cases - Qdek-POS0

| Name      | Description   | Action type | Load group | Duration | Master load case |
|-----------|---------------|-------------|------------|----------|------------------|
|           | Spec          | Load type   |            |          |                  |
| Qdek-POS0 | Q-Dek overall | Variable    | LG2 - Dek  | Short    | None             |
|           | Standard      | Static      |            |          |                  |

### 10.1.3.1. 3D displacement; $U_{total}$

Values:  $U_{total}$

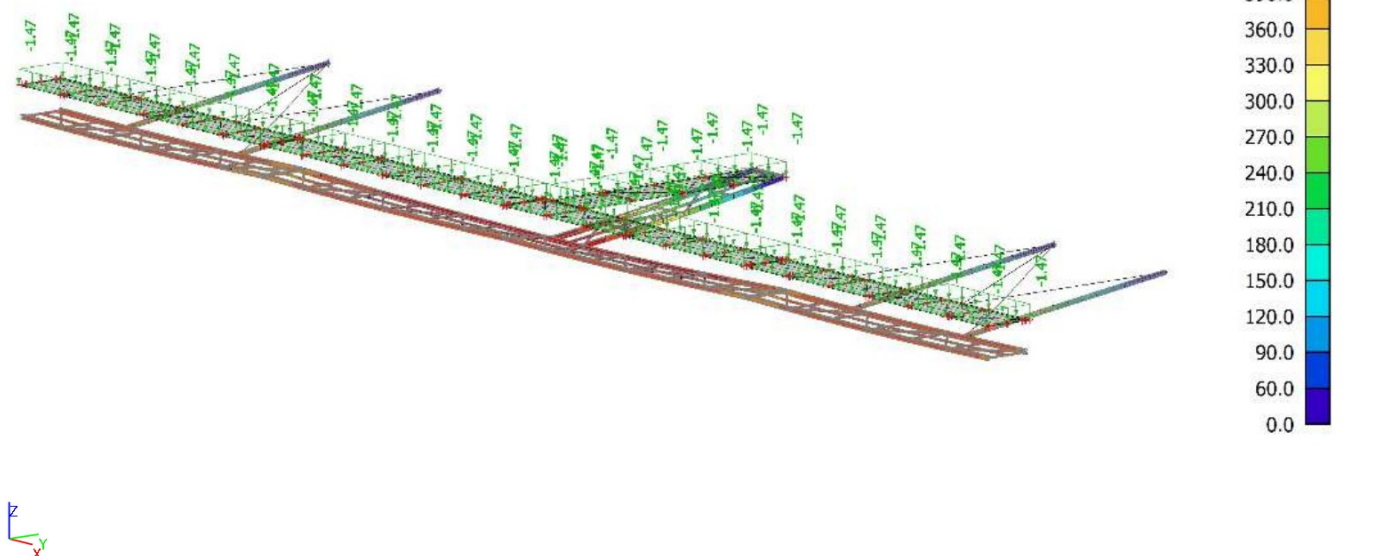
Linear calculation

Load case: Qdek-POS0

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element

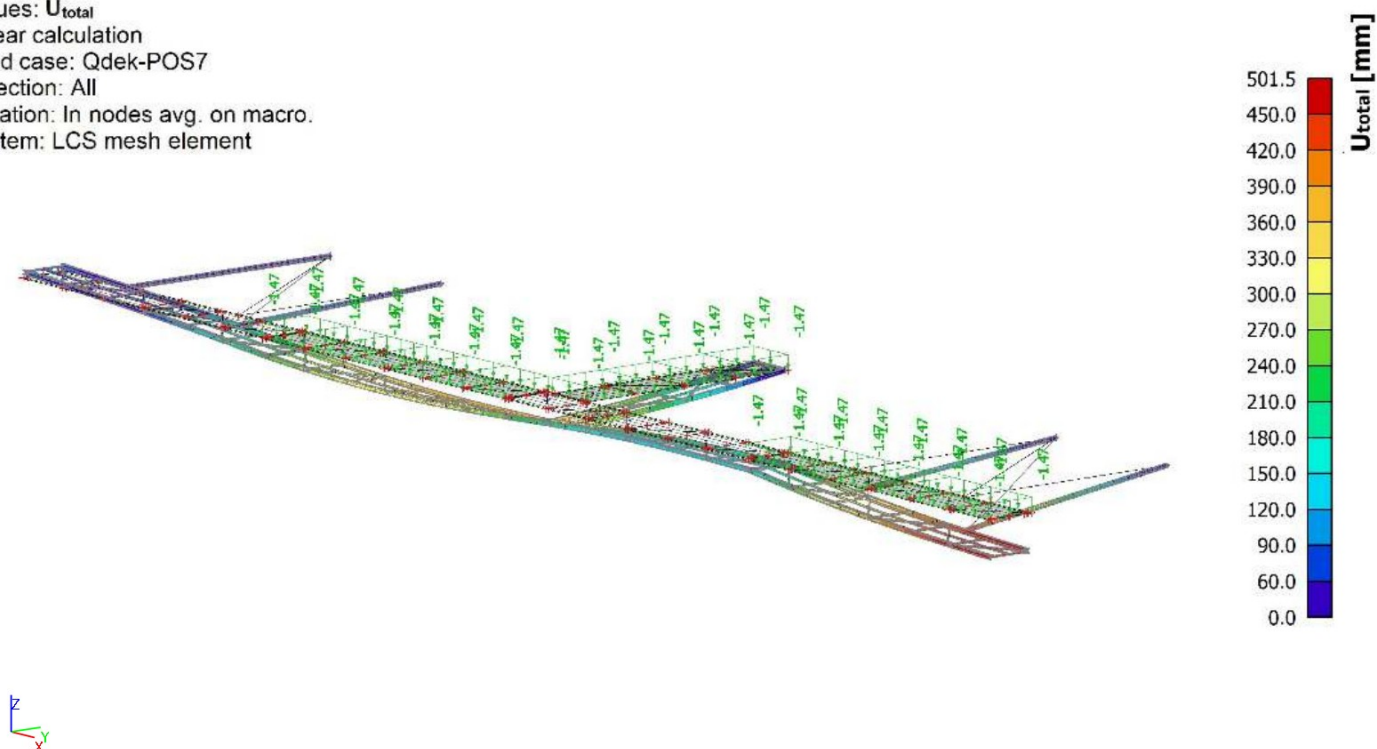


### 10.1.4. Load cases - Qdek-POS7

| Name      | Description<br>Spec | Action type<br>Load type | Load group | Duration | Master load case |
|-----------|---------------------|--------------------------|------------|----------|------------------|
| Qdek-POS7 | Q-Dek-Schaakbord    | Variable                 | LG2 - Dek  | Short    | None             |
|           | Standard            | Static                   |            |          |                  |

#### 10.1.4.1. 3D displacement; $U_{total}$

Values:  $U_{total}$   
 Linear calculation  
 Load case: Qdek-POS7  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



#### 10.1.5. Load cases - Qdek-POS8

| Name      | Description<br>Spec | Action type<br>Load type | Load group | Duration | Master load case |
|-----------|---------------------|--------------------------|------------|----------|------------------|
| Qdek-POS8 | Q-Dek-Schaakbord    | Variable                 | LG2 - Dek  | Short    | None             |
|           | Standard            | Static                   |            |          |                  |

### 10.1.5.1. 3D displacement; $U_{total}$

Values:  $U_{total}$

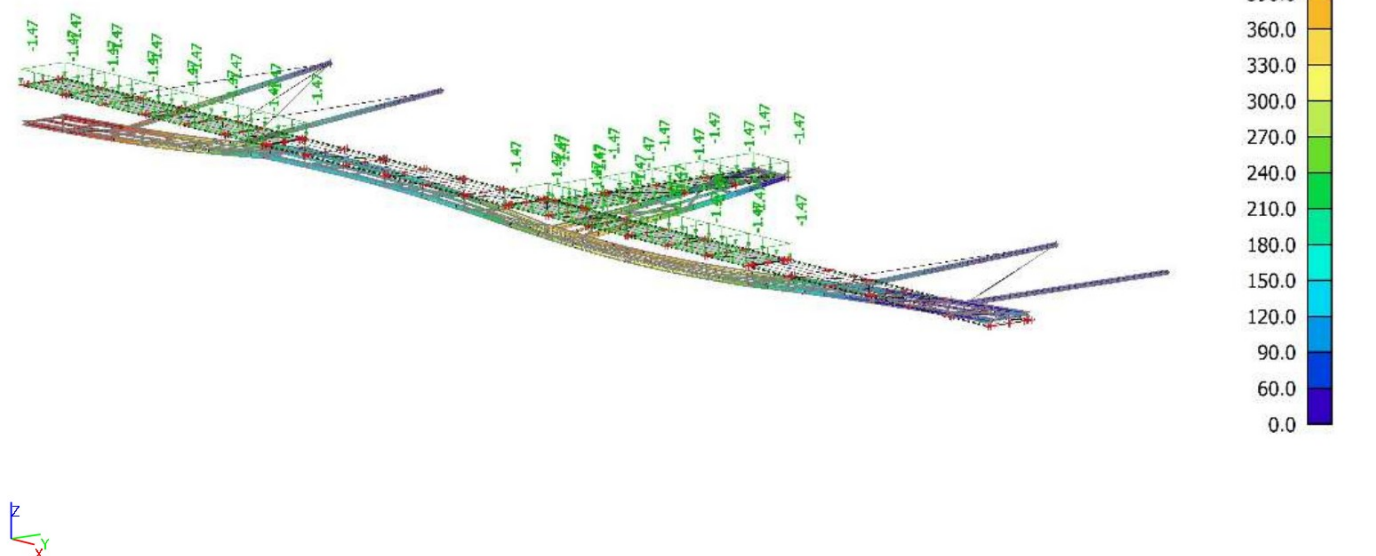
Linear calculation

Load case: Qdek-POS8

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 10.1.6. Load cases - Qdek-POS9

| Name      | Description<br>Spec | Action type<br>Load type | Load group | Duration | Master load case |
|-----------|---------------------|--------------------------|------------|----------|------------------|
| Qdek-POS9 | Q-Dek-Schaakbord    | Variable                 | LG2 - Dek  | Short    | None             |
|           | Standard            | Static                   |            |          |                  |



### 10.1.6.1. 3D displacement; $U_{total}$

Values:  $U_{total}$

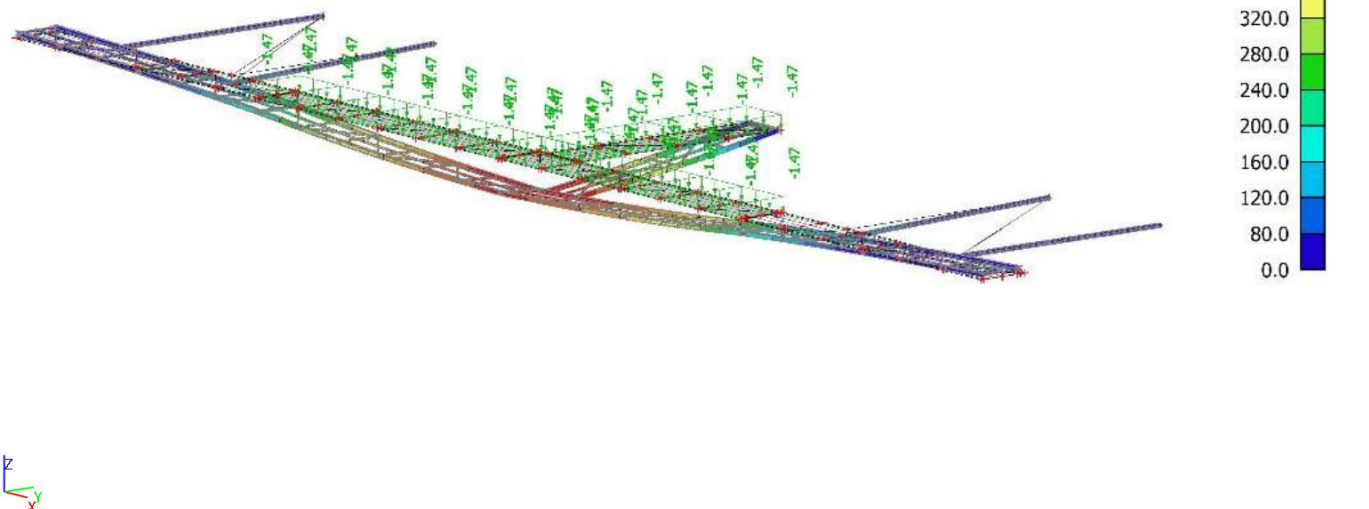
Linear calculation

Load case: Qdek-POS9

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element

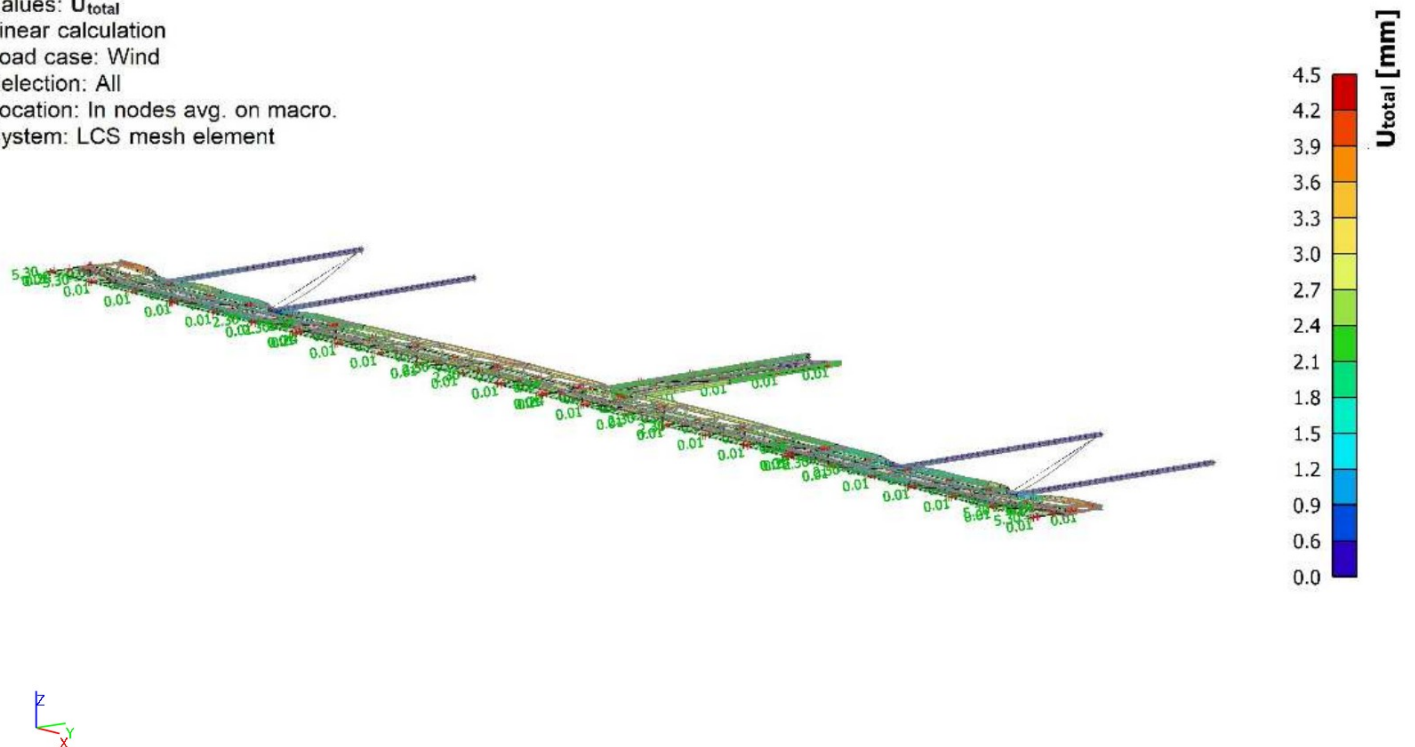


### 10.1.7. Load cases - Wind

| Name | Description<br>Spec  | Action type<br>Load type | Load group | Duration | Master load case |
|------|----------------------|--------------------------|------------|----------|------------------|
| Wind | Wind belasting haaks | Variable                 | LG3 - Wind | Short    | None             |
|      | Standard             | Static                   |            |          |                  |

### 10.1.7.1. 3D displacement; $U_{total}$

Values:  $U_{total}$   
Linear calculation  
Load case: Wind  
Selection: All  
Location: In nodes avg. on macro.  
System: LCS mesh element



## 11. Resultaten - Interne Krachten

### 11.1. Interne krachten

#### 11.1.1. Interne krachten - Hoofdliggers

| Name         | Structural model only | Colour                                                                              |
|--------------|-----------------------|-------------------------------------------------------------------------------------|
| Hoofdliggers | *                     |  |

##### 11.1.1.1. 1D internal forces

Linear calculation  
Class: All ULS  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Layer = Hoofdliggers

| Name | dx [m]  | Case  | N [kN]         | $V_y$ [kN]    | $V_z$ [kN]   | $M_x$ [kNm]  | $M_y$ [kNm]   | $M_z$ [kNm]  |
|------|---------|-------|----------------|---------------|--------------|--------------|---------------|--------------|
| B373 | 8,014+  | C04/1 | <b>-123,50</b> | 10,49         | -0,73        | 0,07         | 1,81          | -1,11        |
| B372 | 9,842+  | C04/1 | <b>104,42</b>  | -8,02         | 0,17         | -0,07        | -1,33         | 5,38         |
| B224 | 1,730+  | C04/1 | -18,65         | <b>-66,29</b> | -1,25        | 0,00         | -0,99         | 8,39         |
| B2   | 1,830+  | C04/1 | 28,78          | <b>58,55</b>  | 0,71         | 0,00         | 1,52          | <b>-9,94</b> |
| B413 | 8,000   | C03/2 | 0,00           | 0,00          | <b>-6,67</b> | 0,00         | 0,20          | 0,00         |
| B2   | 0,150+  | C07/3 | -0,96          | 1,72          | <b>7,30</b>  | -0,01        | 2,07          | 0,20         |
| B225 | 11,901+ | C03/4 | 0,00           | 0,00          | 0,34         | <b>-0,10</b> | 0,24          | 0,00         |
| B225 | 8,014+  | C03/4 | 0,00           | 0,00          | -0,72        | <b>0,08</b>  | 2,29          | 0,00         |
| B1   | 5,968-  | C07/3 | -2,17          | 0,30          | -2,27        | 0,01         | <b>-13,65</b> | -0,17        |
| B413 | 4,040+  | C03/5 | -11,45         | 0,30          | -1,65        | 0,00         | <b>16,38</b>  | -0,02        |
| B2   | 0,330-  | C04/1 | 16,21          | 57,45         | 1,16         | 0,00         | 0,47          | <b>14,72</b> |

| Name  | Combination key                                   |
|-------|---------------------------------------------------|
| C04/1 | 1.10*EG + 1.10*Perm + 1.35*Wind1                  |
| C03/2 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS6              |
| C07/3 | 1.10*EG + 1.10*Perm + 0.41*Wind + 1.20*Qdek-POS8  |
| C03/4 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS4              |
| C03/5 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS6 + 0.41*Wind1 |

### 11.1.2. Interne krachten - Dwarsliggers

| Name         | Structural model only | Colour                              |
|--------------|-----------------------|-------------------------------------|
| Dwarsliggers | *                     | <span style="color: blue;">■</span> |

#### 11.1.2.1. 1D internal forces

Linear calculation  
Class: All ULS  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Layer = Dwarsliggers

| Name | dx [m] | Case  | N [kN]        | V <sub>y</sub> [kN] | V <sub>z</sub> [kN] | M <sub>x</sub> [kNm] | M <sub>y</sub> [kNm] | M <sub>z</sub> [kNm] |
|------|--------|-------|---------------|---------------------|---------------------|----------------------|----------------------|----------------------|
| B397 | 0,000  | C04/1 | <b>-65,60</b> | -0,02               | 0,57                | -0,15                | -0,09                | 0,00                 |
| B256 | 0,000  | C04/1 | <b>66,29</b>  | -0,02               | 0,51                | 0,12                 | 0,00                 | 0,00                 |
| B423 | 0,750+ | C04/2 | 0,02          | <b>6,01</b>         | 2,51                | -0,01                | -1,78                | -4,51                |
| B423 | 0,750- | C03/3 | 0,05          | -1,80               | <b>-7,87</b>        | 0,05                 | -5,64                | -1,35                |
| B205 | 0,000  | C03/4 | 1,89          | 0,00                | 1,95                | <b>-1,56</b>         | -0,02                | 0,00                 |
| B35  | 0,000  | C03/5 | 0,00          | 0,00                | 2,45                | <b>1,15</b>          | 0,00                 | 0,00                 |
| B423 | 0,750+ | C03/6 | 0,00          | 0,00                | <b>7,98</b>         | -0,03                | <b>-5,74</b>         | 0,00                 |
| B424 | 0,750- | C03/7 | 0,00          | 0,00                | 1,99                | -0,02                | <b>1,60</b>          | 0,00                 |
| B423 | 0,750- | C04/2 | 0,17          | <b>-6,01</b>        | -2,52               | 0,01                 | -1,79                | <b>-4,51</b>         |
| B423 | 0,750- | C04/1 | 15,72         | 0,55                | -2,52               | 0,01                 | -1,79                | <b>0,41</b>          |

| Name  | Combination key                                  |
|-------|--------------------------------------------------|
| C04/1 | 1.10*EG + 1.10*Perm + 1.35*Wind1                 |
| C04/2 | 1.10*EG + 1.10*Perm + 1.35*Wind                  |
| C03/3 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS3 + 0.41*Wind |
| C03/4 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS6 + 0.41*Wind |
| C03/5 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS3             |
| C03/6 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS6             |
| C03/7 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS1             |

### 11.1.3. Interne krachten - Schoorstaven

| Name         | Structural model only | Colour                                 |
|--------------|-----------------------|----------------------------------------|
| Schoorstaven | *                     | <span style="color: magenta;">■</span> |

#### 11.1.3.1. 1D internal forces

Linear calculation  
Class: All ULS  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Layer = Schoorstaven

| Name | dx<br>[m] | Case  | N<br>[kN]      | V <sub>y</sub><br>[kN] | V <sub>z</sub><br>[kN] | M <sub>x</sub><br>[kNm] | M <sub>y</sub><br>[kNm] | M <sub>z</sub><br>[kNm] |
|------|-----------|-------|----------------|------------------------|------------------------|-------------------------|-------------------------|-------------------------|
| B263 | 0,000     | C04/1 | <b>-108,90</b> | 0,00                   | 0,11                   | 0,00                    | 0,00                    | 0,00                    |
| B403 | 0,000     | C04/1 | <b>110,21</b>  | <b>0,00</b>            | 0,11                   | -0,08                   | 0,00                    | <b>0,00</b>             |
| B211 | 2,411     | C04/1 | -31,71         | 0,00                   | <b>-0,11</b>           | -0,01                   | 0,00                    | 0,00                    |
| B211 | 0,000     | C03/2 | 0,00           | 0,00                   | <b>0,11</b>            | -0,04                   | 0,00                    | 0,00                    |
| B267 | 0,000     | C03/3 | 0,00           | 0,00                   | 0,11                   | <b>-0,10</b>            | 0,00                    | 0,00                    |
| B42  | 0,000     | C03/4 | 0,00           | 0,00                   | 0,11                   | <b>0,03</b>             | 0,00                    | 0,00                    |
| B438 | 2,389     | C07/5 | 0,00           | 0,00                   | -0,11                  | 0,00                    | <b>0,00</b>             | 0,00                    |
| B421 | 1,195     | C04/1 | -25,44         | 0,00                   | 0,00                   | 0,00                    | <b>0,06</b>             | 0,00                    |

| Name  | Combination key                      |
|-------|--------------------------------------|
| C04/1 | 1.10*EG + 1.10*Perm + 1.35*Wind1     |
| C03/2 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS6 |
| C03/3 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS4 |
| C03/4 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS5 |
| C07/5 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS9 |

#### 11.1.4. Interne krachten - Langsliggers

| Name         | Structural model only | Colour                             |
|--------------|-----------------------|------------------------------------|
| Langsliggers | *                     | <span style="color: red;">■</span> |

##### 11.1.4.1. 1D internal forces

Linear calculation  
Class: All ULS  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Layer = Langsliggers

| Name | dx<br>[m] | Case  | N<br>[kN]    | V <sub>y</sub><br>[kN] | V <sub>z</sub><br>[kN] | M <sub>x</sub><br>[kNm] | M <sub>y</sub><br>[kNm] | M <sub>z</sub><br>[kNm] |
|------|-----------|-------|--------------|------------------------|------------------------|-------------------------|-------------------------|-------------------------|
| B14  | 2,008     | C04/1 | <b>-0,02</b> | 0,00                   | -0,29                  | 0,00                    | -0,08                   | 0,00                    |
| B426 | 1,980     | C04/2 | <b>0,02</b>  | 0,00                   | -0,29                  | 0,00                    | -0,04                   | 0,00                    |
| B237 | 0,000     | C04/3 | 0,00         | <b>-0,01</b>           | 1,51                   | 0,00                    | -0,64                   | 0,00                    |
| B237 | 2,008     | C04/3 | 0,00         | <b>0,01</b>            | -1,49                  | 0,00                    | -0,62                   | 0,00                    |
| B178 | 1,980     | C03/4 | 0,00         | 0,01                   | <b>-1,80</b>           | 0,00                    | -0,74                   | 0,00                    |
| B420 | 0,000     | C03/5 | 0,00         | 0,00                   | <b>2,16</b>            | -0,01                   | -0,95                   | 0,00                    |
| B231 | 0,000     | C03/6 | 0,00         | 0,00                   | 0,30                   | <b>-0,06</b>            | -0,11                   | 0,00                    |
| B186 | 0,000     | C03/7 | 0,00         | 0,00                   | 0,31                   | <b>0,08</b>             | -0,13                   | 0,00                    |
| B420 | 0,000     | C03/8 | 0,00         | -0,01                  | 2,16                   | -0,01                   | <b>-0,95</b>            | 0,00                    |
| B420 | 0,990+    | C03/5 | 0,00         | 0,00                   | -1,14                  | -0,01                   | <b>1,04</b>             | 0,00                    |
| B237 | 1,004-    | C04/3 | 0,00         | 0,00                   | 1,21                   | 0,00                    | 0,72                    | <b>-0,01</b>            |
| B175 | 0,989-    | C08/9 | 0,00         | 0,00                   | 0,03                   | 0,02                    | 0,04                    | <b>0,00</b>             |

| Name  | Combination key                                   |
|-------|---------------------------------------------------|
| C04/1 | 1.10*EG + 1.10*Perm + 1.35*Wind1                  |
| C04/2 | 1.10*EG + 1.10*Perm + 1.35*Wind                   |
| C04/3 | 1.10*EG + 1.10*Perm + 0.96*Fdek-POS1 + 1.35*Wind  |
| C03/4 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS2              |
| C03/5 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS1 + 0.41*Wind1 |
| C03/6 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS5 + 0.41*Wind  |
| C03/7 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS5 + 0.41*Wind  |
| C03/8 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS1              |



| Name  | Combination key                                  |
|-------|--------------------------------------------------|
| C08/9 | 1.10*EG + 1.10*Perm + 1.35*Wind + 0.96*Qdek-POS8 |

### 11.1.5. Interne krachten - Koppelingen

| Name        | Structural model only | Colour |
|-------------|-----------------------|--------|
| Koppelingen | x                     | ■      |

#### 11.1.5.1. 1D internal forces

Linear calculation

Class: All ULS

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Layer = Koppelingen

| Name | dx [m] | Case  | N [kN]        | V <sub>y</sub> [kN] | V <sub>z</sub> [kN] | M <sub>x</sub> [kNm] | M <sub>y</sub> [kNm] | M <sub>z</sub> [kNm] |
|------|--------|-------|---------------|---------------------|---------------------|----------------------|----------------------|----------------------|
| B417 | 0,000  | C04/1 | <b>-73,49</b> | 0,00                | 0,34                | 0,00                 | 0,00                 | 0,00                 |
| B440 | 0,000  | C04/1 | <b>71,29</b>  | 0,00                | 0,09                | 0,00                 | -0,14                | 0,00                 |
| B107 | 0,000  | C04/1 | -30,84        | <b>-12,78</b>       | -0,62               | 0,00                 | 0,04                 | <b>0,83</b>          |
| B107 | 0,000  | C07/2 | -0,73         | -0,14               | <b>-6,40</b>        | 0,00                 | 0,42                 | 0,01                 |
| B441 | 0,000  | C03/3 | 0,00          | 0,00                | 0,09                | <b>0,00</b>          | -0,15                | 0,00                 |
| B106 | 0,000  | C07/4 | 0,00          | 0,00                | <b>3,50</b>         | 0,00                 | <b>-0,23</b>         | 0,00                 |
| B418 | 4,000  | C03/3 | 0,00          | 0,00                | 0,02                | <b>-0,09</b>         | <b>0,73</b>          | 0,00                 |
| B106 | 0,000  | C04/1 | 25,84         | <b>30,72</b>        | 0,00                | 0,00                 | 0,00                 | <b>-2,00</b>         |

| Name  | Combination key                                  |
|-------|--------------------------------------------------|
| C04/1 | 1.10*EG + 1.10*Perm + 1.35*Wind1                 |
| C07/2 | 1.10*EG + 1.10*Perm + 0.41*Wind + 1.20*Qdek-POS8 |
| C03/3 | 1.10*EG + 1.10*Perm + 1.20*Fdek-POS6             |
| C07/4 | 1.10*EG + 1.10*Perm + 1.20*Qdek-POS7             |

### 11.1.6. Interne krachten - Dekoutline

| Name       | Structural model only | Colour |
|------------|-----------------------|--------|
| Dekoutline | x                     | ■      |

#### 11.1.6.1. 1D internal forces

Linear calculation

Class: All ULS

Coordinate system: Principal

Extreme 1D: Global

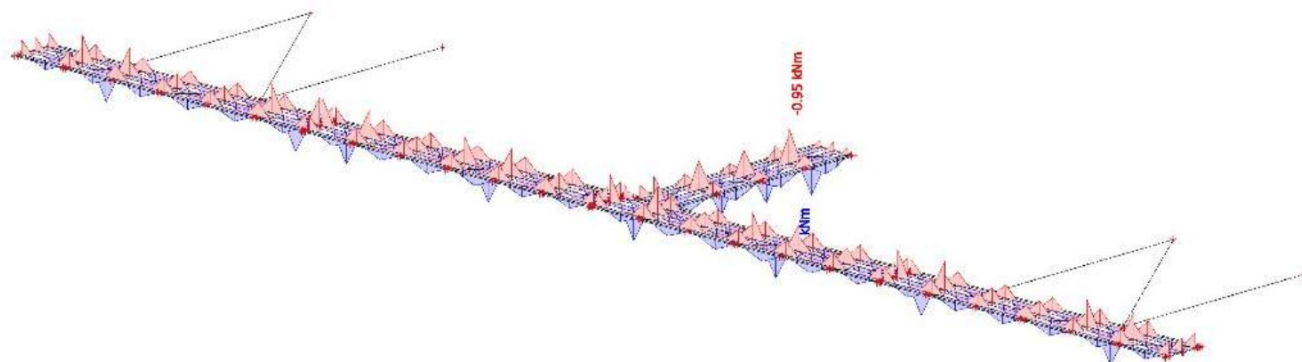
Selection: All

Filter: Layer = Dekoutline

Nothing in selection to display.

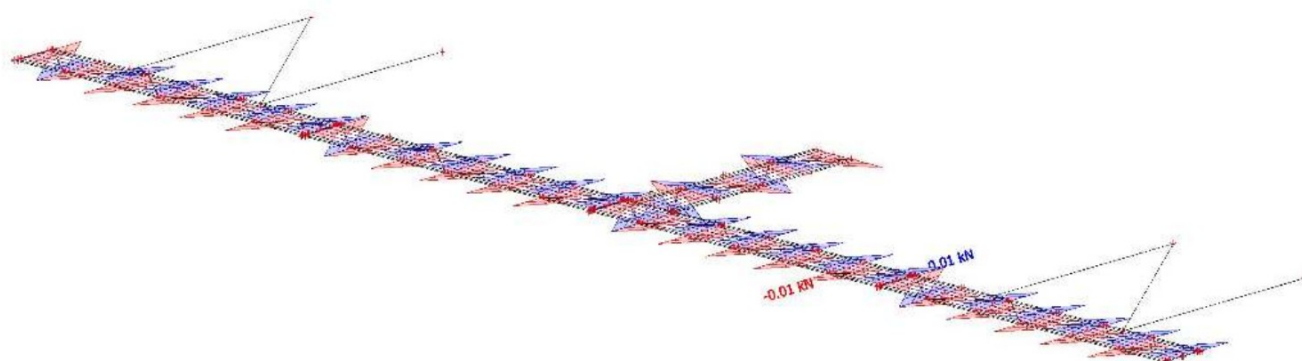
## 11.2. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Langsliggers



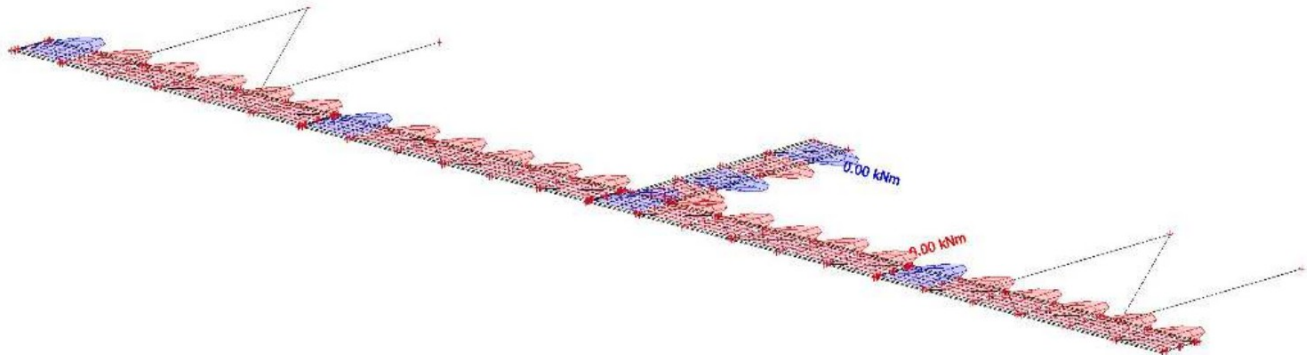
## 11.3. 1D internal forces; $V_y$

Values:  $V_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Langsliggers



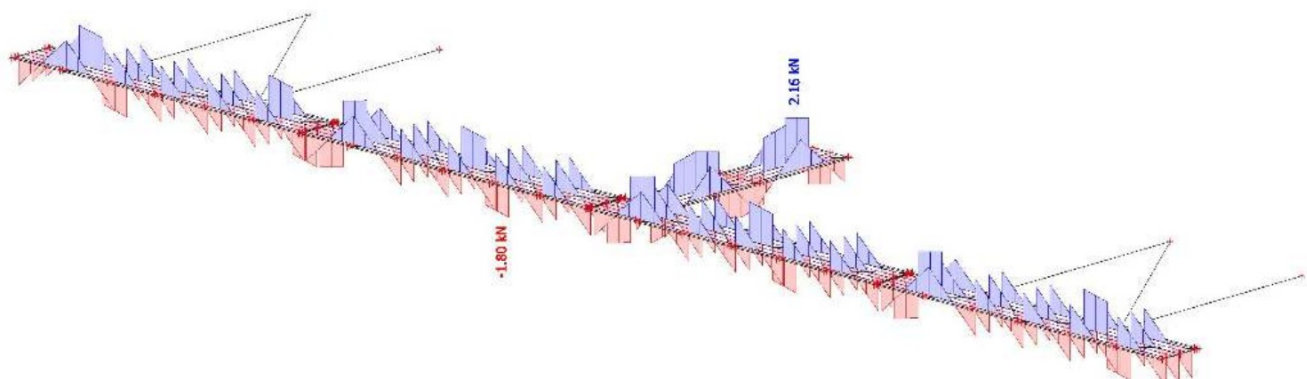
## 11.4. 1D internal forces; $M_z$

Values:  $M_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Langsliggers



## 11.5. 1D internal forces; $V_z$

Values:  $V_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Langsliggers



## 11.6. 1D internal forces; N

Values: N

Linear calculation

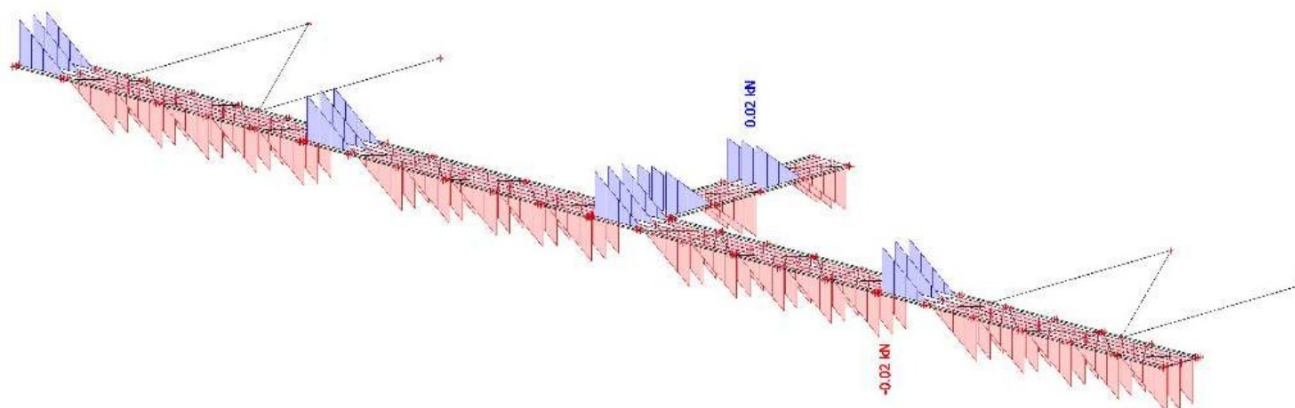
Class: All ULS

Coordinate system: Member

Extreme 1D: Global

Selection: Named selection -

Langsliggers





## 11.7. 1D internal forces; $M_y$

Values:  $M_y$

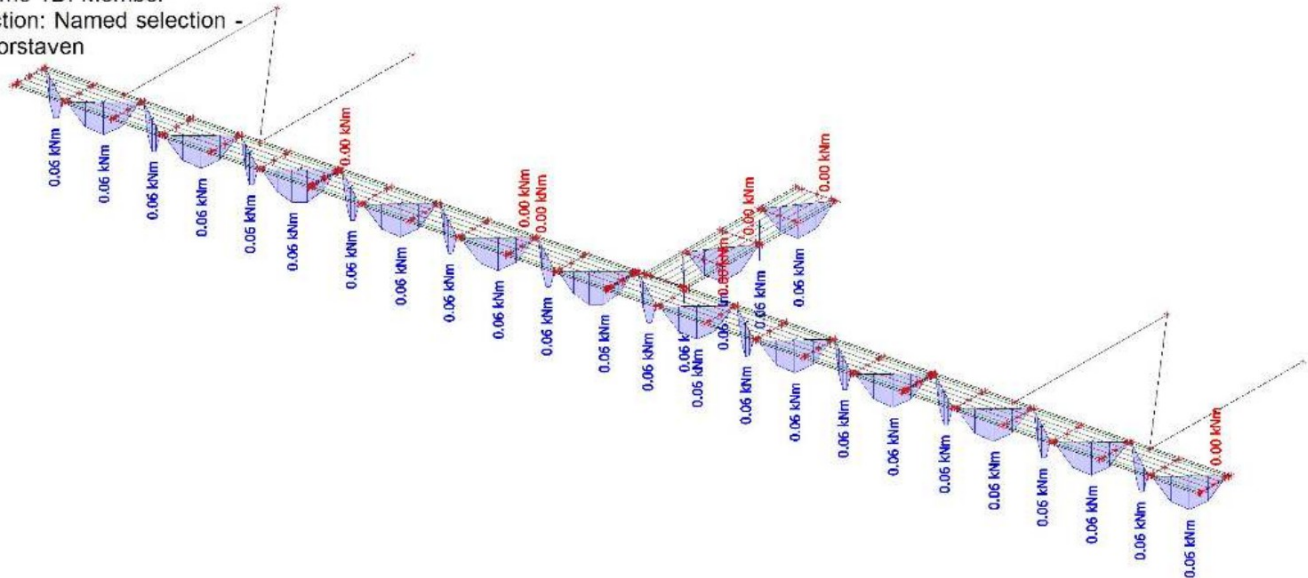
Linear calculation

Class: All ULS

Coordinate system: Member

Extreme 1D: Member

Selection: Named selection -  
Schoorstaven



## 11.8. 1D internal forces; $V_y$

Values:  $V_y$

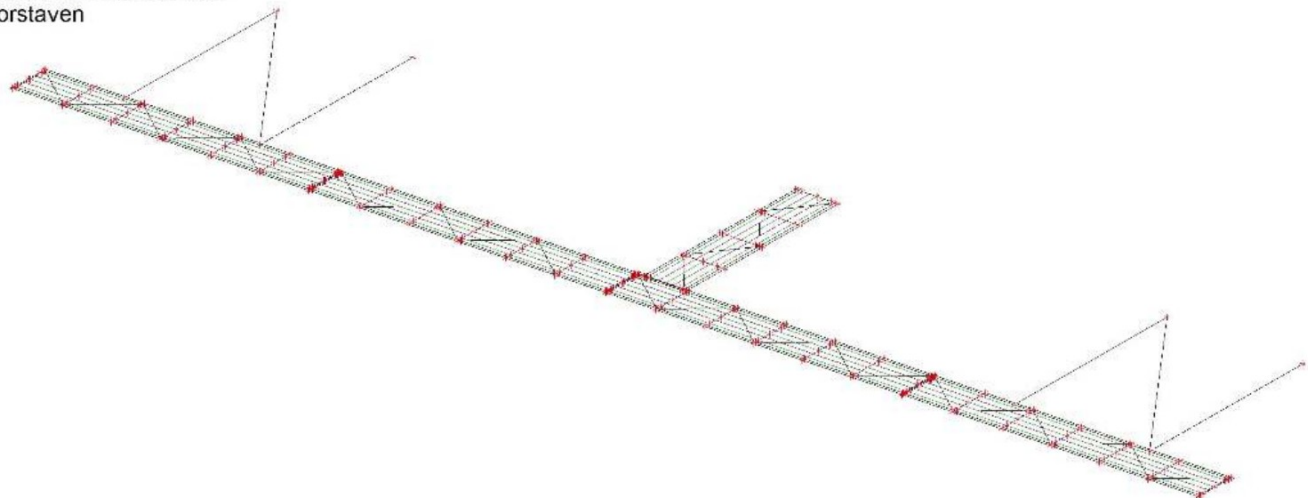
Linear calculation

Class: All ULS

Coordinate system: Member

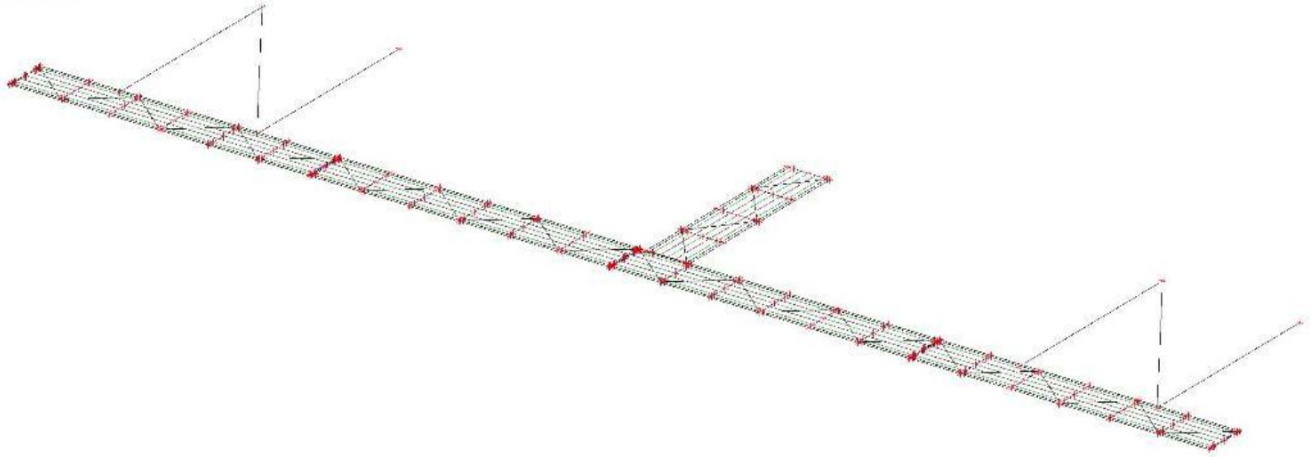
Extreme 1D: Global

Selection: Named selection -  
Schoorstaven



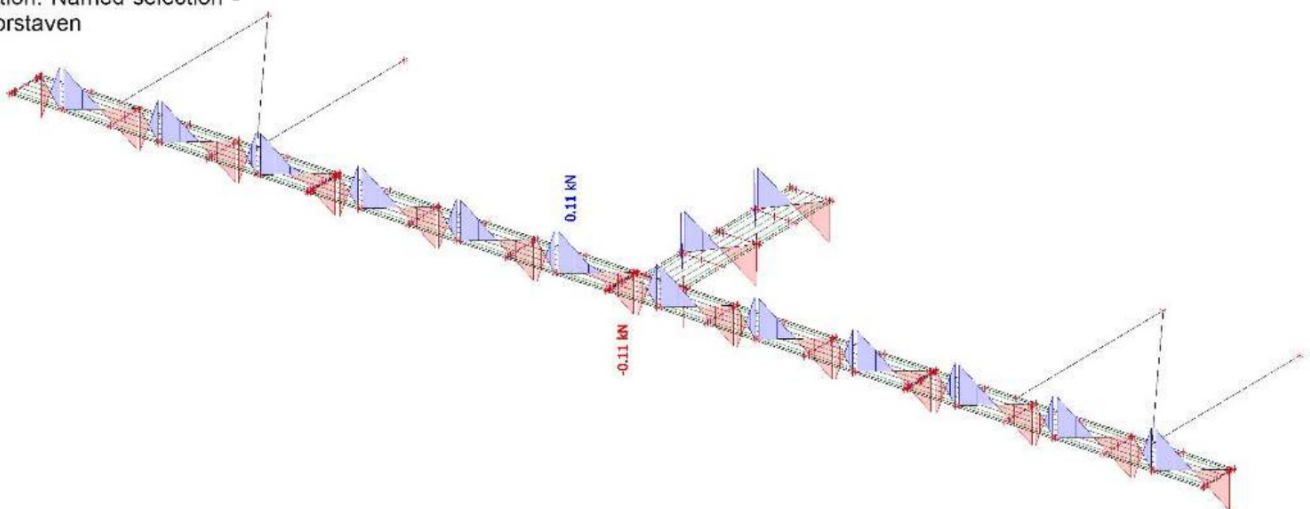
## 11.9. 1D internal forces; $M_z$

Values:  $M_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Schoorstaven



## 11.10. 1D internal forces; $V_z$

Values:  $V_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Schoorstaven



## 11.11. 1D internal forces; N

Values: N

Linear calculation

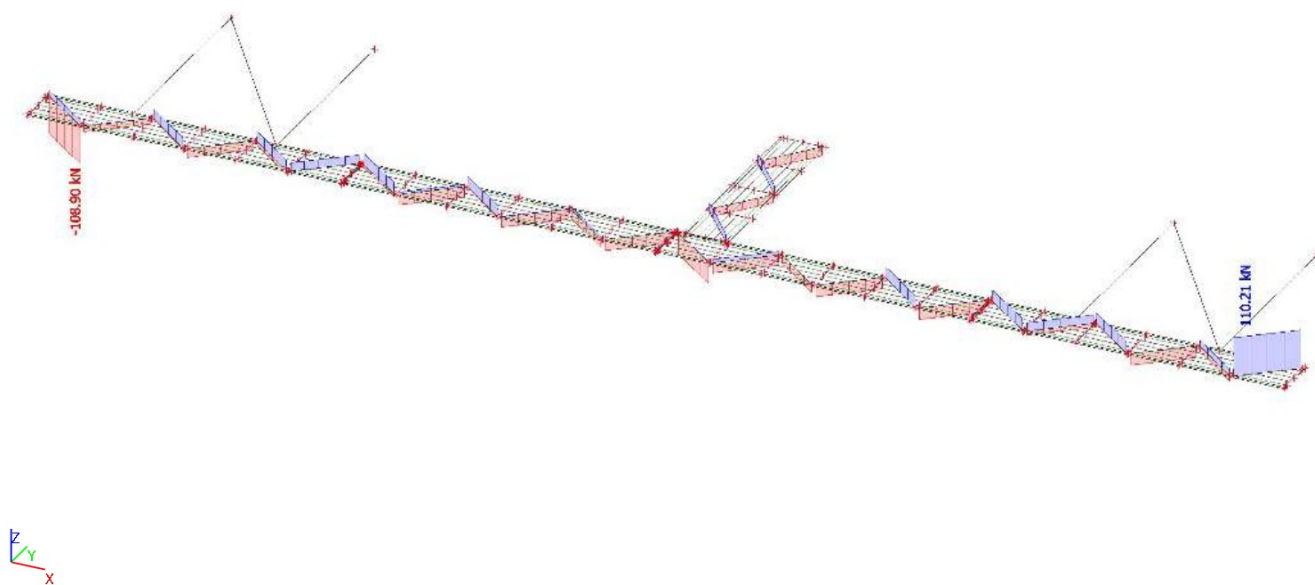
Class: All ULS

Coordinate system: Member

Extreme 1D: Global

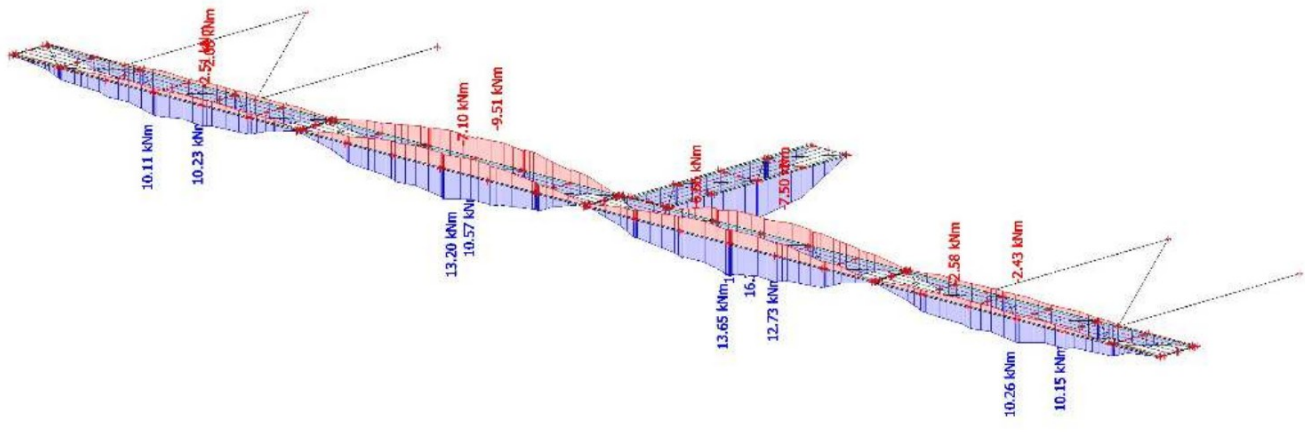
Selection: Named selection -

Schoorstaven



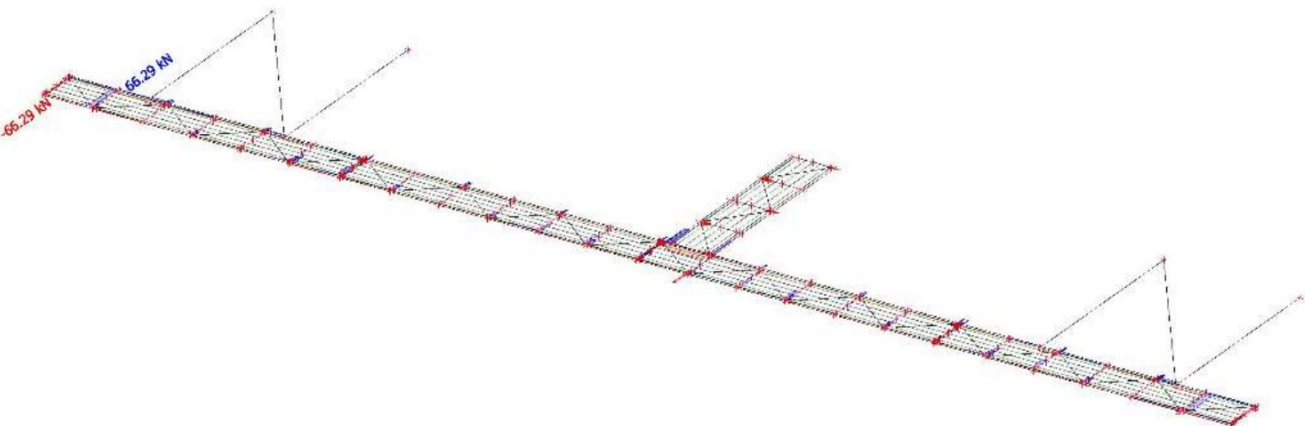
## 11.12. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Member  
 Selection: Named selection -  
 Hoofdliggers



## 11.13. 1D internal forces; $V_y$

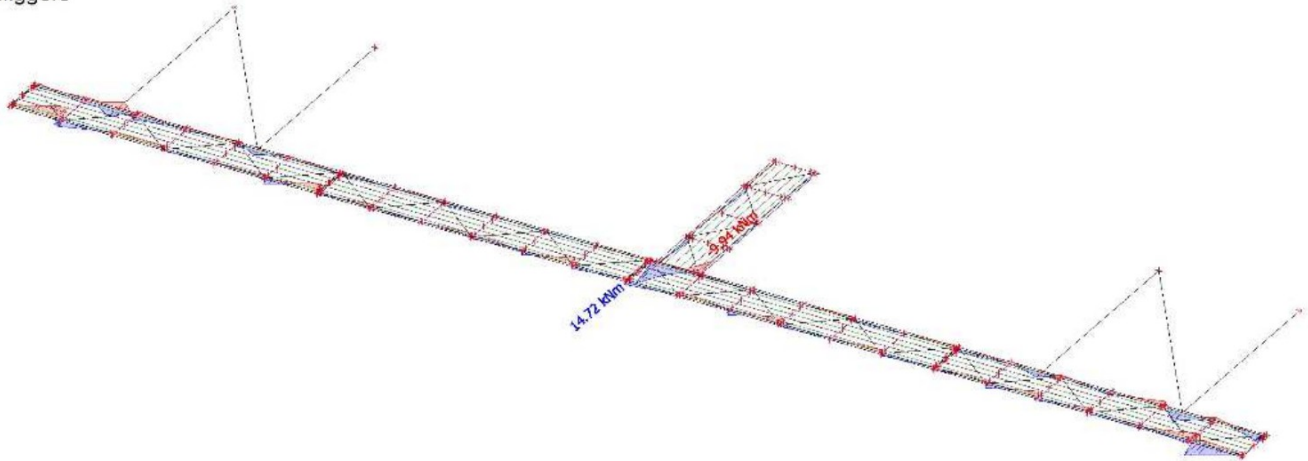
Values:  $V_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Hoofdliggers





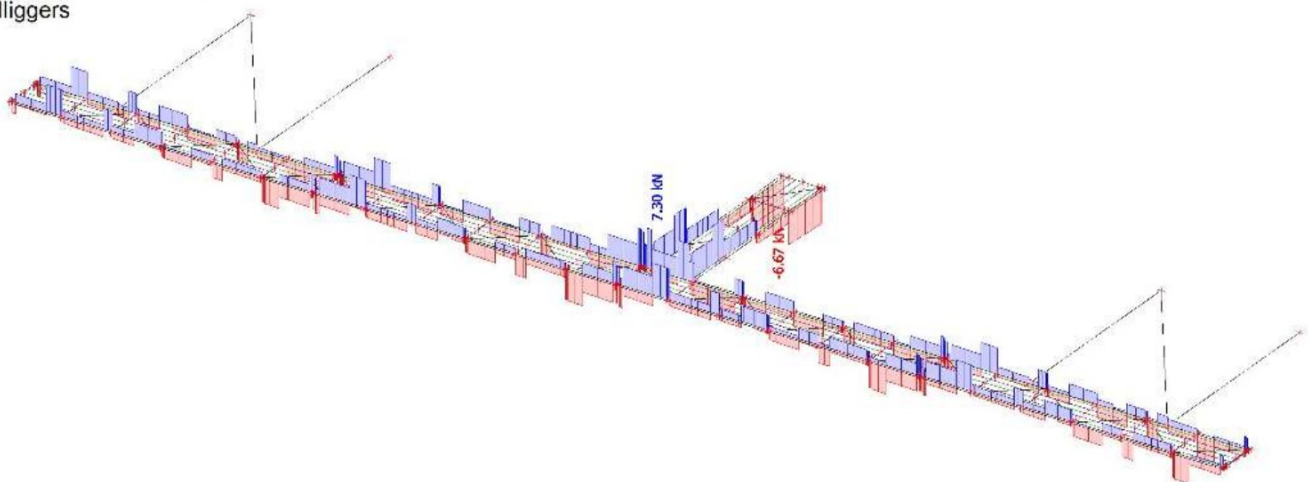
### 11.14. 1D internal forces; $M_z$

Values:  $M_z$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Hoofdliggers



### 11.15. 1D internal forces; $V_z$

Values:  $V_z$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Hoofdliggers



## 11.16. 1D internal forces; N

Values: N

Linear calculation

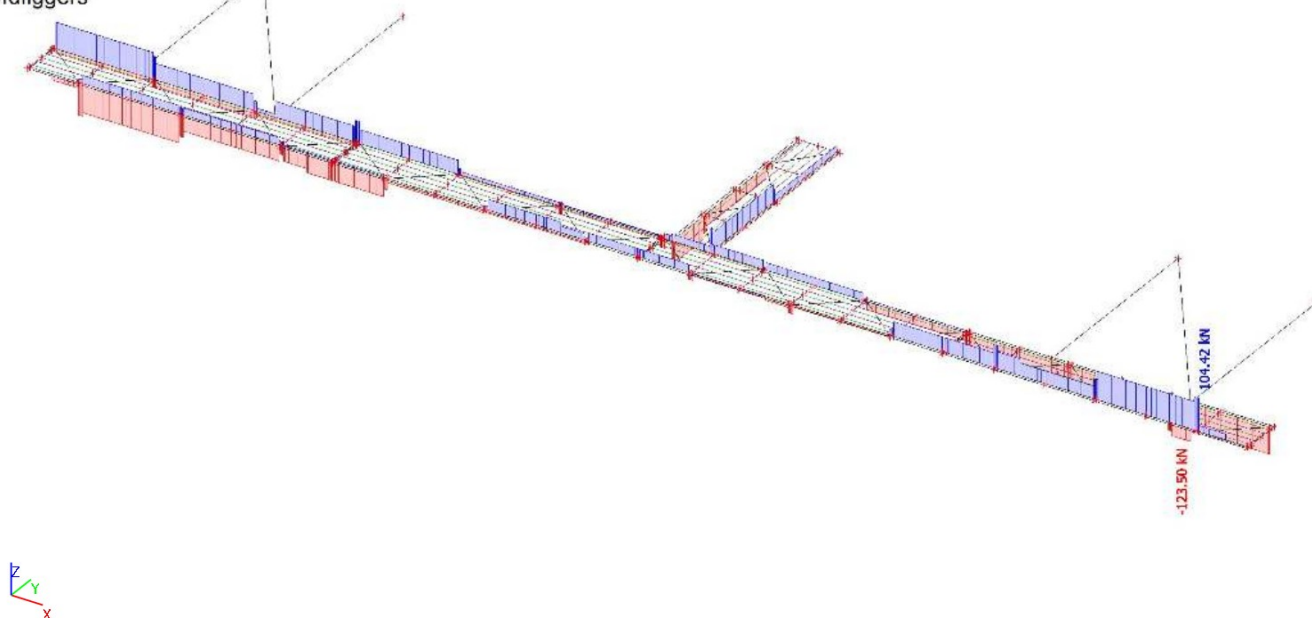
Class: All ULS

Coordinate system: Member

Extreme 1D: Global

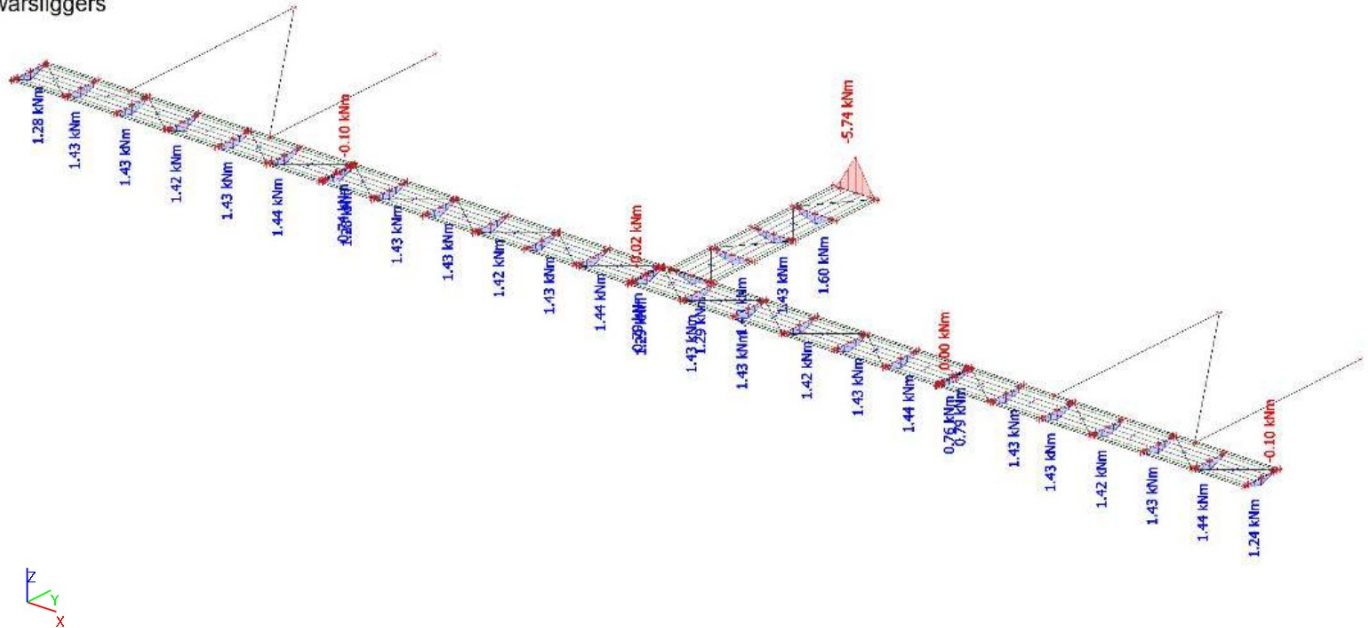
Selection: Named selection -

Hoofdliggers



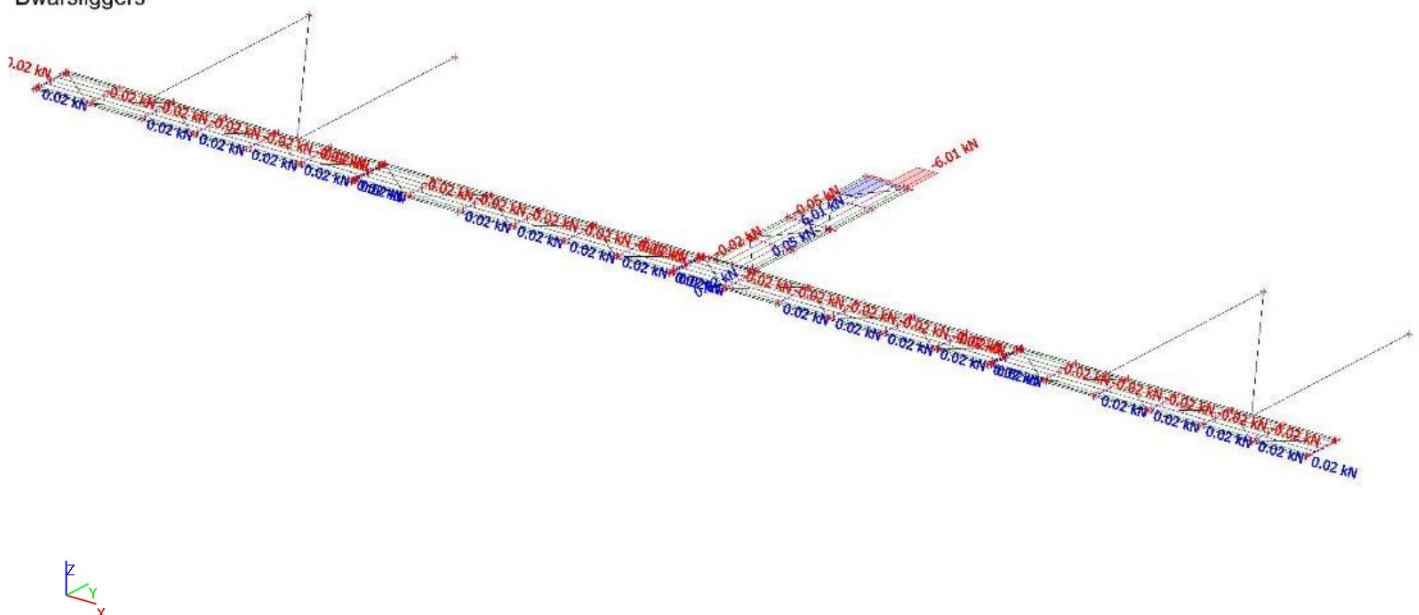
## 11.17. 1D internal forces; $M_y$

Values:  $M_y$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Member  
Selection: Named selection -  
Dwarsliggers



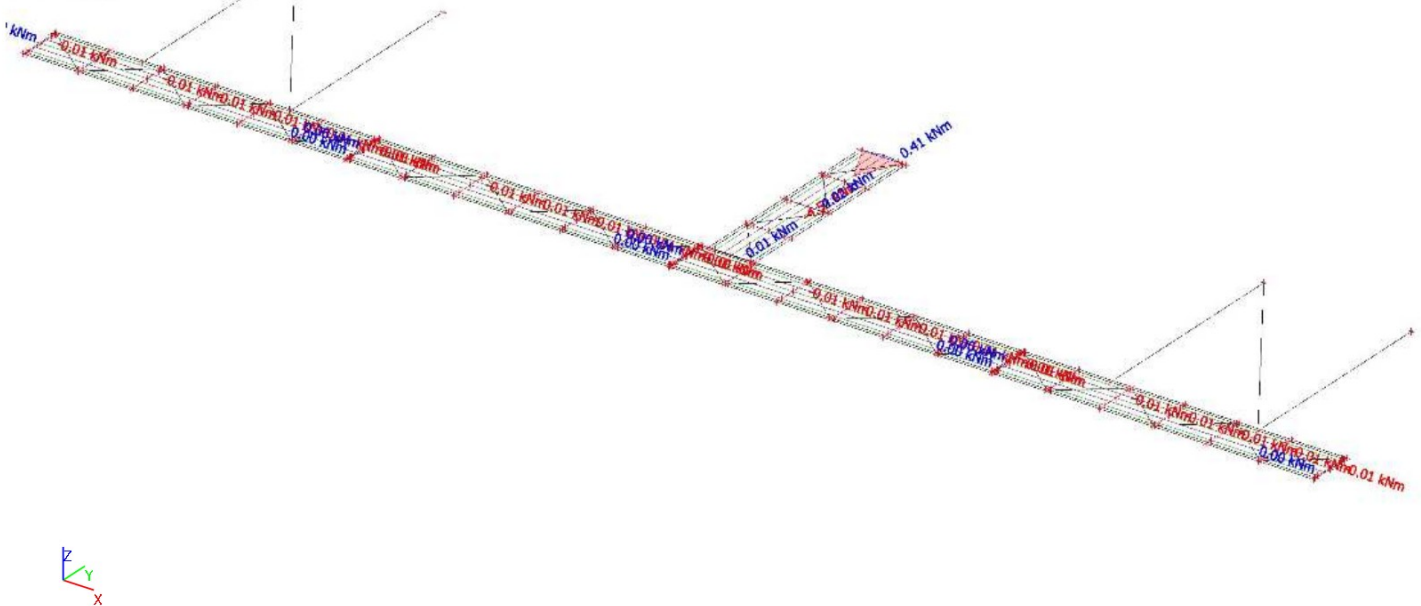
## 11.18. 1D internal forces; $V_y$

Values:  $V_y$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Member  
Selection: Named selection -  
Dwarsliggers



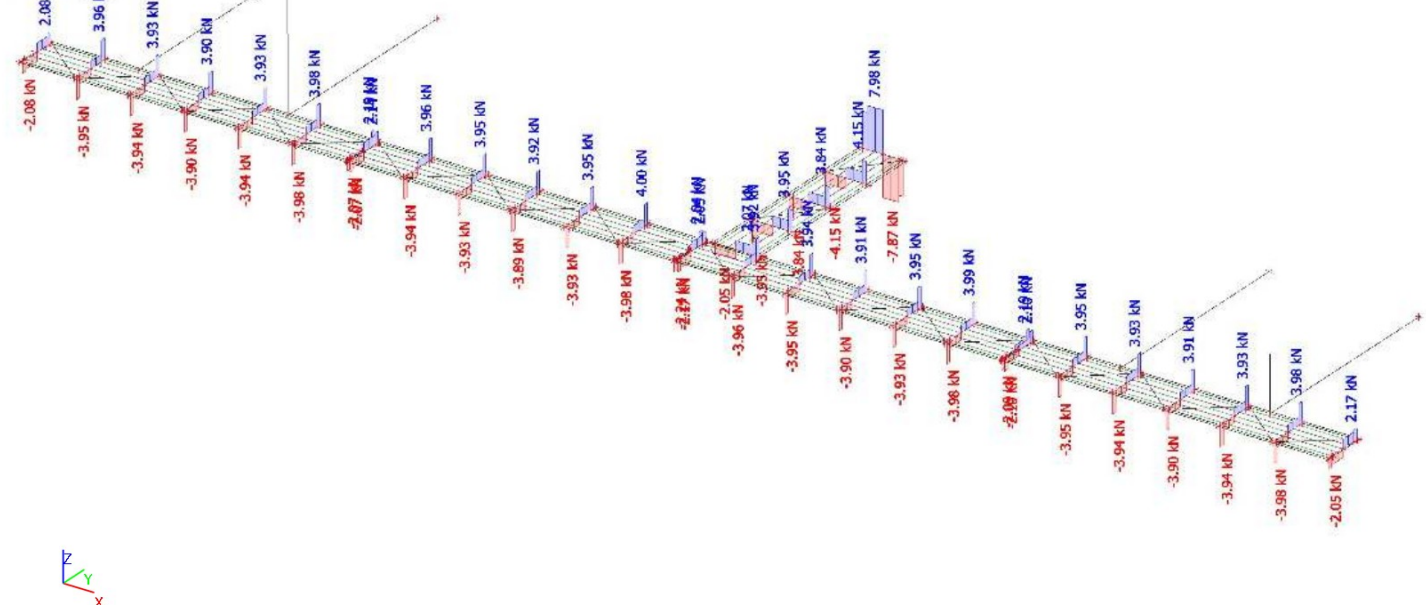
## 11.19. 1D internal forces; $M_z$

Values:  $M_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Member  
Selection: Named selection -  
Dwarsliggers



## 11.20. 1D internal forces; $V_z$

Values:  $V_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Member  
Selection: Named selection -  
Dwarsliggers





## 11.21. 1D internal forces; N

Values: N

Linear calculation

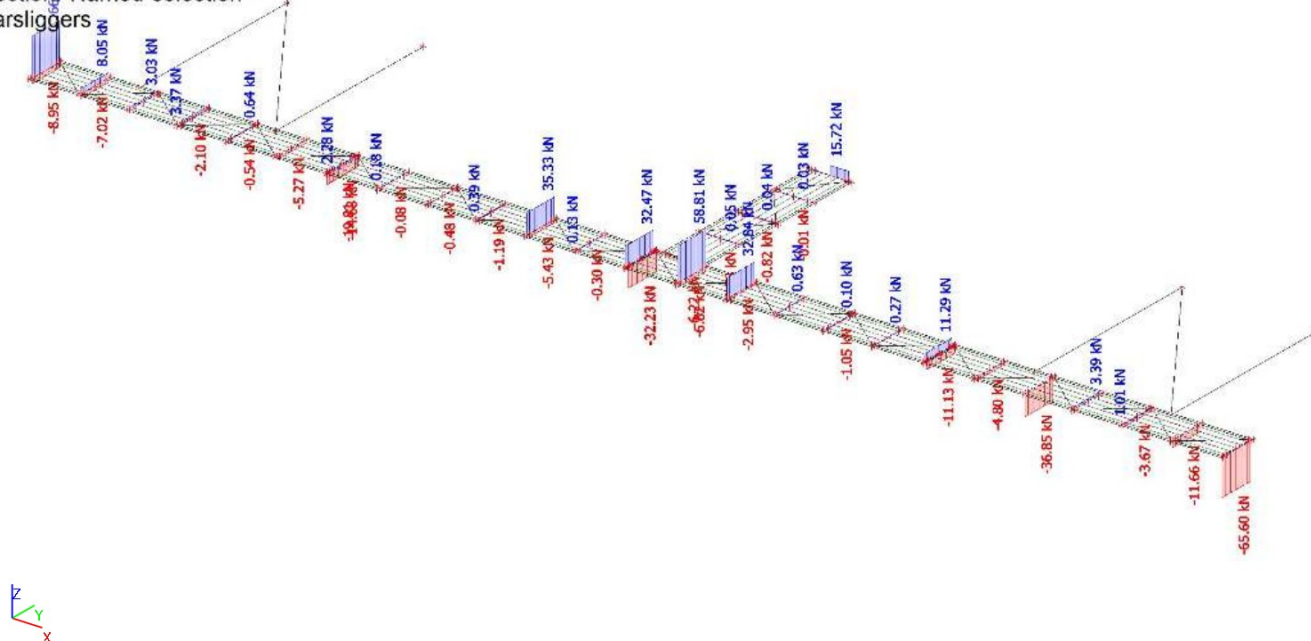
Class: All ULS

Coordinate system: Member

Extreme 1D: Member

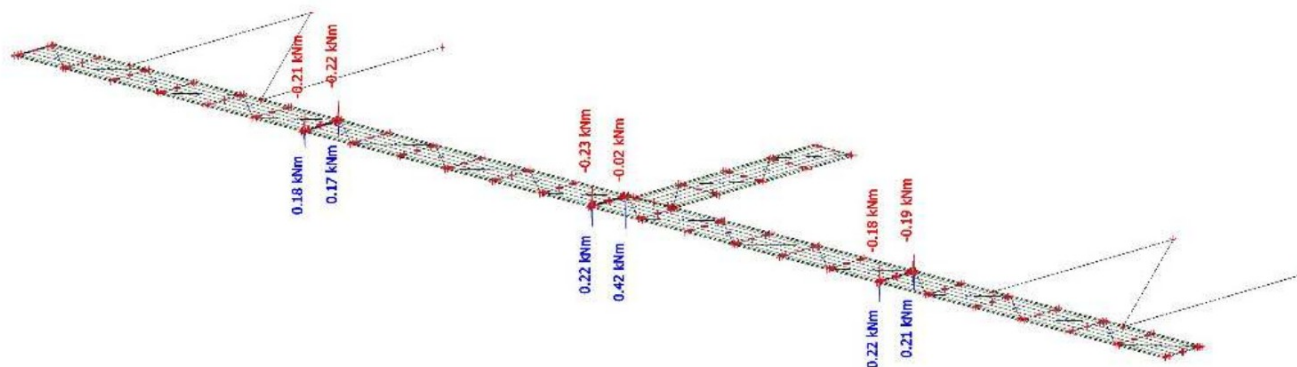
Selection: Named selection -

Dwarsliggers



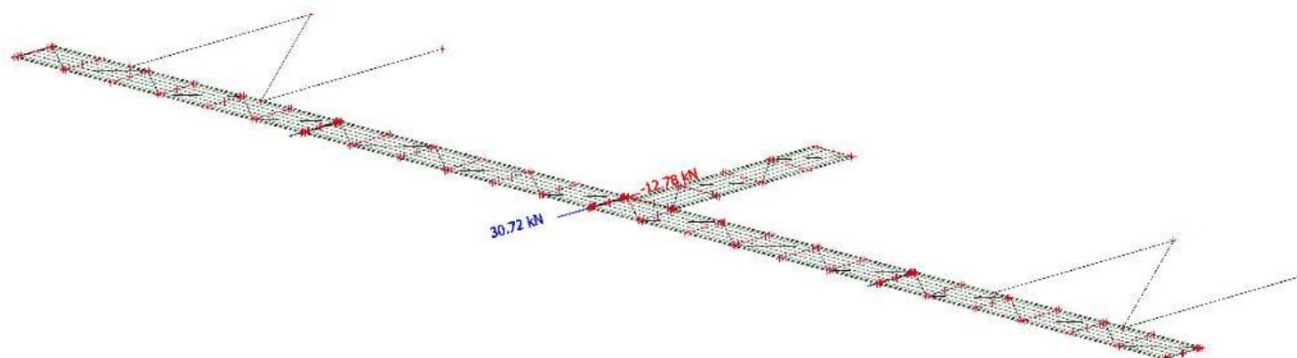
## 11.22. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Member  
 Selection: Named selection -  
 Koppelingen



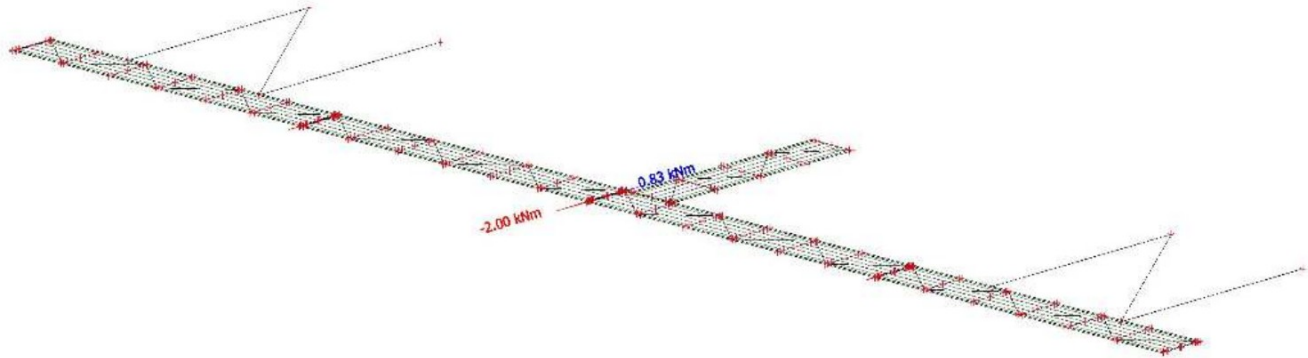
## 11.23. 1D internal forces; $V_y$

Values:  $V_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Global  
 Selection: Named selection -  
 Koppelingen



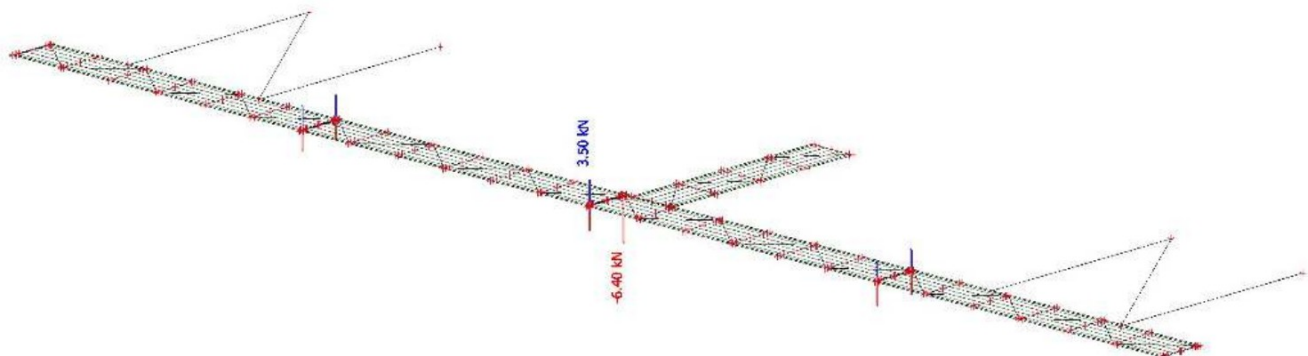
## 11.24. 1D internal forces; $M_z$

Values:  $M_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Koppelingen



## 11.25. 1D internal forces; $V_z$

Values:  $V_z$   
Linear calculation  
Class: All ULS  
Coordinate system: Member  
Extreme 1D: Global  
Selection: Named selection -  
Koppelingen



## 11.26. 1D internal forces; N

Values: N

Linear calculation

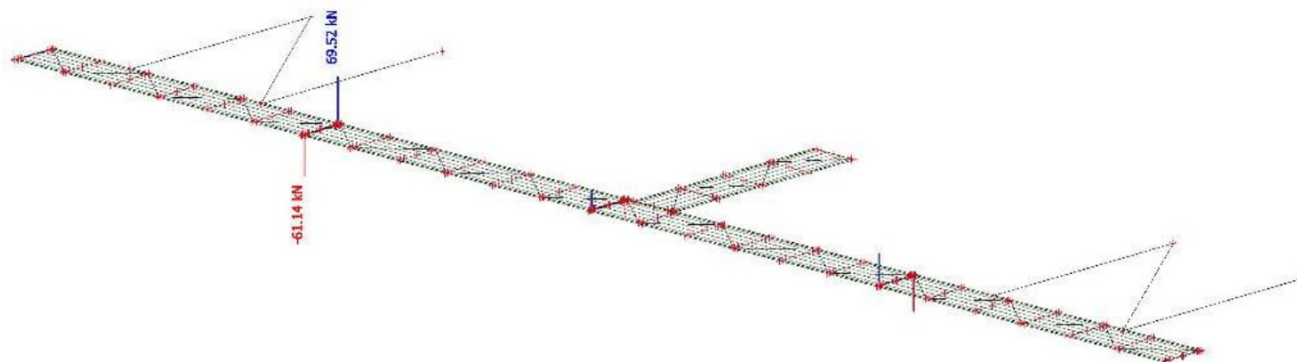
Class: All ULS

Coordinate system: Member

Extreme 1D: Global

Selection: Named selection -

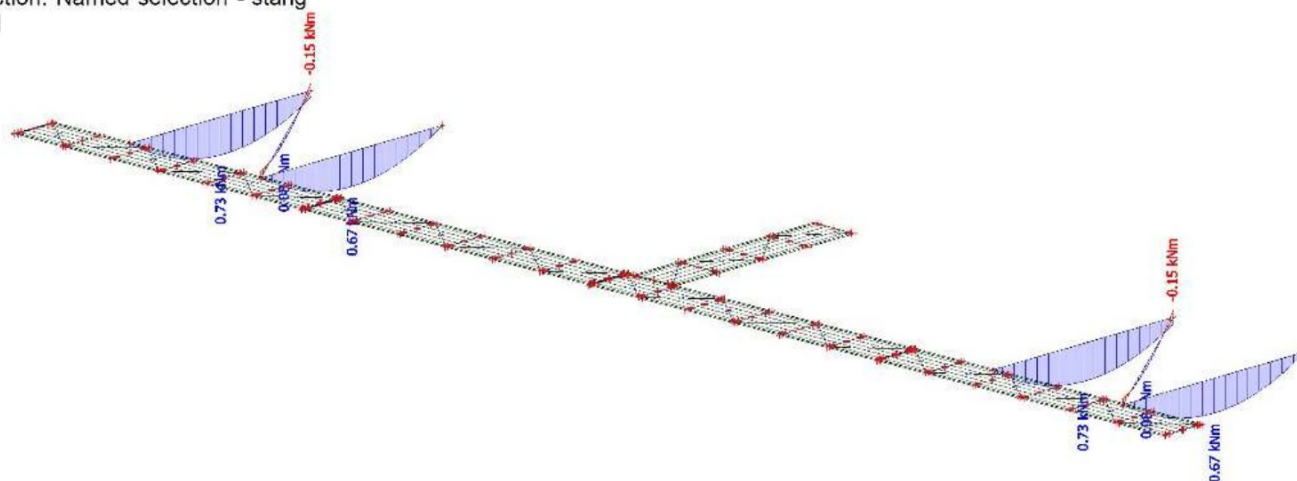
Koppelingen





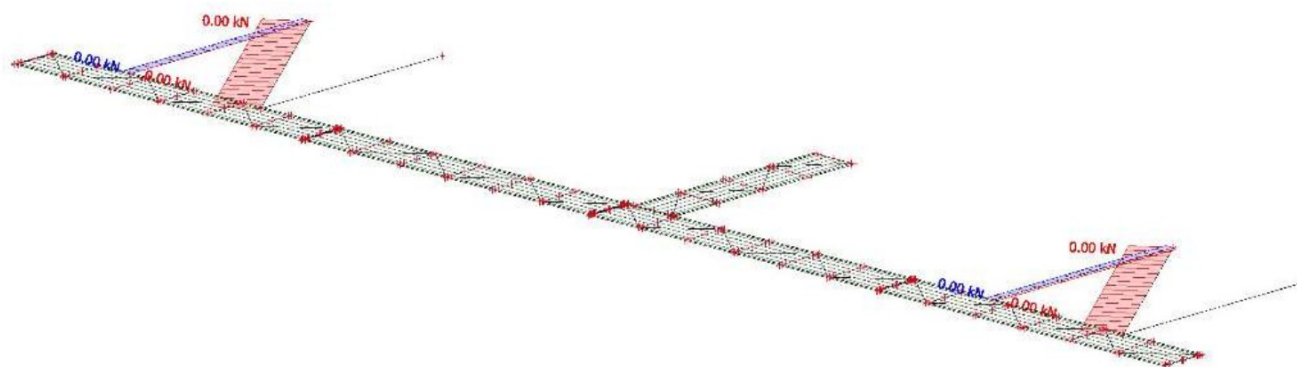
## 11.27. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Member  
 Selection: Named selection - stang  
 kabel



## 11.28. 1D internal forces; $V_y$

Values:  $V_y$   
 Linear calculation  
 Class: All ULS  
 Coordinate system: Member  
 Extreme 1D: Member  
 Selection: Named selection - stang  
 kabel



## 11.29. 1D internal forces; $M_z$

Values:  $M_z$

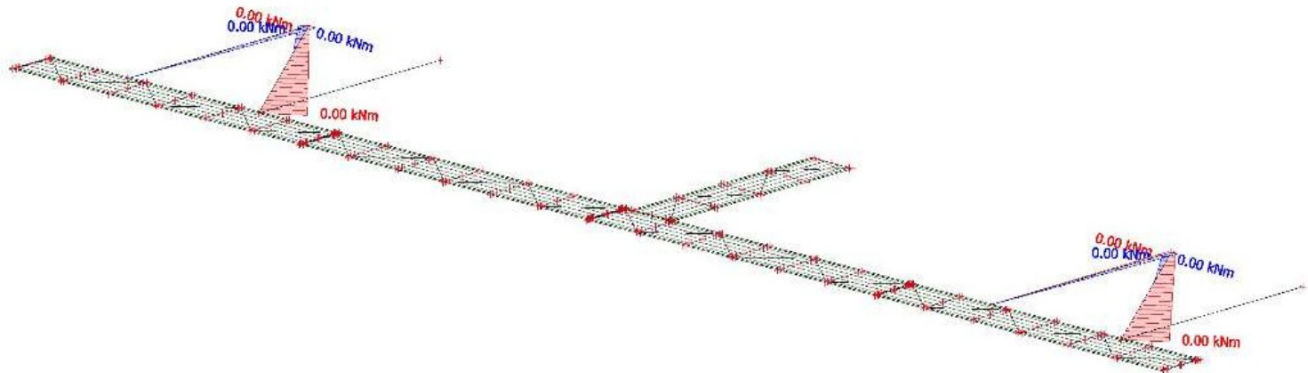
Linear calculation

Class: All ULS

Coordinate system: Member

Extreme 1D: Member

Selection: Named selection - stang  
kabel



## 11.30. 1D internal forces; $V_z$

Values:  $V_z$

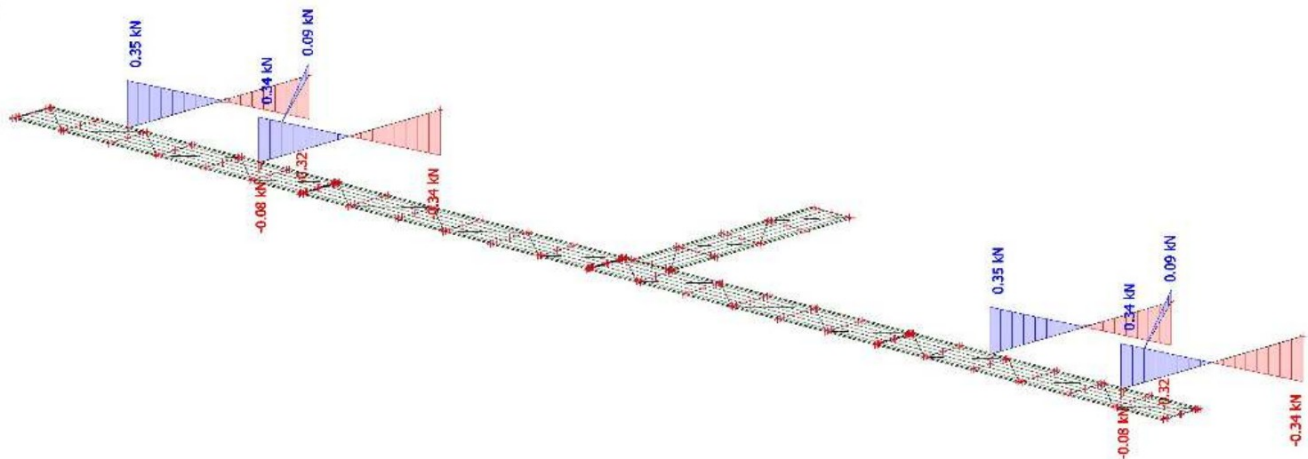
Linear calculation

Class: All ULS

Coordinate system: Member

Extreme 1D: Member

Selection: Named selection - stang  
kabel



## 11.31. 1D internal forces; N

Values: N

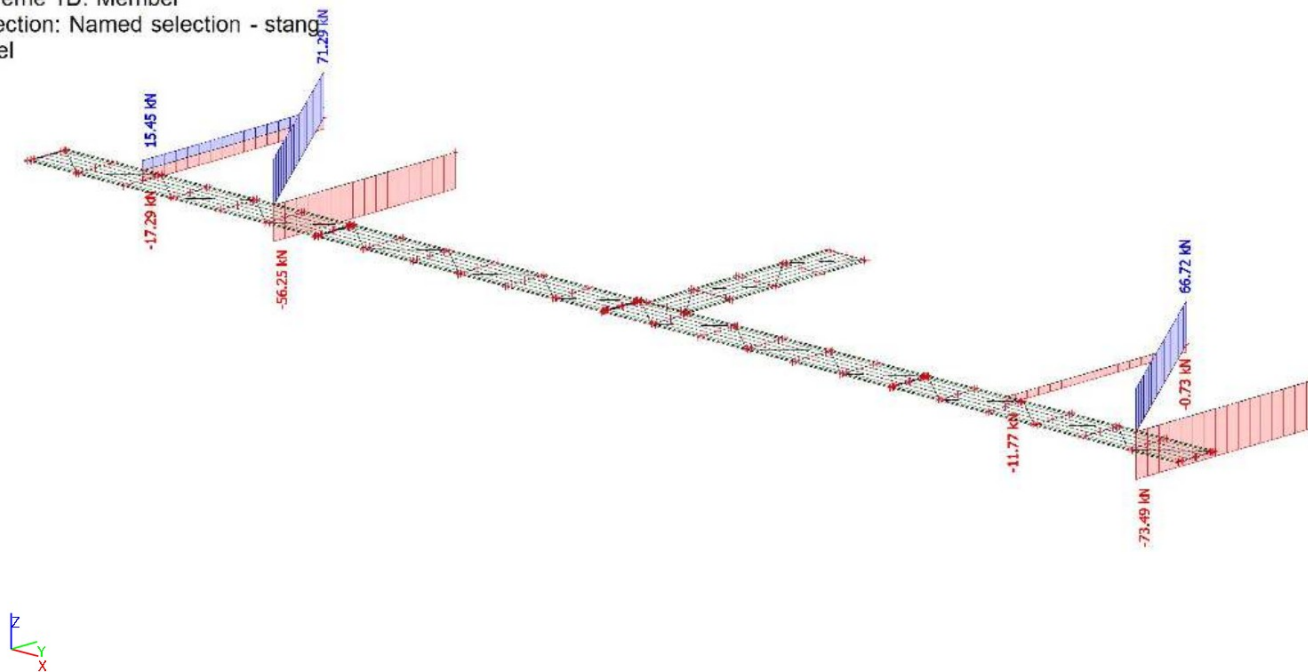
Linear calculation

Class: All ULS

Coordinate system: Member

Extreme 1D: Member

Selection: Named selection - stang  
kabel



# SCIA Engineering rapport - Verificatie Dwarsliggers en Schoorstaven

## **Drijvende Oversteek Schipperskerk**

Klant: Inter Boat Marinas B.V.

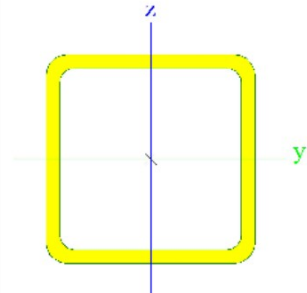
## 1. Table of contents

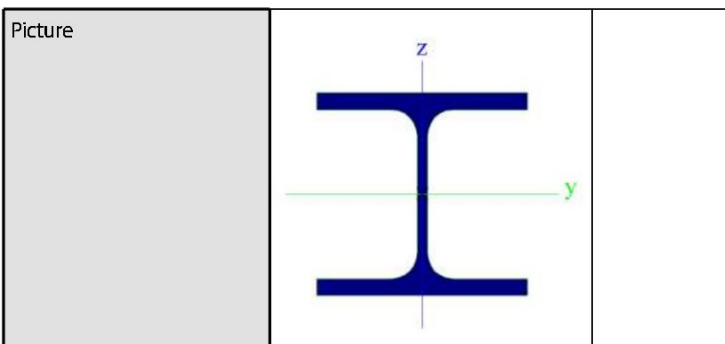
|                                                |    |
|------------------------------------------------|----|
| 1. Table of contents                           | 2  |
| 2. Verificatie Dwarsliggers                    | 3  |
| 2.1. Cross-sections                            | 3  |
| 2.2. EC-EN 1993 Steel check ULS                | 4  |
| 2.3. EC-EN 1993 Steel check ULS; Section check | 8  |
| 3. Verificatie Schoorstaven                    | 8  |
| 3.1. Cross-sections                            | 8  |
| 3.2. EC-EN 1993 Steel check ULS                | 9  |
| 3.3. EC-EN 1993 Steel check ULS; Section check | 12 |



## 2. Verificatie Dwarsliggers

### 2.1. Cross-sections

| CS2                                                |                                                                                     |  |            |
|----------------------------------------------------|-------------------------------------------------------------------------------------|--|------------|
| Type                                               | SHS60/60/4.0                                                                        |  |            |
| Formcode                                           | 2 - Rectangular hollow section                                                      |  |            |
| Shape type                                         | Thin-walled                                                                         |  |            |
| Item material                                      | S 355                                                                               |  |            |
| Fabrication                                        | rolled                                                                              |  |            |
| Colour                                             |    |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z    | a                                                                                   |  | a          |
| A [m²]                                             | 8.7900e-04                                                                          |  |            |
| A <sub>y</sub> [m²], A <sub>z</sub> [m²]           | 4.3926e-04                                                                          |  | 4.3926e-04 |
| A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]       | 2.3000e-01                                                                          |  | 4.3075e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]   | 30                                                                                  |  | 30         |
| α [deg]                                            | 0.00                                                                                |  |            |
| I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]           | 4.5400e-07                                                                          |  | 4.5400e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]           | 23                                                                                  |  | 23         |
| W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]     | 1.5100e-05                                                                          |  | 1.5100e-05 |
| W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]     | 1.8300e-05                                                                          |  | 1.8300e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm] | 6495.60                                                                             |  | 6495.60    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm] | 6495.60                                                                             |  | 6495.60    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]           | 0                                                                                   |  | 0          |
| I <sub>t</sub> [m⁴], I <sub>w</sub> [m⁶]           | 7.2500e-07                                                                          |  | 2.5920e-10 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]           | 0                                                                                   |  | 0          |
| Picture                                            |  |  |            |
| CS14                                               |                                                                                     |  |            |
| Type                                               | HEA100                                                                              |  |            |
| Formcode                                           | 1 - I section                                                                       |  |            |
| Shape type                                         | Thin-walled                                                                         |  |            |
| Item material                                      | S 235                                                                               |  |            |
| Fabrication                                        | rolled                                                                              |  |            |
| Colour                                             |  |  |            |
| Flexural buckling y-y,<br>Flexural buckling z-z    | b                                                                                   |  | c          |
| A [m²]                                             | 2.1200e-03                                                                          |  |            |
| A <sub>y</sub> [m²], A <sub>z</sub> [m²]           | 1.4881e-03                                                                          |  | 4.7795e-04 |
| A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]       | 5.6100e-01                                                                          |  | 5.6130e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]   | 50                                                                                  |  | 48         |
| α [deg]                                            | 0.00                                                                                |  |            |
| I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]           | 3.4900e-06                                                                          |  | 1.3400e-06 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]           | 41                                                                                  |  | 25         |
| W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]     | 7.2800e-05                                                                          |  | 2.6800e-05 |
| W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]     | 8.2917e-05                                                                          |  | 4.1125e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm] | 19527.28                                                                            |  | 19527.28   |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm] | 9671.68                                                                             |  | 9671.68    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]           | 0                                                                                   |  | 0          |
| I <sub>t</sub> [m⁴], I <sub>w</sub> [m⁶]           | 5.2084e-08                                                                          |  | 2.4750e-09 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]           | 0                                                                                   |  | 0          |



| Explanations of symbols |                                                                                   |
|-------------------------|-----------------------------------------------------------------------------------|
| Formcode                | h - Height<br>b - Width<br>s - Thickness<br>r - Outer radius<br>r1 - Inner radius |
| A                       | Area                                                                              |
| A <sub>y</sub>          | Shear Area in principal y-direction                                               |
| A <sub>z</sub>          | Shear Area in principal z-direction                                               |
| A <sub>L</sub>          | Circumference per unit length                                                     |
| A <sub>D</sub>          | Drying surface per unit length                                                    |
| C <sub>y,UCS</sub>      | Centroid coordinate in Y-direction of Input axis system                           |
| C <sub>z,UCS</sub>      | Centroid coordinate in Z-direction of Input axis system                           |
| I <sub>y,LCS</sub>      | Second moment of area about the YLCS axis                                         |
| I <sub>z,LCS</sub>      | Second moment of area about the ZLCS axis                                         |
| I <sub>yz,LCS</sub>     | Product moment of area in the LCS system                                          |
| α                       | Rotation angle of the principal axis system                                       |
| I <sub>y</sub>          | Second moment of area about the principal y-axis                                  |
| I <sub>z</sub>          | Second moment of area about the principal z-axis                                  |
| i <sub>y</sub>          | Radius of gyration about the principal y-axis                                     |

| Explanations of symbols |                                                                             |
|-------------------------|-----------------------------------------------------------------------------|
| i <sub>z</sub>          | Radius of gyration about the principal z-axis                               |
| W <sub>el,y</sub>       | Elastic section modulus about the principal y-axis                          |
| W <sub>el,z</sub>       | Elastic section modulus about the principal z-axis                          |
| W <sub>pl,y</sub>       | Plastic section modulus about the principal y-axis                          |
| W <sub>pl,z</sub>       | Plastic section modulus about the principal z-axis                          |
| M <sub>pl,y,+</sub>     | Plastic moment about the principal y-axis for a positive My moment          |
| M <sub>pl,y,-</sub>     | Plastic moment about the principal y-axis for a negative My moment          |
| M <sub>pl,z,+</sub>     | Plastic moment about the principal z-axis for a positive Mz moment          |
| M <sub>pl,z,-</sub>     | Plastic moment about the principal z-axis for a negative Mz moment          |
| d <sub>y</sub>          | Shear center coordinate in principal y-direction measured from the centroid |
| d <sub>z</sub>          | Shear center coordinate in principal z-direction measured from the centroid |
| I <sub>t</sub>          | Torsional constant                                                          |
| I <sub>w</sub>          | Warping constant                                                            |
| β <sub>y</sub>          | Mono-symmetry constant about the principal y-axis                           |
| β <sub>z</sub>          | Mono-symmetry constant about the principal z-axis                           |

## 2.2. EC-EN 1993 Steel check ULS

Linear calculation

Class: All ULS

Coordinate system: Principal

Extreme 1D: Global

Selection: Named selection - Dwarsliggers

### EN 1993-1-1 Code Check

National annex: Dutch NEN-EN NA

|             |                 |              |       |         |        |
|-------------|-----------------|--------------|-------|---------|--------|
| Member B397 | 0,161 / 1,500 m | SHS60/60/4.0 | S 235 | All ULS | 0,63 - |
|-------------|-----------------|--------------|-------|---------|--------|

| Combination key                                                                       |
|---------------------------------------------------------------------------------------|
| All ULS / $1.10 \cdot EG + 1.10 \cdot Perm + 0.96 \cdot Fdek-POS3 + 1.35 \cdot Wind1$ |

| Partial safety factors                         |      |
|------------------------------------------------|------|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability    | 1,00 |
| $\gamma_{M2}$ for resistance of net sections   | 1.25 |

| Material          |       |        |     |
|-------------------|-------|--------|-----|
| Yield strength    | $f_y$ | 235,0  | MPa |
| Ultimate strength | $f_u$ | 360,0  | MPa |
| Fabrication       |       | Rolled |     |

.....SECTION CHECK:.....

The critical check is on position 0,161 m

| Internal forces |            | Calculated | Unit |
|-----------------|------------|------------|------|
| Normal force    | $N_{Ed}$   | -65,60     | kN   |
| Shear force     | $V_{y,Ed}$ | -0,01      | kN   |
| Shear force     | $V_{z,Ed}$ | 1,44       | kN   |
| Torsion         | $T_{Ed}$   | -0,04      | kNm  |
| Bending moment  | $M_{y,Ed}$ | 0,19       | kNm  |
| Bending moment  | $M_{z,Ed}$ | 0,00       | kNm  |

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m <sup>2</sup> ] | $\sigma_2$ [kN/m <sup>2</sup> ] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|----|------|--------|--------|---------------------------------|---------------------------------|------------|----------------|--------------|---------|-------------------|-------------------|-------------------|-------|
| 1  | I    | 48     | 4      | 63398,151                       | 62989,206                       | 1,0        |                | 1,0          | 12,0    | 28,0              | 34,0              | 38,1              | 1     |
| 3  | I    | 48     | 4      | 64592,290                       | 84238,232                       | 0,8        |                | 1,0          | 12,0    | 28,0              | 34,0              | 41,3              | 1     |
| 5  | I    | 48     | 4      | 85909,472                       | 86318,417                       | 1,0        |                | 1,0          | 12,0    | 28,0              | 34,0              | 38,1              | 1     |
| 7  | I    | 48     | 4      | 84715,334                       | 65069,392                       | 0,8        |                | 1,0          | 12,0    | 28,0              | 34,0              | 41,3              | 1     |

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

|                        |            |            |                |
|------------------------|------------|------------|----------------|
| Cross-section area     | A          | 8,7900e-04 | m <sup>2</sup> |
| Compression resistance | $N_{c,Rd}$ | 206,56     | kN             |
| Unity check            |            | 0,32       | -              |

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

|                         |               |            |                |
|-------------------------|---------------|------------|----------------|
| Plastic section modulus | $W_{pl,y}$    | 1,8300e-05 | m <sup>3</sup> |
| Plastic bending moment  | $M_{pl,y,Rd}$ | 4,30       | kNm            |
| Unity check             |               | 0,04       | -              |

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

|                         |               |            |                |
|-------------------------|---------------|------------|----------------|
| Plastic section modulus | $W_{pl,z}$    | 1,8300e-05 | m <sup>3</sup> |
| Plastic bending moment  | $M_{pl,z,Rd}$ | 4,30       | kNm            |
| Unity check             |               | 0,00       | -              |

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Project Drijvende oversteek - Oudega  
Part Bijlage 2 SCIA reken model  
Author XXXXXXXXXX  
Current date 20.07.2023  
Project filename schipperskerk.esa

|                                    |               |            |                |
|------------------------------------|---------------|------------|----------------|
| Shear correction factor            | $\eta$        | 1,20       |                |
| Shear area                         | $A_v$         | 4,3950e-04 | m <sup>2</sup> |
| Plastic shear resistance for $V_y$ | $V_{pl,y,Rd}$ | 59,63      | kN             |
| Unity check                        |               | 0,00       | -              |

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

|                                    |               |            |                |
|------------------------------------|---------------|------------|----------------|
| Shear correction factor            | $\eta$        | 1,20       |                |
| Shear area                         | $A_v$         | 4,3950e-04 | m <sup>2</sup> |
| Plastic shear resistance for $V_z$ | $V_{pl,z,Rd}$ | 59,63      | kN             |
| Unity check                        |               | 0,02       | -              |

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

|                          |          |       |     |
|--------------------------|----------|-------|-----|
| Index of fibre           | Fibre    | 2     |     |
| Total torsional moment   | $T_{Ed}$ | 1,6   | MPa |
| Elastic shear resistance | $T_{Rd}$ | 135,7 | MPa |
| Unity check              |          | 0,01  | -   |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

|                                                          |              |      |     |
|----------------------------------------------------------|--------------|------|-----|
| Design plastic moment resistance reduced due to $N_{Ed}$ | $M_{N,y,Rd}$ | 3,80 | kNm |
| Exponent of bending ratio $y$                            | $\alpha$     | 1,87 |     |
| Design plastic moment resistance reduced due to $N_{Ed}$ | $M_{N,z,Rd}$ | 3,80 | kNm |
| Exponent of bending ratio $z$                            | $\beta$      | 1,87 |     |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ....:STABILITY CHECK:....

#### Classification for member buckling design

Decisive position for stability classification: 0,750 m

Decisive utilisation factor  $\eta$ : 0,50

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| ID | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m <sup>2</sup> ] | $\sigma_2$ [kN/m <sup>2</sup> ] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|----|------|--------|--------|---------------------------------|---------------------------------|------------|----------------|--------------|---------|-------------------|-------------------|-------------------|-------|
| 1  | I    | 48     | 4      | 12172,049                       | 11254,421                       | 0,9        |                | 1,0          | 12,0    | 28,0              | 34,0              | 39,0              | 1     |
| 3  | I    | 48     | 4      | 20169,463                       | 128067,595                      | 0,2        |                | 1,0          | 12,0    | 28,0              | 34,0              | 53,7              | 1     |
| 5  | I    | 48     | 4      | 137135,574                      | 138053,202                      | 1,0        |                | 1,0          | 12,0    | 28,0              | 34,0              | 38,1              | 1     |
| 7  | I    | 48     | 4      | 129138,160                      | 21240,029                       | 0,2        |                | 1,0          | 12,0    | 28,0              | 34,0              | 53,5              | 1     |

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

**Note:** The decisive position for the stability classification is based on the utilisation factor  $\eta$  according to Semi-Comp+.

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters |          | yy     | zz       |    |
|---------------------|----------|--------|----------|----|
| Sway type           |          | sway   | non-sway |    |
| System length       | L        | 1,500  | 0,589    | m  |
| Buckling factor     | k        | 1,00   | 1,00     |    |
| Buckling length     | $l_{cr}$ | 1,500  | 0,589    | m  |
| Critical Euler load | $N_{cr}$ | 418,21 | 2716,95  | kN |

| Buckling parameters  |                   | yy     | zz     |    |
|----------------------|-------------------|--------|--------|----|
| Slenderness          | $\lambda$         | 66,00  | 25,89  |    |
| Relative slenderness | $\lambda_{rel}$   | 0,70   | 0,28   |    |
| Limit slenderness    | $\lambda_{rel,0}$ | 0,20   | 0,20   |    |
| Buckling curve       |                   | a      | a      |    |
| Imperfection         | $\alpha$          | 0,21   | 0,21   |    |
| Reduction factor     | $\chi$            | 0,85   | 0,98   |    |
| Buckling resistance  | $N_{b,Rd}$        | 174,84 | 203,07 | kN |

| Flexural Buckling verification |            |            |                |
|--------------------------------|------------|------------|----------------|
| Cross-section area             | A          | 8,7900e-04 | m <sup>2</sup> |
| Buckling resistance            | $N_{b,Rd}$ | 174,84     | kN             |
| Unity check                    |            | 0,38       | -              |

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns an RHS section with ' $h/b < 10 / \lambda_{rel,z}$ '.

This section is thus not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters |             |                      |                |
|------------------------------------------------|-------------|----------------------|----------------|
| Interaction method                             |             | alternative method 2 |                |
| Cross-section area                             | A           | 8,7900e-04           | m <sup>2</sup> |
| Plastic section modulus                        | $W_{pl,y}$  | 1,8300e-05           | m <sup>3</sup> |
| Plastic section modulus                        | $W_{pl,z}$  | 1,8300e-05           | m <sup>3</sup> |
| Design compression force                       | $N_{Ed}$    | 65,60                | kN             |
| Design bending moment (maximum)                | $M_{y,Ed}$  | 1,02                 | kNm            |
| Design bending moment (maximum)                | $M_{z,Ed}$  | -0,01                | kNm            |
| Characteristic compression resistance          | $N_{Rk}$    | 206,56               | kN             |
| Characteristic moment resistance               | $M_{y,Rk}$  | 4,30                 | kNm            |
| Characteristic moment resistance               | $M_{z,Rk}$  | 4,30                 | kNm            |
| Reduction factor                               | $\chi_y$    | 0,85                 |                |
| Reduction factor                               | $\chi_z$    | 0,98                 |                |
| Reduction factor                               | $\chi_{LT}$ | 1,00                 |                |
| Interaction factor                             | $k_{yy}$    | 1,07                 |                |
| Interaction factor                             | $k_{yz}$    | 0,48                 |                |
| Interaction factor                             | $k_{zy}$    | 0,64                 |                |
| Interaction factor                             | $k_{zz}$    | 0,80                 |                |

Maximum moment  $M_{y,Ed}$  is derived from beam B397 position 0,750 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B397 position 0,750 m.

| Interaction method 2 parameters |             |                 |
|---------------------------------|-------------|-----------------|
| Method for interaction factors  |             | Table B.1       |
| Sway type y                     |             | sway            |
| Equivalent moment factor        | $C_{my}$    | 0,90            |
| Resulting load type z           |             | linear moment M |
| Ratio of end moments            | $\psi_z$    | 0,45            |
| Equivalent moment factor        | $C_{mz}$    | 0,78            |
| Resulting load type LT          |             | linear moment M |
| Ratio of end moments            | $\psi_{LT}$ | 0,18            |
| Equivalent moment factor        | $C_{mLT}$   | 0,67            |

Unity check (6.61) = 0,38 + 0,25 + 0,00 = 0,63 -

Unity check (6.62) = 0,32 + 0,15 + 0,00 = 0,48 -



The member satisfies the stability check.

## 2.3. EC-EN 1993 Steel check ULS; Section check

Values:  $U_{C_{Overall}}$

Linear calculation

Class: All ULS

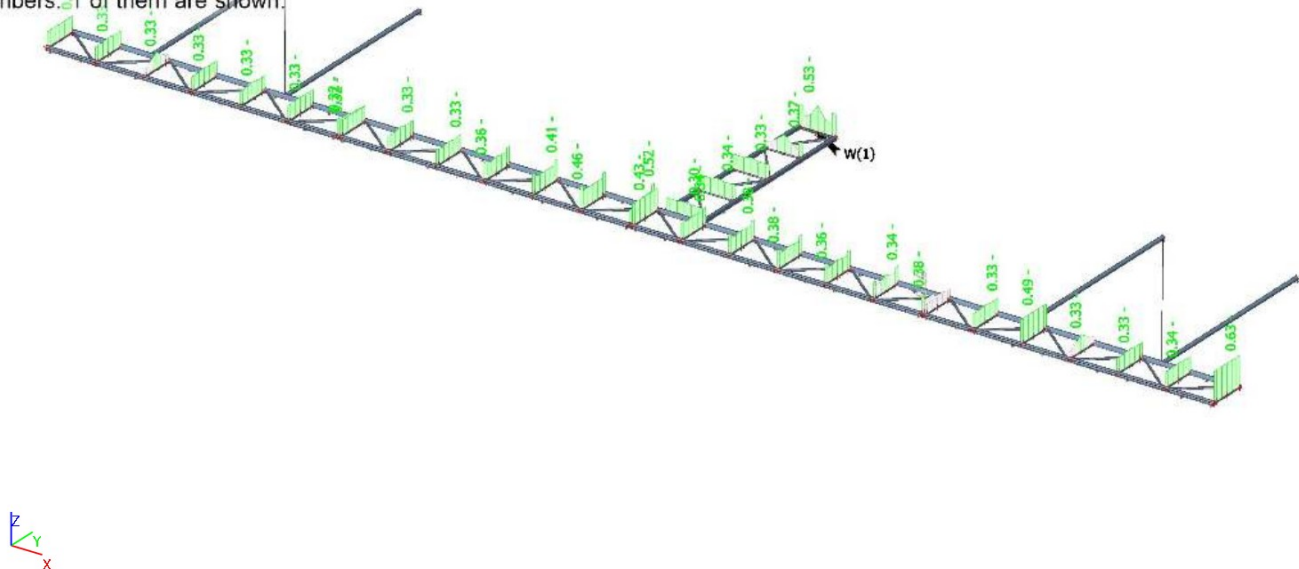
Coordinate system: Principal

Extreme 1D: Member

Selection: Named selection -

Dwarsliggers

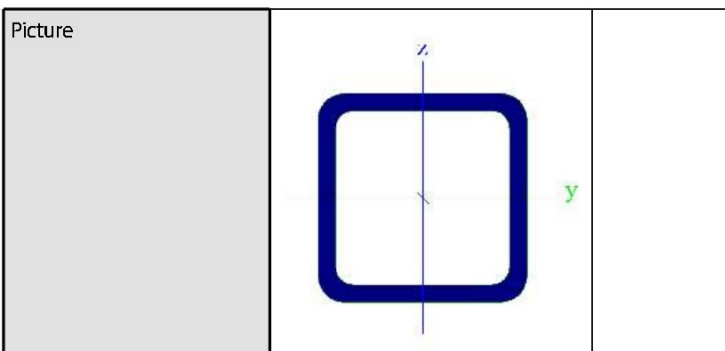
There are 1 warnings on selected members. 1 of them are shown.



## 3. Verificatie Schoorstaven

### 3.1. Cross-sections

| CS5                                                                      |                                                                                     |            |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| Type                                                                     | SHS60/60/5.0                                                                        |            |
| Formcode                                                                 | 2 - Rectangular hollow section                                                      |            |
| Shape type                                                               | Thin-walled                                                                         |            |
| Item material                                                            | S 235                                                                               |            |
| Fabrication                                                              | rolled                                                                              |            |
| Colour                                                                   |  |            |
| Flexural buckling y-y, Flexural buckling z-z                             | a                                                                                   | a          |
| A [m <sup>2</sup> ]                                                      | 1.0700e-03                                                                          |            |
| A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]       | 5.3634e-04                                                                          | 5.3634e-04 |
| A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]   | 2.2700e-01                                                                          | 4.1844e-01 |
| c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]                         | 30                                                                                  | 30         |
| α [deg]                                                                  | 0.00                                                                                |            |
| I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]       | 5.3300e-07                                                                          | 5.3300e-07 |
| i <sub>y</sub> [mm], i <sub>z</sub> [mm]                                 | 22                                                                                  | 22         |
| W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ] | 1.7800e-05                                                                          | 1.7800e-05 |
| W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ] | 2.1900e-05                                                                          | 2.1900e-05 |
| M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]                       | 5141.72                                                                             | 5141.72    |
| M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]                       | 5141.72                                                                             | 5141.72    |
| d <sub>y</sub> [mm], d <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |
| I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]       | 8.6400e-07                                                                          | 3.2400e-10 |
| β <sub>y</sub> [mm], β <sub>z</sub> [mm]                                 | 0                                                                                   | 0          |



| Explanations of symbols |                                                                                   |
|-------------------------|-----------------------------------------------------------------------------------|
| Formcode                | h - Height<br>b - Width<br>s - Thickness<br>r - Outer radius<br>r1 - Inner radius |
| A                       | Area                                                                              |
| A <sub>y</sub>          | Shear Area in principal y-direction                                               |
| A <sub>z</sub>          | Shear Area in principal z-direction                                               |
| A <sub>L</sub>          | Circumference per unit length                                                     |
| A <sub>D</sub>          | Drying surface per unit length                                                    |
| C <sub>y,UCS</sub>      | Centroid coordinate in Y-direction of Input axis system                           |
| C <sub>z,UCS</sub>      | Centroid coordinate in Z-direction of Input axis system                           |
| I <sub>y,LCS</sub>      | Second moment of area about the YLCS axis                                         |
| I <sub>z,LCS</sub>      | Second moment of area about the ZLCS axis                                         |
| I <sub>yz,LCS</sub>     | Product moment of area in the LCS system                                          |
| α                       | Rotation angle of the principal axis system                                       |
| I <sub>y</sub>          | Second moment of area about the principal y-axis                                  |
| I <sub>z</sub>          | Second moment of area about the principal z-axis                                  |
| i <sub>y</sub>          | Radius of gyration about the principal y-axis                                     |

| Explanations of symbols |                                                                             |
|-------------------------|-----------------------------------------------------------------------------|
| i <sub>z</sub>          | Radius of gyration about the principal z-axis                               |
| W <sub>el,y</sub>       | Elastic section modulus about the principal y-axis                          |
| W <sub>el,z</sub>       | Elastic section modulus about the principal z-axis                          |
| W <sub>pl,y</sub>       | Plastic section modulus about the principal y-axis                          |
| W <sub>pl,z</sub>       | Plastic section modulus about the principal z-axis                          |
| M <sub>pl,y,+</sub>     | Plastic moment about the principal y-axis for a positive My moment          |
| M <sub>pl,y,-</sub>     | Plastic moment about the principal y-axis for a negative My moment          |
| M <sub>pl,z,+</sub>     | Plastic moment about the principal z-axis for a positive Mz moment          |
| M <sub>pl,z,-</sub>     | Plastic moment about the principal z-axis for a negative Mz moment          |
| d <sub>y</sub>          | Shear center coordinate in principal y-direction measured from the centroid |
| d <sub>z</sub>          | Shear center coordinate in principal z-direction measured from the centroid |
| I <sub>t</sub>          | Torsional constant                                                          |
| I <sub>w</sub>          | Warping constant                                                            |
| β <sub>y</sub>          | Mono-symmetry constant about the principal y-axis                           |
| β <sub>z</sub>          | Mono-symmetry constant about the principal z-axis                           |

### 3.2. EC-EN 1993 Steel check ULS

Linear calculation

Class: All ULS

Coordinate system: Principal

Extreme 1D: Global

Selection: Named selection - Schoorstaven

#### EN 1993-1-1 Code Check

National annex: Dutch NEN-EN NA

|             |                 |              |       |         |        |
|-------------|-----------------|--------------|-------|---------|--------|
| Member B263 | 0,000 / 2,388 m | SHS60/60/5.0 | S 235 | All ULS | 0,78 - |
|-------------|-----------------|--------------|-------|---------|--------|

| Combination key |                                                      |
|-----------------|------------------------------------------------------|
| All ULS /       | $1.10 \cdot EG + 1.10 \cdot Perm + 1.35 \cdot Wind1$ |

| Partial safety factors                         |      |
|------------------------------------------------|------|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability    | 1,00 |
| $\gamma_{M2}$ for resistance of net sections   | 1,25 |

| Material          |       |        |     |
|-------------------|-------|--------|-----|
| Yield strength    | $f_y$ | 235,0  | MPa |
| Ultimate strength | $f_u$ | 360,0  | MPa |
| Fabrication       |       | Rolled |     |

....SECTION CHECK:....

The critical check is on position 0,000 m

| Internal forces |            | Calculated | Unit |
|-----------------|------------|------------|------|
| Normal force    | $N_{Ed}$   | -108,90    | kN   |
| Shear force     | $V_{y,Ed}$ | 0,00       | kN   |
| Shear force     | $V_{z,Ed}$ | 0,11       | kN   |
| Torsion         | $T_{Ed}$   | 0,00       | kNm  |
| Bending moment  | $M_{y,Ed}$ | 0,00       | kNm  |
| Bending moment  | $M_{z,Ed}$ | 0,00       | kNm  |

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m <sup>2</sup> ] | $\sigma_2$ [kN/m <sup>2</sup> ] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|----|------|--------|--------|---------------------------------|---------------------------------|------------|----------------|--------------|---------|-------------------|-------------------|-------------------|-------|
| 1  | I    | 45     | 5      | 101488,175                      | 101488,175                      | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |
| 3  | I    | 45     | 5      | 101488,175                      | 101488,175                      | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |
| 5  | I    | 45     | 5      | 101488,175                      | 101488,175                      | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |
| 7  | I    | 45     | 5      | 101488,175                      | 101488,175                      | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

|                        |            |            |                |
|------------------------|------------|------------|----------------|
| Cross-section area     | A          | 1,0700e-03 | m <sup>2</sup> |
| Compression resistance | $N_{c,Rd}$ | 251,45     | kN             |
| Unity check            |            | 0,43       | -              |

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

|                                    |               |            |                |
|------------------------------------|---------------|------------|----------------|
| Shear correction factor            | $\eta$        | 1,20       |                |
| Shear area                         | $A_v$         | 5,3500e-04 | m <sup>2</sup> |
| Plastic shear resistance for $V_z$ | $V_{pl,z,Rd}$ | 72,59      | kN             |
| Unity check                        |               | 0,00       | -              |

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

|                          |          |       |     |
|--------------------------|----------|-------|-----|
| Index of fibre           | Fibre    | 1     |     |
| Total torsional moment   | $T_{Ed}$ | 0,0   | MPa |
| Elastic shear resistance | $T_{Rd}$ | 135,7 | MPa |
| Unity check              |          | 0,00  | -   |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

The member satisfies the section check.

# ....:STABILITY CHECK:....

## Classification for member buckling design

Decisive position for stability classification: 1,194 m

Decisive utilisation factor  $\eta$ : 0,44

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m <sup>2</sup> ] | $\sigma_2$ [kN/m <sup>2</sup> ] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|----|------|--------|--------|---------------------------------|---------------------------------|------------|----------------|--------------|---------|-------------------|-------------------|-------------------|-------|
| 1  | I    | 45     | 5      | 98152,477                       | 98152,477                       | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |
| 3  | I    | 45     | 5      | 98758,967                       | 104217,383                      | 0,9        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,7              | 1     |
| 5  | I    | 45     | 5      | 104823,873                      | 104823,873                      | 1,0        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,0              | 1     |
| 7  | I    | 45     | 5      | 104217,383                      | 98758,967                       | 0,9        |                | 1,0          | 9,0     | 28,0              | 34,0              | 38,7              | 1     |

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

**Note:** The decisive position for the stability classification is based on the utilisation factor  $\eta$  according to Semi-Comp+.

## Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters  |                   | yy     | zz       |    |
|----------------------|-------------------|--------|----------|----|
| Sway type            |                   | sway   | non-sway |    |
| System length        | L                 | 2,388  | 2,388    | m  |
| Buckling factor      | k                 | 1,00   | 1,00     |    |
| Buckling length      | $l_{cr}$          | 2,388  | 2,388    | m  |
| Critical Euler load  | $N_{cr}$          | 193,78 | 193,79   | kN |
| Slenderness          | $\lambda$         | 106,98 | 106,98   |    |
| Relative slenderness | $\lambda_{rel}$   | 1,14   | 1,14     |    |
| Limit slenderness    | $\lambda_{rel,0}$ | 0,20   | 0,20     |    |
| Buckling curve       | a                 | a      | a        |    |
| Imperfection         | $\alpha$          | 0,21   | 0,21     |    |
| Reduction factor     | $\chi$            | 0,57   | 0,57     |    |
| Buckling resistance  | $N_{b,Rd}$        | 143,22 | 143,22   | kN |

| Flexural Buckling verification |            |            |                |
|--------------------------------|------------|------------|----------------|
| Cross-section area             | A          | 1,0700e-03 | m <sup>2</sup> |
| Buckling resistance            | $N_{b,Rd}$ | 143,22     | kN             |
| Unity check                    |            | 0,76       | -              |

## Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

## Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters |             |                      |                |
|------------------------------------------------|-------------|----------------------|----------------|
| Interaction method                             |             | alternative method 2 |                |
| Cross-section area                             | A           | 1,0700e-03           | m <sup>2</sup> |
| Plastic section modulus                        | $W_{pl,y}$  | 2,1900e-05           | m <sup>3</sup> |
| Design compression force                       | $N_{Ed}$    | 108,90               | kN             |
| Design bending moment (maximum)                | $M_{y,Ed}$  | 0,06                 | kNm            |
| Design bending moment (maximum)                | $M_{z,Ed}$  | 0,00                 | kNm            |
| Characteristic compression resistance          | $N_{Rk}$    | 251,45               | kN             |
| Characteristic moment resistance               | $M_{y,Rk}$  | 5,15                 | kNm            |
| Reduction factor                               | $\chi_y$    | 0,57                 |                |
| Reduction factor                               | $\chi_z$    | 0,57                 |                |
| Reduction factor                               | $\chi_{LT}$ | 1,00                 |                |
| Interaction factor                             | $k_{yy}$    | 1,45                 |                |

#### Bending and axial compression check parameters

|                    |          |      |  |
|--------------------|----------|------|--|
| Interaction factor | $k_{zy}$ | 0,87 |  |
|--------------------|----------|------|--|

Maximum moment  $M_{y,Ed}$  is derived from beam B263 position 1,194 m.  
Maximum moment  $M_{z,Ed}$  is derived from beam B263 position 0,000 m.

#### Interaction method 2 parameters

|                                |                 |             |     |
|--------------------------------|-----------------|-------------|-----|
| Method for interaction factors |                 | Table B.1   |     |
| Sway type y                    |                 | sway        |     |
| Equivalent moment factor       | $C_{my}$        | 0,90        |     |
| Resulting load type LT         |                 | line load q |     |
| End moment                     | $M_{h,LT}$      | 0,00        | kNm |
| Field moment                   | $M_{s,LT}$      | 0,06        | kNm |
| Factor                         | $\alpha_{h,LT}$ | 0,00        |     |
| Ratio of end moments           | $\psi_{LT}$     | 1,00        |     |
| Equivalent moment factor       | $C_{mLT}$       | 0,95        |     |

Unity check (6.61) =  $0,76 + 0,02 + 0,00 = 0,78$  -

Unity check (6.62) =  $0,76 + 0,01 + 0,00 = 0,77$  -

The member satisfies the stability check.

### 3.3. EC-EN 1993 Steel check ULS; Section check

Values:  $UC_{Overall}$

Linear calculation

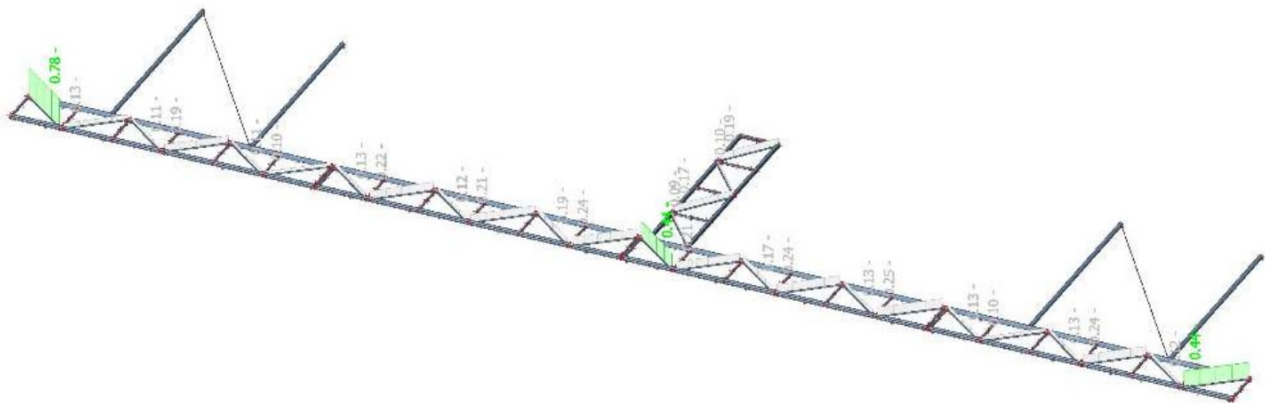
Class: All ULS

Coordinate system: Principal

Extreme 1D: Member

Selection: Named selection -

Schoorstaven





Vertrouwelijk



## A3 Verificaties

**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
18/07/2023  
2

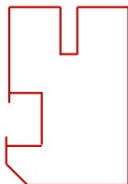
## Toetsing Aluminium Langsprofiel

### Omschrijving

In deze verificatiesheet wordt de doorsnedecapaciteit van het aluminium langsprofiel getoetst. De doorsnede is geschematiseerd als een rechthoekigkokerprofiel. Waarbij de dwarskracht door één lijf wordt opgenomen. Dit is een conservatieve benadering, gezien de werkelijk doorsnedegrootheden (A, Av, Wy, Wpl) in werkelijkheid groter zijn dan geschematiseerd.

### Referenties:

NEN-EN 1999-1-1+A1:2011  
SCIA berekenings uitvoer



Schets werkelijke geometrie



Schets model geometrie

Als alternatief kan er een koker 70x40x3mm worden toegepast  
Deze is aanzienlijk sterker dan

### Invoer

#### Geometrie

Profiel: Geschematiseerd als Rechthoekigkoker profiel

Breedte profiel

Hoogte profiel

Wanddikte

|   |      |    |
|---|------|----|
| b | 45.0 | mm |
| h | 70.0 | mm |
| t | 1.5  | mm |

Oppervlakte profiel

Oppervlak voor afschuiving

Reductie factor afschuiving

Gereduceerd oppervlak voor afschuiving

|        |       |                    |
|--------|-------|--------------------|
| A      | 336.0 | mm <sup>2</sup>    |
| Av     | 210   | mm <sup>2</sup>    |
| red    | 0.5   | [1 lijf werkt mee] |
| Av.red | 105   | mm <sup>2</sup>    |

Traagheidsmoment

Elastisch weerstandsmoment

Plastisch weerstandsmoment

Reductiefactor buigweerstand

Gereduceerd elastisch weerstandsmoment

Gereduceerd plastisch weerstandsmoment

|                       |        |                 |
|-----------------------|--------|-----------------|
| I <sub>y</sub>        | 233580 | mm <sup>4</sup> |
| W <sub>y,el</sub>     | 5327   | mm <sup>3</sup> |
| W <sub>y,pl</sub>     | 7991   | mm <sup>3</sup> |
| red                   | 1.0    |                 |
| W <sub>y,el,red</sub> | 5327   | mm <sup>3</sup> |
| W <sub>y,pl,red</sub> | 7991   | mm <sup>3</sup> |

#### Materiaaleigenschappen

Legering ENAW

Spanning 0.2% rekgrens

Treksterkte

E-modulus

|                  |                         |
|------------------|-------------------------|
| 6063T6           |                         |
| f <sub>0.2</sub> | 190 N/mm <sup>2</sup>   |
| f <sub>t</sub>   | 220 N/mm <sup>2</sup>   |
| E                | 70000 N/mm <sup>2</sup> |

Partiële factor

Partiële factor

|                 |   |
|-----------------|---|
| γ <sub>M0</sub> | 1 |
| γ <sub>M1</sub> | 1 |

[berekende waarde voldoende conservatief, W voor werkelijke doorsnede ca 20-30% hoger]  
[W<sub>y,el,scia</sub> = 7022mm<sup>3</sup>]  
[W<sub>y,pl,scia</sub> = 9460mm<sup>3</sup>]

#### Belastingen (Scia Uitvoer)

Buigend moment

Dwarskracht

|                   |      |     |
|-------------------|------|-----|
| M <sub>y,Ed</sub> | 1.0  | kNm |
| V <sub>z,Ed</sub> | 2.16 | kN  |

### Doorsnede Classificatie - Buiging

#### Gelijkmatig spanningsverloop in het lijf - onder buiging

Interne hoogte

Plaatdikte

Slankheid van lijf onder buiging

|                     |      |    |
|---------------------|------|----|
| h <sub>i</sub>      | 67   | mm |
| t                   | 1.5  | mm |
| β <sub>M,lijf</sub> | 17.9 | -  |

0.4 x h<sub>i</sub> / t

#### Continue drukspanning in onderflens (druk in onderflens bij steunpuntsmoment)

Breedte van hoeklijn

Interne breedte onverstijfd plaatdeel

Plaatdikte

Slankheid van flens onder buiging

|                      |      |    |
|----------------------|------|----|
| s                    | 9    | mm |
| b <sub>i</sub>       | 34.5 | mm |
| t                    | 1.5  | mm |
| β <sub>M,flens</sub> | 23.0 | -  |

b<sub>i</sub> / t

Maximum slankheid (flens of lijf)

|                |      |
|----------------|------|
| β <sub>M</sub> | 23.0 |
|----------------|------|

#### Klassificatie voorwaarden voor buiging [EN1998-1-1 tab 6.2]

Materiaal klasse A, zonder lassen, inwendig deel

Max slankheid voor doorsnedeklasse 1

Max slankheid voor doorsnedeklasse 2

Max slankheid voor doorsnedeklasse 3

|                |       |
|----------------|-------|
| ε              | 1.147 |
| β <sub>1</sub> | 12.62 |
| β <sub>2</sub> | 18.35 |
| β <sub>3</sub> | 25.24 |

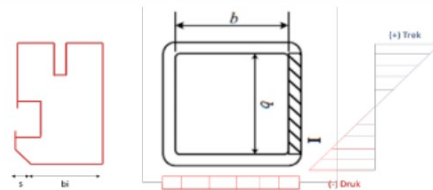
Doorsnede klasse voor toetsing op buiging

**Klasse 3 - geen plooi-toetsing noodzakelijk**

Plasticiteitsfactor α<sub>pl</sub> = Min[vormfactor α<sub>3,u</sub>; W<sub>pl</sub>/W<sub>el</sub>]

|   |     |
|---|-----|
| α | 1.2 |
|---|-----|

$$\alpha_{3,u} = 1 + \left( \frac{\beta_3 - \beta}{\beta_3 - \beta_2} \right) \left( \frac{W_{pl}}{W_{el}} - 1 \right)$$



Tabel 6.2 — Slankheidsparameters β<sub>1</sub>/ε, β<sub>2</sub>/ε en β<sub>3</sub>/ε

| Materiaalclassificatie volgens tabel 3.2 | Inwendig deel     |                   |                   | Uitwendig deel    |                   |                   |
|------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                                          | β <sub>1</sub> /ε | β <sub>2</sub> /ε | β <sub>3</sub> /ε | β <sub>1</sub> /ε | β <sub>2</sub> /ε | β <sub>3</sub> /ε |
| Klasse A, zonder lassen                  | 11                | 16                | 22                | 3                 | 4.5               | 6                 |
| Klasse A, met lassen                     | 9                 | 13                | 18                | 2.5               | 4                 | 5                 |
| Klasse B, zonder lassen                  | 13                | 16.5              | 18                | 3.5               | 4.5               | 5                 |
| Klasse B, met lassen                     | 10                | 13.5              | 15                | 3                 | 3.5               | 4                 |

ε = √(250/f<sub>yk</sub>), f<sub>yk</sub> in N/mm<sup>2</sup>

**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
[Redacted]  
18/07/2023  
2

### Toetsing Aluminium Langsprofiel

#### Doorsnedeklassificatie - Afschuiving

|                                             |                                       |       |                                      |
|---------------------------------------------|---------------------------------------|-------|--------------------------------------|
| Interne hoogte                              | hi                                    | 67    | mm                                   |
| Plaatdikte                                  | t                                     | 1.5   | mm                                   |
| Slankheid van lijf onder afschuiving        | $\beta_v$                             | 44.7  | -                                    |
|                                             |                                       |       | hi / t                               |
|                                             | $\epsilon$                            | 1.147 | -                                    |
| Max slankheid voor afschuiving zonder plooi | $\beta_{slank}$                       | 44.7  | $\beta_{slank} = 39 \times \epsilon$ |
| Conclusie                                   | Niet Slank - afschuiving zonder plooi |       |                                      |

#### Verificatie Doorsnedecapaciteit

##### Verificatie Buigweerstand

|                                           |              |      |                                              |
|-------------------------------------------|--------------|------|----------------------------------------------|
| Rekenwaarde buigend moment (SCIA uitvoer) | $M_{ed}$     | 1.04 | kNm                                          |
| Weerstand                                 | $M_{c,Rd}$   | 1.18 | kNm                                          |
| Unity Check                               | $UC_{bets1}$ | 0.88 | -                                            |
|                                           |              |      | $M_{c,Rd} = \alpha W_{el} f_o / \gamma_{M1}$ |
|                                           |              |      | $\frac{M_{Ed}}{M_{Rd}} \leq 1.0$             |

##### Verificatie Dwarskracht

|                                        |              |      |                                                 |
|----------------------------------------|--------------|------|-------------------------------------------------|
| Rekenwaarde dwarskracht (SCIA uitvoer) | $V_{ed}$     | 2.16 | kN                                              |
| Weerstand                              | $V_{Rd}$     | 23.0 | kN                                              |
| Unity Check                            | $UC_{bets2}$ | 0.09 | -                                               |
|                                        |              |      | $V_{Rd} = A_v \frac{f_o}{\sqrt{3} \gamma_{M1}}$ |
|                                        |              |      | $\frac{V_{Ed}}{V_{Rd}} \leq 1.0$                |

##### Gecombineerde buiging en dwarskrachtsverificatie

De bijdrage van de dwarskracht mag verwaarloosd worden  $V_{ed} < 0.5 V_{Rd}$

**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
2

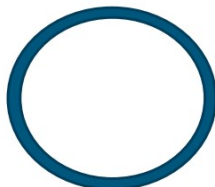
## Toetsing Aluminium buisprofiel

### Omschrijving

In deze verificatiesheet wordt de doorsnedecapaciteit van het aluminium stangen getoetst.  
Een aluminium buisprofiel wordt toegepast als stang.

### Referenties:

NEN-EN 1999-1-1+A1:2011  
SCIA berekenings uitvoer



Doorsnede

## Invoer

### Geometrie

|                 |   |       |    |
|-----------------|---|-------|----|
| Buiten diameter | D | 159.0 | mm |
| Binnen diameter | d | 147.0 | mm |
| Wanddikte       | t | 6.0   | mm |

|                                        |        |      |                 |
|----------------------------------------|--------|------|-----------------|
| Oppervlakte profiel                    | A      | 2884 | mm <sup>2</sup> |
| Oppervlak voor afschuiving             | Av     | 1836 | mm <sup>2</sup> |
| Reductie factor afschuiving            | red    | 1.0  |                 |
| Gereduceerd oppervlak voor afschuiving | Av.red | 1836 | mm <sup>2</sup> |

|                                        |                       |         |                 |
|----------------------------------------|-----------------------|---------|-----------------|
| Traagheidsmoment                       | I <sub>y</sub>        | 8451870 | mm <sup>4</sup> |
| Elastisch weerstandsmoment             | W <sub>y,el</sub>     | 106313  | mm <sup>3</sup> |
| Plastisch weerstandsmoment             | W <sub>y,pl</sub>     | 140526  | mm <sup>3</sup> |
| Reductiefactor buigweerstand           | red                   | 1.0     |                 |
| Gereduceerd elastisch weerstandsmoment | W <sub>y,el,red</sub> | 106313  | mm <sup>3</sup> |
| Gereduceerd plastisch weerstandsmoment | W <sub>y,pl,red</sub> | 140526  | mm <sup>3</sup> |
| Kniklengte                             | L <sub>cr</sub>       | 8000    | mm              |

### Belastingen (Scia Uitvoer)

|                    |         |        |     |
|--------------------|---------|--------|-----|
| Normaalkracht trek | N.t.Ed  | 15.45  | kN  |
| Normaalkracht druk | N.d.Ed  | -73.50 | kN  |
| Buigend moment     | M.y.Ed  | 0.73   | kNm |
| Dwarskracht        | V.z.E.d | 0.35   | kN  |

### Materiaaleigenschappen

|                        |                |        |                   |
|------------------------|----------------|--------|-------------------|
| Legering ENAW          |                | 6063T6 |                   |
| Spanning 0.2% rekgrens | f <sub>0</sub> | 190    | N/mm <sup>2</sup> |
| Treksterkte            | f <sub>u</sub> | 220    | N/mm <sup>2</sup> |
| E-modulus              | E              | 70000  | N/mm <sup>2</sup> |

|                 |                 |   |
|-----------------|-----------------|---|
| Partiële factor | γ <sub>M0</sub> | 1 |
| Partiële factor | γ <sub>M1</sub> | 1 |

| Name | dx [m] | Case  | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|------|--------|-------|--------|---------|---------|----------|----------|----------|
| B417 | 0.000  | C04/1 | -73.49 | 0.00    | 0.34    | 0.00     | 0.00     | 0.00     |
| B415 | 0.000  | C04/1 | 15.45  | 0.00    | 0.35    | -0.08    | 0.00     | 0.00     |
| B416 | 8.000  | C04/1 | -56.25 | 0.00    | -0.34   | 0.00     | 0.00     | 0.00     |
| B418 | 0.000  | C03/2 | 0.00   | 0.00    | 0.35    | -0.09    | 0.00     | 0.00     |
| B418 | 4.000  | C03/2 | 0.00   | 0.00    | 0.02    | -0.09    | 0.73     | 0.00     |
| B418 | 8.000  | C04/1 | -0.52  | 0.00    | -0.32   | -0.08    | 0.12     | 0.00     |
| B415 | 8.000  | C04/3 | -17.29 | 0.00    | -0.32   | -0.08    | 0.12     | 0.00     |

## Doorsnede Classificatie - Buiging

### Gelijkmatig spanningsverloop in doorsnede - onder buiging

|                |                    |      |    |
|----------------|--------------------|------|----|
| Profiel hoogte | h <sub>i</sub>     | 135  | mm |
| Plaatdikte     | t                  | 6.0  | mm |
| Slankheid      | β <sub>M,ijf</sub> | 22.5 | -  |
|                | h <sub>i</sub> / t |      |    |

### Maximum slankheid

|                |      |
|----------------|------|
| β <sub>M</sub> | 22.5 |
|----------------|------|

### Klassificatie voorwaarden voor buiging [EN1998-1-1 tab 6.2]

Materiaal klasse A, zonder lassen, inwendig deel

|                                      |            |       |
|--------------------------------------|------------|-------|
|                                      | $\epsilon$ | 1.147 |
| Max slankheid voor doorsnedeklasse 1 | $\beta_1$  | 12.62 |
| Max slankheid voor doorsnedeklasse 2 | $\beta_2$  | 18.35 |
| Max slankheid voor doorsnedeklasse 3 | $\beta_3$  | 25.24 |

### Doorsnede klasse voor toetsing op buiging

Klasse 3 - geen plooi-toetsing noodzakelijk

Plasticiteitsfactor α<sub>pl</sub> = Min[vormfactor α<sub>3u</sub>; W<sub>pl</sub>/W<sub>el</sub>]

|   |     |
|---|-----|
| α | 1.1 |
|---|-----|

$$\alpha_{3,u} = \left[ 1 + \left( \frac{\beta_3 - \beta}{\beta_3 - \beta_2} \right) \left( \frac{W_{pl}}{W_{el}} - 1 \right) \right]$$

Tabel 6.2 — Slankheidsparameters β<sub>1</sub>/ε, β<sub>2</sub>/ε en β<sub>3</sub>/ε

| Materiaalclassificatie volgens tabel 3.2 | Inwendig deel     |                   |                   | Uitwendig deel    |                   |                   |
|------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                                          | β <sub>1</sub> /ε | β <sub>2</sub> /ε | β <sub>3</sub> /ε | β <sub>1</sub> /ε | β <sub>2</sub> /ε | β <sub>3</sub> /ε |
| Klasse A, zonder lassen                  | 11                | 16                | 22                | 3                 | 4.5               | 6                 |
| Klasse A, met lassen                     | 9                 | 13                | 18                | 2.5               | 4                 | 5                 |
| Klasse B, zonder lassen                  | 13                | 16.5              | 18                | 3.5               | 4.5               | 5                 |
| Klasse B, met lassen                     | 10                | 13.5              | 15                | 3                 | 3.5               | 4                 |

$$\epsilon = \sqrt{250/f_{0.2}} \cdot \epsilon_0 \text{ in N/mm}^2$$

**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

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**Datum**  
**Pagina's**

1  
10/07/2023  
2

## Toetsing Aluminium buisprofiel

### Doorsnedeklassificatie - Afschuiving

|                                             |                                       |       |    |                                      |
|---------------------------------------------|---------------------------------------|-------|----|--------------------------------------|
| Interne hoogte                              | hi                                    | 159.0 | mm |                                      |
| Plaatdikte                                  | t                                     | 6.0   | mm |                                      |
| Slankheid van lijf onder afschuiving        | $\beta_v$                             | 26.5  | -  | hi / t                               |
|                                             | $\epsilon$                            | 1.147 | -  |                                      |
| Max slankheid voor afschuiving zonder plooi | $\beta_{slank}$                       | 44.7  | -  | $\beta_{slank} = 39 \times \epsilon$ |
| Conclusie                                   | Niet Slank - afschuiving zonder plooi |       |    |                                      |

### Verificatie Doorsnedecapaciteit

#### Verificatie axial trek

Materiaal klasse A, zonder lassen en boutgaten  
Brutto oppervlak  
Weerstand  
Rekenwaarde buigend moment (SCIA uitvoer)  
Unity Check

|                    |       |    |                                    |
|--------------------|-------|----|------------------------------------|
| $A_g$              | 2884  | 0  |                                    |
| N.t.Rd             | 548   | kN | $N_{o,Rd} = A_g f_o / \gamma_{M1}$ |
| N.t.Ed             | 15.45 | kN | $\frac{N_{Ed}}{N_{t,Rd}} \leq 1.0$ |
| UC <sub>bets</sub> | 0.03  | -  |                                    |

#### Verificatie axial druk

Materiaal klasse A, zonder lassen en boutgaten  
Brutto oppervlak  
Weerstand  
Rekenwaarde buigend moment (SCIA uitvoer)  
Unity Check

|                    |        |   |                                        |
|--------------------|--------|---|----------------------------------------|
| $A_g$              | 2884   |   |                                        |
| N.d.Rd             | 548    |   | $N_{c,Rd} = A_{eff} f_o / \gamma_{M1}$ |
| N.d.Ed             | -73.50 |   | $\frac{N_{Ed}}{N_{c,Rd}} \leq 1.0$     |
| UC <sub>bets</sub> | 0.13   | - |                                        |

#### Verificatie Buigweerstand

Rekenwaarde buigend moment (SCIA uitvoer)  
Weerstand  
Unity Check

|                     |       |     |                                         |
|---------------------|-------|-----|-----------------------------------------|
| $M_{ed}$            | 0.73  | kNm |                                         |
| $M_{c,Rd}$          | 22.78 | kNm | $M_{c,Rd} = a W_{el} f_o / \gamma_{M1}$ |
| UC <sub>bets1</sub> | 0.03  | -   | $\frac{M_{Ed}}{M_{Rd}} \leq 1.0$        |

#### Verificatie Dwarskracht

Rekenwaarde dwarskracht (SCIA uitvoer)  
Weerstand  
Unity Check

|                     |       |    |                                                 |
|---------------------|-------|----|-------------------------------------------------|
| $V_{ed}$            | 0.35  | kN |                                                 |
| $V_{Rd}$            | 201.4 | kN | $V_{Rd} = A_v \frac{f_o}{\sqrt{3} \gamma_{M1}}$ |
| UC <sub>bets2</sub> | 0.00  | -  | $\frac{V_{Ed}}{V_{Rd}} \leq 1.0$                |

#### Gecombineerde buiging en dwarskrachtsverificatie

De bijdrage van de dwarskracht mag verwaarloosd worden  $V_{ed} < 0.5 V_{Rd}$

### Verificatie stabiliteit

Materiaal klasse A, zonder lassen en boutgaten

|                                        |                    |        |    |             |     |
|----------------------------------------|--------------------|--------|----|-------------|-----|
| Kritieke elastische kracht             | $N_{cr}$           | 91.2   | kN | $\lambda_0$ | 0.1 |
| Slankheid                              | $\lambda$          | 2.5    |    | $\alpha$    | 0.2 |
|                                        | $\phi$             | 3.7    |    |             |     |
|                                        | $\chi$             | 0.2    |    |             |     |
| Rekenwaarde dwarskracht (SCIA uitvoer) | N.d.Ed             | -73.50 |    |             |     |
| Weerstand                              | N.b.Rd             | 83.52  | kN |             |     |
|                                        | UC <sub>bets</sub> | 0.88   | -  |             |     |



**Project:** BI7934 Interboat - Schipperskerk  
**Onderdeel:** Bijlage 3 - Verificaties  
**Datum:** 12/07/2023  
**Auteur:** A.Akyel

**Versie Rekenblad:** 1.1  
**Gecontroleerd door:** [REDACTED]  
**Datum:** 18/07/2023  
**Pagina's:** 9

## Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]

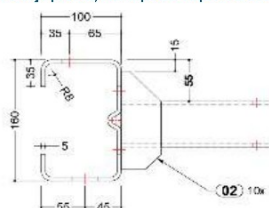
### Beschrijving van de berekening:

In deze berekening wordt de hoofdligger van het steigerframe, uitgevoerd als koudgewalst C-profiel geleverd. Hierbij wordt getoetst op de weerstand tegen interne krachten en stabiliteit. Het C-profiel is voor de berekening iets vereenvoudigd geschematiseerd, zoals weergegeven hieronder. De verstijving in het lijf van de doorsnede heeft een gunstig effect op de totale doorsnede echter kan het zijn dat het een kleine reductie geeft bij buiging om de z-as en dwarskracht. De doorsnede heeft een lage slankheid, waardoor deze als Klasse 2 - Klasse 3 is te beschouwen. Dit geeft aan de weerstand tegen lokale instabiliteit hoog is. Daarom wordt het effect van de verstijving verwaarloosbaar geacht. Het effect van gaten is wel meegenomen in de toetsing.

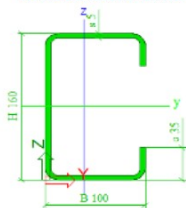
### Referenties:

EN1993-1-1 Ontwerp staalconstructies algemeen  
EN1993-1-3 Koudgevormde profielen  
Bouwen Met Staal - Technisch Dossier 4  
Bouwen Met Staal - Rekensteels voor effectieve doorsnede param  
<https://www.bouwenmetstaal.nl/tools/berekenen>  
SCIA berekeningsuitvoer

### Werkelijk profiel, incl kipsteun t.p.v. verbinding dwarsligger



### Geschematiseerd doorsnede



## Invoer

### Geometrie

Hoogte van C-sectie  
Breedte van C-sectie  
Liphoogte  
Dikte  
Radius t.p.v. hoeken

|     |     |    |
|-----|-----|----|
| $h$ | 160 | mm |
| $b$ | 100 | mm |
| $c$ | 35  | mm |
| $t$ | 5   | mm |
| $r$ | 8   | mm |

### Materiaaleigenschappen

|                 |          |        |                   |
|-----------------|----------|--------|-------------------|
| Staal kwaliteit |          | S355   |                   |
| Vloei spanning  | $f_{yb}$ | 355    | N/mm <sup>2</sup> |
| Treksterkte     | $f_u$    | 510    | N/mm <sup>2</sup> |
| E-modulus       | $E_s$    | 210000 | N/mm <sup>2</sup> |
| G-modulus       | G        | 80769  | N/mm <sup>2</sup> |
| Poisson Ratio   | $\nu$    | 0.3    | -                 |

### Geometrie

Kniklengte t.b.v. Kipstabiliteit (lateral torsion buckling)  
Kniklengte t.b.v. Knikstabiliteit (compression buckling)

|              |      |   |
|--------------|------|---|
| $L_{kip}$    | 1.98 | m |
| $L_{knik,y}$ | 5.50 | m |
| $L_{knik,z}$ | 1.98 | m |

### Materiaalfactoren

|               |      |
|---------------|------|
| $\gamma_{M0}$ | 1.0  |
| $\gamma_{M1}$ | 1.0  |
| $\gamma_{M2}$ | 1.25 |

### Belastingen (SCIA uitvoer)

#### Externen

|         |        |     |
|---------|--------|-----|
| M.y.Ed+ | 16.3   | kNm |
| M.y.Ed- | 9.53   | kNm |
| M.z.Ed  | 13.79  | kNm |
| V.y.Ed  | 66.18  | kN  |
| V.z.Ed  | 7.3    | kN  |
| NE.t.d  | 104.1  | kN  |
| NE.c.d  | -123.6 | kN  |
| R.Ed    | nvt    | kN  |

### Gecombineerde krachten (samen optredend in 1 doorsnede)

|        | N.Ed [kN] | V.y.Ed [kN] | V.z.Ed [kN] | M.y.Ed [kNm] | M.z.Ed[kNm] |
|--------|-----------|-------------|-------------|--------------|-------------|
| NE.c.d | -123.5    | 10.49       | 0.73        | 1.81         | 1.11        |
| NE.t.d | 104.4     | 8.02        | 0.17        | 1.33         | 5.38        |
| V.y.Ed | -18.65    | 66.29       | 1.25        | 0.99         | 8.4         |
| V.z.Ed | 0.95      | 1.72        | 7.3         | 2.07         | 0.2         |
| M.y.Ed | -11.45    | 0           | 1.65        | 16.4         | 0           |
| M.y.Ed | 0         | 0           | 0.67        | 9.51         | 0           |
| M.z.Ed | 16.21     | 57.5        | 1.16        | 0.47         | 14.72       |
| M.z.Ed | 21.19     | 16.44       | 1.41        | 1.52         | 9.95        |

### Ongereduceerde en effectieve doorsnede-eigenschappen [Zonder gat aftrek]

De effectieve doorsnede-eigenschappen zijn bepaald met behulp van de Rekensteels van Bouwen Met Staal, zie link: <https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

De bruto doorsnede-eigenschappen zijn bepaald m.b.v. SCIA engineers (zie berekeningsuitvoer)

Let op, deze doorsnedeparameters zijn niet gereduceerd m.b.t. gataftrek, dit zal bij de relevante verificaties worden gedaan.

| Eigenschappen van de bruto doorsnede               |            |                         |
|----------------------------------------------------|------------|-------------------------|
| Plaatdikte                                         | $t$        | 5.00 mm                 |
| Doorsnede-oppervlak                                | $A_s$      | 1959.87 mm <sup>2</sup> |
| Dwarskrachtoppervlak y-as                          | $A_{xy}$   | 950                     |
| Dwarskrachtoppervlak z-as                          | $A_{xz}$   | 775                     |
| Hoogte neutrale lijn t.o.v. onderkant              | $z$        | 80.0                    |
| Y-coördinaat neutrale lijn t.o.v. buitenzijde lijf | $y$        | 39.1                    |
| Traagheidsmomenten                                 | $I_y$      | 7.941E+06               |
|                                                    | $I_z$      | 2.746E+06               |
| Traagheidsraalen                                   | $I_y$      | 63.7                    |
|                                                    | $I_z$      | 37.4                    |
| Weerstandsmoment Elastisch                         | $W_{y,el}$ | 9.926E+04               |
|                                                    | $W_{z,el}$ | 4.508E+04               |
| Weerstandsmomenten Plastisch                       | $W_{y,pl}$ | 1.163E+05               |
|                                                    | $W_{z,pl}$ | 6.528E+04               |
| Torsietraagheidsmoment                             | $I_t$      | 1.71E+04                |
| Wolwingstraagheidsmoment                           | $I_w$      | 1.99E+10                |

### Gereduceerde profieleigenschappen

|             |           |                 |        |
|-------------|-----------|-----------------|--------|
| $t_{red}$   | 5.00      |                 | factor |
| $A_{s,eff}$ | 1959.87   | mm <sup>2</sup> | 1      |
| $z_{eff}$   | 80.0      |                 |        |
| $y_{eff}$   | 39.1      |                 |        |
| $I_{y,eff}$ | 7.941E+06 | mm <sup>4</sup> | 1      |
| $I_{z,eff}$ | 2.746E+06 | mm <sup>4</sup> | 1      |
| $I_{y,eff}$ | 63.65     | mm              | 1      |
| $I_{z,eff}$ | 37.43     | mm              | 1      |
| $W_{y,eff}$ | 99257     | mm <sup>3</sup> | 1      |
| $W_{z,eff}$ | 45080     | mm <sup>3</sup> | 1      |

### Opmerkingen m.b.t. doorsnede-stabiliteit

Profiel doorsnede-klasse 2-3, weerstand mag worden verhoogd

!!  $A_s = A_{s,eff}$  - Verhoog normaal druk weerstand - Conform vergelijking EN1993-1-3 verg(6.3)

!!  $W_y = W_{y,eff}$  - Moment weerstand > elastisch - Conform EN1993-1-3 vergelijking (6.5)

!!  $W_y = W_{z,eff}$  - Moment weerstand > elastisch - Conform EN1993-1-3 vergelijking (6.5)

!! Geen verschuiving normaalkrachten centrum - M.Ed hoeft niet te worden verhoogd

### Invoer m.b.t. gaten in de doorsnede

In het profiel zijn verschillende gaten geboord t.b.v. het bevestigen van verschillende onderdelen zoals de drijvers, houten rand profielen, bolders etc.

Het effect van deze gaten wordt, indien nodig in rekening gebracht op de weerstand. Een overzicht van de gaten is hieronder gegeven.

|                                                   | [mm] | [mm <sup>2</sup> ] |                        |
|---------------------------------------------------|------|--------------------|------------------------|
| Gaten in bovenflens t.b.v. fixeren div onderdelen | 18   | 1                  | 90                     |
|                                                   |      |                    | Buiging, normaalkracht |

Project:  
Onderdeel  
Datum  
Auteur

BI7934 Interboat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

Versie Rekenblad:  
Gecontroleerd door:  
Datum  
Pagina's

1.1  
[Redacted]  
[Redacted]  
9

## Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]

|                                            |    |   |            |                        |
|--------------------------------------------|----|---|------------|------------------------|
| Gaten in lijf                              | 12 | 2 | 120        | normaalkracht          |
| Gaten in onderflens t.b.v fixeren drijvers | 32 | 1 | 160        | Buiging, normaalkracht |
| <b>totaal</b>                              |    |   | <b>370</b> |                        |

### Verificatie Doorsnedecapaciteit

#### Axiale Trek EN1993-1-3 art. 6.1.2

|                                                                     |            |        |                 |
|---------------------------------------------------------------------|------------|--------|-----------------|
| Opneembare trekkracht (zonder gataftrek)                            | $N_{t,Rd}$ | 696    | kN              |
| Netto doorsnede (gatafterk)                                         | $A_{net}$  | 1589.9 | mm <sup>2</sup> |
| Opneembare trekkracht in netto doorsnede                            | $N_{u,Rd}$ | 584    | kN              |
| Optredende trekkracht                                               | $N_{t,Ed}$ | 104.1  | kN              |
| $UC_{tens1} = \frac{N_{t,Ed}}{N_{u,Rd}} = \frac{104.1}{584} = 0.18$ |            |        |                 |

#### Normaalkracht - Druk EN1993-1-3 art. 6.2.4

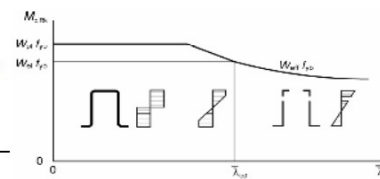
|                                                                                                                                                      |                            |       |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------|-------------------|
| Aantal 90° gebogen hoeken                                                                                                                            | n                          | 4     | -                 |
| Andere vorming                                                                                                                                       | k                          | 5     | -                 |
| Gemiddeld vloeispanning                                                                                                                              | $f_{yk}$                   | 395   | N/mm <sup>2</sup> |
| Slankheidsparameters plaatvelden                                                                                                                     | $\lambda_e$                | 0.38  | 0.36              |
| Referentie slankheid                                                                                                                                 | $\lambda_{e0}$             | 0.673 | 0.673             |
| Slankheids ratio                                                                                                                                     | $\lambda_e / \lambda_{e0}$ | 0.57  | 0.54              |
| Mobilisatie voor verschillende plaatvelden                                                                                                           | mob                        | 100%  | 100%              |
| Toegestane mobilisatie van plastische weerstand                                                                                                      |                            | 14%   | 14%               |
| $f_{ya} = f_{yb} + (f_u - f_{yb}) \frac{k n t^2}{A_g}$ but $f_{ya} \leq \frac{(f_u + f_{yb})}{2}$                                                    |                            |       |                   |
|                                                                                                                                                      | $N_{c,Rd}$                 | 707   | kN                |
|                                                                                                                                                      | $N_{c,Ed}$                 | 123.6 | kN                |
| $N_{c,Rd} = A_g (f_{yb} + (f_{ya} - f_{yb}) 4(1 - \bar{\lambda}_e / \bar{\lambda}_{e0})) / \gamma_{M0}$ but not more than $A_g f_{ya} / \gamma_{M0}$ |                            |       |                   |
| $UC_{tens2} = \frac{N_{c,Ed}}{N_{c,Rd}} = \frac{123.6}{707} = 0.17$                                                                                  |                            |       |                   |

#### Momentweerstand om sterke as (y-y) met druk in bovenflens - EN1993-1-3 art 6.1.4 - incl gataftrek

De momentweerstand met druk in de bovenflens dient gereduceerd te worden met het effect van de gaten in de onderflens. De gaten in het op druk belaste deel (de bovenflens) zijn namelijk gevuld met verbindingmiddelen. De doorsnede eigenschappen zijn bepaald met Scia Engineer.

#### Verhoging van "elastische" weerstand omdat $W_y = W_{y,eff}$

|                                                 |                            |        |                 |
|-------------------------------------------------|----------------------------|--------|-----------------|
| Gereduceerd elastisch moment                    | $W_{y,el,red}$             | 78956  | mm <sup>3</sup> |
| Gereduceerd plastisch moment                    | $W_{y,pl,red}$             | 102800 | mm <sup>3</sup> |
| Slankheidsparameters plaatvelden                | $\lambda_e$                | 0.38   | 0.36            |
| Referentie slankheid                            | $\lambda_{e0}$             | 0.673  | 0.673           |
| Slankheids ratio                                | $\lambda_e / \lambda_{e0}$ | 0.57   | 0.54            |
| Mobilisatie voor verschillende plaatvelden      | mob                        | 100%   | 100%            |
| Toegestane mobilisatie van plastische weerstand | Mob                        | 41%    | 41%             |



|                                                                       |                    |      |     |
|-----------------------------------------------------------------------|--------------------|------|-----|
| Opneembaar moment                                                     | M <sub>y,Rd+</sub> | 31.5 | kNm |
| Maximum moment (drukkracht in Bovenflens)                             | M <sub>y,Ed+</sub> | 16.3 | kNm |
| $UC_{bent3} = \frac{M_{y,Ed+}}{M_{y,Rd+}} = \frac{16.3}{31.5} = 0.52$ |                    |      |     |

#### Moment weerstand om sterke as (y-y) met druk in onderflens - EN1993-1-3 art 6.1.4 - incl gataftrek

De moment weerstand met druk in de onderflens dient gereduceerd te worden met het effect van de gaten in zowel de onder- als bovenflens. De gaten in het op druk belaste deel (t.b.v. verbinding met drijvers) zijn niet "gevuld" met verbindingmiddelen.

|                                                 |                |       |                         |
|-------------------------------------------------|----------------|-------|-------------------------|
| Gereduceerd elastisch moment                    | $W_{y,el,red}$ | 76112 | mm <sup>3</sup>         |
| Gereduceerd plastisch moment                    | $W_{y,pl,red}$ | 96713 | mm <sup>3</sup>         |
| Toegestane mobilisatie van plastische weerstand | mob            | 41%   | Zie brekening hierboven |

|                                                                      |                    |      |     |
|----------------------------------------------------------------------|--------------------|------|-----|
| Opneembaar moment                                                    | M <sub>y,Rd-</sub> | 29.6 | kNm |
| Maximum moment (drukkracht in onderflens)                            | M <sub>y,Ed-</sub> | 9.5  | kNm |
| $UC_{bent4} = \frac{M_{y,Ed-}}{M_{y,Rd-}} = \frac{9.5}{29.6} = 0.32$ |                    |      |     |

#### Momentweerstand om zwakke as (z-z) - EN1993-1-3 art 6.1.4

##### Trekspanning in lippen ( $M_{z1}$ ), incl. gataftrek

Het lijf van profiel wordt op druk belast en de gaten in het lijf zijn gevuld met verbindingmiddelen. Het lijf van profiel wordt daarom volledig meegenomen in de berekening. De doorsnede eigenschappen zijn bepaald met Scia Engineer.

|                                                 |                            |       |                   |
|-------------------------------------------------|----------------------------|-------|-------------------|
| Gereduceerd elastisch moment                    | $W_{z,el,red}$             | 41274 | mm <sup>3</sup>   |
| Gereduceerd plastisch moment                    | $W_{z,pl,red}$             | 57765 | mm <sup>3</sup>   |
| Slankheidsparameters plaatvelden                | $\lambda_e$                | 0.64  | 0.12              |
| Referentie slankheid                            | $\lambda_{e0}$             | 0.67  | 0.67              |
| Slankheids ratio                                | $\lambda_e / \lambda_{e0}$ | 0.96  | 0.18              |
| Mobilisatie voor verschillende plaatvelden      | mob                        | 17%   | 100%              |
| Toegestane mobilisatie van plastische weerstand | Mob                        | 17%   |                   |
| Effectief, elastisch weerstandsmoment           | $W_{z,el,eff}$             | 41274 | mm <sup>3</sup>   |
| Vloeispanning                                   | $f_y$                      | 355   | N/mm <sup>2</sup> |
| Momentweerstand                                 | M <sub>z,Rd</sub>          | 15.7  | kNm               |

##### Drukspanning in lippen ( $M_{z2}$ ), incl. gataftrek

Het lijf van de doorsnede wordt op trek belast waardoor het effect van de gataftrek op de doorsnedegrootheden in rekening dient gebracht te worden

|                              |                         |                         |                         |
|------------------------------|-------------------------|-------------------------|-------------------------|
| Gereduceerd elastisch moment | $W_{z,el,red}$          | 40337                   | mm <sup>3</sup>         |
| Gereduceerd plastisch moment | $W_{z,pl,red}$          | 55947                   | mm <sup>3</sup>         |
|                              | $\lambda_e = \lambda_p$ | $\lambda_e = \lambda_p$ | $\lambda_e = \lambda_d$ |

**Project:**  
**Onderdeel:**  
**Datum:**  
**Auteur:**

BI7934 Interboat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum:**  
**Pagina's**

1.1  
[Redacted]  
[Redacted]  
9

### Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]

Slankheidsparameters plaatvelden  
Referentie slankheid  
Slankheids ratio  
Mobilisatie voor verschillende plaatvelden  
Toegestane mobilisatie van plastische weerstand

|                            |            |       |      |
|----------------------------|------------|-------|------|
| $\lambda_e$                | 0.20       | 0.36  | 0.59 |
| $\lambda_{e0}$             | 0.84       | 0.673 | 0.65 |
| $\lambda_e / \lambda_{e0}$ | 0.23       | 0.54  | 0.91 |
| mob                        | 100%       | 100%  | 35%  |
| <b>Mob</b>                 | <b>35%</b> |       |      |

Effectief, elastisch weerstandsmoment  
Vloeispanning  
Momentweerstand

|               |             |                   |
|---------------|-------------|-------------------|
| $W_{zel,eff}$ | 40337       | mm <sup>3</sup>   |
| $f_y$         | 355         | N/mm <sup>2</sup> |
| M.z.R.d       | <b>16.3</b> | kNm               |
| M.z.E.d       | <b>13.8</b> | kNm               |

UC<sub>betst5</sub> **0.88** -

#### Dwarskrachtweerstand - EN1993-1-3 art 6.1.4.3

De dwarskracht wordt verifieerd rekening houdend met de slankheid van het lijf. Gataftrek behoeft niet in rekening te worden gebracht conform art 6.2.6 (7)

#### Dwarskrachttoetsing y-as

Breedte van de flens tot 1/2 in het lijf  
Plaatdikte  
Slankheid van de flens

|                |      |        |                                                                 |
|----------------|------|--------|-----------------------------------------------------------------|
| $b_w$          | 97.5 | mm     | sw=bw = b - 0.5t                                                |
| t              | 5    | mm     |                                                                 |
| $\lambda_{wy}$ | 0.28 | < 0.83 | Lijf is niet slank, geen reductie fbv benodigd, conform Tab 6.1 |

$$\lambda_{w,cr} = 0.346 \frac{E}{t} \sqrt{\frac{I_{tw}}{E}}$$

Dwarskrachttoppervlak  
Vloeispanning [EN1993-1-3 tab 6.1]  
Dwarskrachtweerstand  
Max dwarskracht

|          |              |                   |
|----------|--------------|-------------------|
| $A_{wy}$ | 975          | mm <sup>2</sup>   |
| fbv      | 205          | N/mm <sup>2</sup> |
| V.y.R.d  | <b>199.8</b> | kN                |
| V.y.E.d  | <b>66.2</b>  | kN                |

$$V_{h,Rd} = \frac{h_w}{\gamma_{M0}} \frac{f_{yw}}{\gamma_{M0}}$$

UC<sub>betst6</sub> **0.33** -

#### Dwarskrachttoetsing z-as

Breedte van de flens tot 1/2 in het lijf  
Plaatdikte  
Slankheid van de flens

|                |      |                                                                          |
|----------------|------|--------------------------------------------------------------------------|
| $h_p$          | 155  | mm                                                                       |
| t              | 5    | mm                                                                       |
| $\lambda_{wz}$ | 0.44 | < 0.83 - Lijf is niet slank, geen reductie fbv benodigd, conform Tab 6.1 |

Dwarskracht oppervlak  
Vloeispanning [EN1993-1-3 tab 6.1]  
Dwarskrachtweerstand  
Max dwarskracht

|          |              |                   |
|----------|--------------|-------------------|
| $A_{wz}$ | 775          | mm <sup>2</sup>   |
| fbv      | 205          | N/mm <sup>2</sup> |
| V.z.R.d  | <b>158.8</b> | kN                |
| V.z.E.d  | <b>7.3</b>   | kN                |

UC<sub>betst7</sub> **0.05** -

#### Gecombineerde toets voor afschuiving en moment

Toetsing niet noodzakelijk, invloed dwarskracht op momentweerstand verwaarloosbaar  $V_{Ed} < 0.5 \times V_{Rd}$

#### Gecombineerde toets voor dubbele buiging en normaalkracht - Trek - NEN1993-1-3 art 6.1.8

De weerstand tegen gecombineerde buiging en normaalkrachten zijn getoetst voor verschillende combinaties van simultaan optredende krachten. Hierbij zijn de extra momenten door het verschuiven van de neutrale lijn door de aanwezigheid van gaten genegeerd.

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.t.Ed [kN]  | 104.4     | 583.8     | 0.18        |
| M.y.E. [kNm] | 1.33      | 29.6      | 0.04        |
| M.z.Ed [kNm] | 5.38      | 15.7      | 0.34 +      |
|              |           |           | <b>0.57</b> |

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.t.Ed [kN]  | -11.45    | 583.8     | -0.02       |
| M.y.Ed [kNm] | 16.4      | 29.6      | 0.55        |
| M.z.Ed [kNm] | 0         | 15.7      | 0.00 +      |
|              |           |           | <b>0.53</b> |

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.t.Ed [kN]  | 0         | 583.8     | 0.00        |
| M.y.Ed [kNm] | 9.51      | 29.6      | 0.32        |
| M.z.Ed [kNm] | 0         | 15.7      | 0.00 +      |
|              |           |           | <b>0.32</b> |

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.t.Ed [kN]  | 16.21     | 583.8     | 0.03        |
| M.y.Ed [kNm] | 0.47      | 29.6      | 0.02        |
| M.z.Ed [kNm] | 14.72     | 15.7      | 0.94 +      |
|              |           |           | <b>0.98</b> |

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.t.Ed [kN]  | 21.19     | 583.8     | 0.04        |
| M.y.Ed [kNm] | 1.52      | 29.6      | 0.05        |
| M.z.Ed [kNm] | 9.95      | 15.7      | 0.64 +      |
|              |           |           | <b>0.72</b> |

UC<sub>betst8</sub> **0.98** -

#### Gecombineerde toets voor dubbele buiging en normaalkracht - Druk - NEN1993-1-3 art 6.1.9

De weerstand tegen gecombineerde buiging en normaalkrachten zijn getoetst voor verschillende combinaties van simultaan optredende krachten. Hierbij zijn de extra momenten door het verschuiven van de neutrale lijn door de aanwezigheid van gaten genegeerd. De excentriciteiten hebben een verwaarloosbaar klein effect. De toetsing is uitgevoerd met de hierboven berekende waarden. Hiermee wordt uitgegaan dat de trek en druk op dezelfde zijde van de doorsnede optreedt. Dit is een conservatieve aanname, want de buigmoment capaciteit is met lage weerstandsmomenten bepaald.

$$\frac{N_{Ed}}{N_{c,Rd}} + \frac{M_{y,Ed} + \Delta M_{y,Ed}}{M_{cy,Rd,com}} + \frac{M_{z,Ed} + \Delta M_{z,Ed}}{M_{cz,Rd,com}} \leq 1$$

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.c.Ed [kN]  | 123.5     | 706.8     | 0.17        |
| M.y.Ed [kNm] | 1.81      | 29.6      | 0.06        |
| M.z.Ed [kNm] | 1.11      | 15.7      | 0.07 +      |
|              |           |           | <b>0.31</b> |

|              | Belasting | Weerstand | UC          |
|--------------|-----------|-----------|-------------|
| N.d.Ed [kN]  | 0         | 706.8     | 0.00        |
| M.y.Ed [kNm] | 16.4      | 29.6      | 0.55        |
| M.z.Ed [kNm] | 0         | 15.7      | 0.00 +      |
|              |           |           | <b>0.55</b> |



**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 Interboat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1.1  
18/07/2023  
9

## Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]

|                | Belasting | Weerstand | UC   |
|----------------|-----------|-----------|------|
| N.d.Ed [kN]    | 0         | 706.8     | 0.00 |
| M.y.Ed [kNm]   | 9.51      | 29.6      | 0.32 |
| M.z.Ed - [kNm] | 0         | 15.7      | 0.00 |
|                |           |           | 0.32 |

|              | Belasting | Weerstand | UC   |
|--------------|-----------|-----------|------|
| N.d.Ed [kN]  | 0         | 706.8     | 0.00 |
| M.y.Ed [kNm] | 0.47      | 29.6      | 0.02 |
| M.z.Ed [kNm] | 14.72     | 15.7      | 0.94 |
|              |           |           | 0.96 |

|                | Belasting | Weerstand | UC   |
|----------------|-----------|-----------|------|
| N.d.Ed [kN]    | 0         | 706.8     | 0.00 |
| M.y.Ed [kNm]   | 1.52      | 29.6      | 0.05 |
| M.z.Ed - [kNm] | 9.95      | 15.7      | 0.64 |
|                |           |           | 0.69 |

|                     |      |
|---------------------|------|
| UC <sub>petsg</sub> | 0.96 |
|---------------------|------|

### Verificatie Kipstabiliteit

De kipstabiliteit is geverifieerd voor buiging om de sterke as (maatgevend), zonder gataftrek. De gaten hebben alleen invloed op de lokale weerstand

### Berekening elastisch kipmoment

|                                |           |       |                         |                                                                                                                                          |
|--------------------------------|-----------|-------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Slankheidsverhouding lijf      | $h/t_w$   | 32    | <                       | 75                                                                                                                                       |
| Reductiefactor kipmoment       | $k_{red}$ | 1     | = 1 indien $h/t_w < 75$ |                                                                                                                                          |
| Kniklengte voor kipstabiliteit | $L_{kT}$  |       | 1990 mm                 |                                                                                                                                          |
| Elastisch kipmoment            | $M_{cr}$  | 131.3 | kNm                     | $M_{cr} = k_{red} \cdot \frac{\pi^2}{L_{kT}^2} \sqrt{E^* I_y^* G^* I_t^* \left( 1 + \frac{\pi^2 E^* I_y^*}{L_{kT}^2 G^* I_t^*} \right)}$ |

### Berekening weerstandsmoment

|                                              |                |                        |                                              |
|----------------------------------------------|----------------|------------------------|----------------------------------------------|
| Effectieve elastisch weerstandsmoment        | $W_{y,el,eff}$ | 99257 mm <sup>3</sup>  |                                              |
| Plastisch weerstandsmoment (zonder gataftek) | $W_{y,pl}$     | 116330 mm <sup>3</sup> |                                              |
| Toegestane mobilisatie plastische weerstand  | Mob            | 41% -                  | [Zie verificatie moment weerstand]           |
| Weerstandsmoment                             | $W_y$          | 106212 mm <sup>3</sup> | $W_{y,el} + (W_{y,pl} - W_{y,el}) \cdot mob$ |

### Kip-weerstand

|                                                      |                              |              |     |                                                                                        |
|------------------------------------------------------|------------------------------|--------------|-----|----------------------------------------------------------------------------------------|
| Slankeidsparameter                                   | $\lambda_{LT}$               | 0.54         | -   | $\lambda_{LT} = \sqrt[4]{\frac{W_{y,fy}}{M_{cr}}}$                                     |
| Imperfectorfactor [Knikkromme b, EN1993-1-1 tab 6.1] | $\alpha_{LT}$<br>$\Phi_{LT}$ | 0.34<br>0.70 | -   | $\Phi_{LT} = 0.5 \left[ 1 + \alpha_{LT} (\lambda_{LT} - 0.2) + \lambda_{LT}^2 \right]$ |
| Reductiefactor momentweerstand (brutto doorsnd)      | $X_{LT}$                     | 0.87         | -   | $X_{LT} = \frac{1}{\Phi_{LT} + \sqrt[4]{\omega_{LT}^2 - \lambda_{LT}^2}}$              |
|                                                      | $M_{b,rd}$                   | 32.7         | kNm | $M_{b,rd} = X_{LT} W_y \frac{f_y}{\gamma_{M1}}$                                        |

### Verificatie Knikstabiliteit EN1993-1-3 art 6.2

De knikstabiliteit is geverifieerd, zonder gataftrek. De gaten hebben alleen invloed op de lokale weerstand

### Buigknik - Elastische Knickkraft

|                       |              |          |              |           |
|-----------------------|--------------|----------|--------------|-----------|
| Kniklengte            | $L_{knik,y}$ | 5500 mm  | $L_{knik,z}$ | 1980 mm   |
| Elastische knikkracht | $N_{cr,y}$   | 544.1 kN | $N_{cr,z}$   | 1451.6 kN |

### Torsionstechnik - Elastische Knickkraft

|                                                     |            |         |                                                                             |
|-----------------------------------------------------|------------|---------|-----------------------------------------------------------------------------|
| Knik lengte voor torsiëknik (gelijk aan kip lengte) | $L_{LT}$   | 1980 mm | $i_y^2 = i_z^2 + i_x^2 + y_o^2 + z_o^2$                                     |
| Elastische knikkracht                               | $i_o$      | 75 mm   |                                                                             |
|                                                     | $N_{cr,T}$ | 2132 kN | $N_{cr} = \frac{1}{\left( \frac{1}{G I} + \frac{\pi^2 E I_w}{L^2} \right)}$ |

**Maatgevende knikkracht**

|                      |                     |                     |
|----------------------|---------------------|---------------------|
| Maatgeven mechanisme | Buigknik maatgevend | Buigknik maatgevend |
|----------------------|---------------------|---------------------|

### Relatieve slankheid

|                                                       |            |      |            |      |
|-------------------------------------------------------|------------|------|------------|------|
| Imperfekte factor [Nikkikromme b, EN1993-1-1 tab 5.1] | $\alpha_y$ | 0.34 | $\alpha_z$ | 0.34 |
|                                                       | $\Phi_y$   | 1.30 | $\Phi_z$   | 0.82 |
| Reductiefactor drukweerstand                          | $X_y$      | 0.52 | $X_z$      | 0.79 |

Effectieve doorsnede-oppervlak

|                                     |                      |                         |                      |                         |                                         |
|-------------------------------------|----------------------|-------------------------|----------------------|-------------------------|-----------------------------------------|
| Verhoogde toelaatbare vloeispanning | $f_y$                | #REF! N/mm <sup>2</sup> | $f_y$                | #REF! N/mm <sup>2</sup> | [Zie toetsing op normaal drukkracht]    |
| Knikweerstand                       | Nb.y.Rd              | 359.7                   | Nb.z.Rd              | 548.3                   |                                         |
| Max optredende normaalkracht        | N.c.E.d              | -123.6                  | N.c.E.d              | -123.6                  | $N_{b,Rd} = \frac{X_y A_{eff}}{Y_{M1}}$ |
|                                     | UC <sub>toets1</sub> | 0.34                    | UC <sub>toets2</sub> | 0.23                    |                                         |

### Verificatie Stabiliteit Buiging + Druk EN1993-1-3 art 6.2.5

De gecombineerde stabiliteit tegen knik en kip is geverifieerd voor de gecombineerde krachten, d.w.z. krachten die gelijktijdig en in dezelfde doorsnede optreden.

Gezien de Unity Check op moment en kip beduidend hoger is dan knik, wordt de combinatie met het maximum moment aangehouden.

**Doorsnede weerstand**

|                                           |                       |        |     |    |      |                                                                                                        |
|-------------------------------------------|-----------------------|--------|-----|----|------|--------------------------------------------------------------------------------------------------------|
| Knikweerstand                             | Nb.Rd                 | 359.7  | kN  |    |      |                                                                                                        |
| Kipweerstand                              | Mb.y.Rd               | 32.7   | kNm |    |      |                                                                                                        |
| Maximale drukkracht                       | NcEd                  | -123.5 | kN  |    |      |                                                                                                        |
| Buigmoment bij maximale normaaldrukkracht | MyEd                  | 1.8    | kNm | UC | 0.52 | $\left( \frac{N_{Ed}}{N_{b,Rd}} \right)^{0.8} + \left( \frac{M_{Ed}}{M_{b,Rd}} \right)^{0.8} \leq 1.0$ |
| Drukkracht bij maximale buigmoment        | NcEd                  | -11.45 | kN  |    |      |                                                                                                        |
| Maximale buigmoment                       | MyEd                  | 16.4   | kNm | UC | 0.64 |                                                                                                        |
|                                           | UC <sub>lasted3</sub> | 0.64   |     |    |      |                                                                                                        |

Project:  
Onderdeel  
Datum  
Auteur

BI7934 Interboat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A.Akyel

Versie Rekenblad:  
Gecontroleerd door:  
Datum  
Pagina's

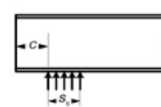
1.1  
[Redacted]  
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9

## Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]

### Verificatie Oplegreactie EN1993-1-3 art 6.1.7.2

Ter plaatse van de opleggingen op het landhoofd is de oplegreactie geverifieerd.

|                                               |                |         |                    |
|-----------------------------------------------|----------------|---------|--------------------|
| Breedte van de oplegging                      | $S_a$          | 200 mm  |                    |
| Randafstand                                   | $c$            | 0 mm    |                    |
| Hoogte profiel tussen hart flenzen            | $h_w$          | 155 mm  | $h_w = h - t$      |
| Hoek tussen flens en lijf                     | $\phi$         | 90 deg  |                    |
| Factoren t.b.v. de weerstand van de oplegging |                |         |                    |
|                                               | $k$            | 1.56    | $k_3$ 1.00         |
|                                               | $k_1$          | 0.82    | $k_4$ 0.88         |
|                                               | $k_2$          | 0.91    | $k_5$ 0.96         |
| Verhouding randafstand / profielhoogte        | $c/h_w$        | 0.0     |                    |
| Verhouding oplegbreedte / flensdikte          | $S_a/t$        | 40.0    |                    |
| Weerstand oplegkracht t.p.v steunpunt         | $R_w R_d$      | 78.7 kN | vergelijking 6.15a |
| Optredende reactiekracht t.p.v. steunpunt     | Red            | nvt     |                    |
|                                               | $UC_{toets14}$ | nvb     |                    |



$$R_{w,Red} = \frac{k_1 k_2 k_3 \left[ 9.04 - \frac{h_w/t}{60} \right] \left[ 1 + 0.01 \frac{S_a}{t} \right] t^2 f_{yb}}{\gamma_{M1}} \quad (6.15a)$$

$$R_{w,Red} = \frac{k_1 k_2 k_3 \left[ 14.7 - \frac{h_w/t}{49.5} \right] \left[ 1 + 0.007 \frac{S_a}{t} \right] t^2 f_{yb}}{\gamma_{M1}} \quad (6.15d)$$

$$R_{w,Red} = \frac{k_1 k_2 k_3 \left[ 14.7 - \frac{h_w/t}{49.5} \right] \left[ 0.75 + 0.011 \frac{S_a}{t} \right] t^2 f_{yb}}{\gamma_{M1}} \quad (6.15e)$$

$$k = f_{yb} / 228$$

$$k_1 = 1.33 - 0.33 \lambda$$

$$k_2 = 1.15 - 0.15 \eta \quad \text{but } k_2 \geq 0.50 \text{ and } k_2 \leq 1.0$$

$$k_3 = 0.7 + 0.3 (\rho / 90)^2$$

$$k_4 = 1.22 - 0.22 k$$

$$k_5 = 1.06 - 0.06 \eta \quad \text{but } k_5 \leq 1.0$$



Project: BI7934 Interboat - Schipperskerk  
Onderdeel: Bijlage 3 - Verificaties  
Datum: 12/07/2023  
Auteur: A.Akyel

Versie Rekenblad: 1.1  
Gecontroleerd door: [REDACTED]  
Datum: 12/07/2023  
Pagina's: 9

Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdiglijer]

Input,output - Rekensheet Bouwen Met Staal - C - My:

<https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

| Profielafmetingen |        | Materiaaleigenschappen |                          | INPUT |
|-------------------|--------|------------------------|--------------------------|-------|
| $h$               | 160 mm | $E$                    | 210000 N/mm <sup>2</sup> |       |
| $b$               | 100 mm | $\nu$                  | 0.3                      |       |
| $c$               | 35 mm  | $f_{yb}$               | 355 N/mm <sup>2</sup>    |       |
| $t$               | 5 mm   | $Y_{MO}$               | 1                        |       |
| $r$               | 8 mm   | $Y_{MT}$               | 1.25                     |       |

Invl. afrondingsstralen mag niet worden genegeerd

Profiel fysisch mogelijk

Voorwaarde voor de berekening

Plaatdikte

Geometrie van profiel

| plaatdeel         | h/t | 32.00 ≤ 500 | Voldoet |
|-------------------|-----|-------------|---------|
| plaatdeel 1       | h/t | 32.00 ≤ 500 | Voldoet |
| plaatdeel 2       | b/t | 20.00 ≤ 60  | Voldoet |
| plaatdeel 3 [lip] | c/t | 7.00 ≤ 50   | Voldoet |
| plaatdeel 3 [lip] | c/b | 0.35 ≥ 0.2  | Voldoet |
| plaatdeel 3 [lip] | c/b | 0.35 ≤ 0.6  | Voldoet |

De lip mag worden meegenomen in de berekening

$r \leq 0.04 \cdot t \cdot E / f_y$

$8 \leq 118.3$  Voldoet

| Eigenschappen effectieve doorsnede |                           | OUTPUT       |          |
|------------------------------------|---------------------------|--------------|----------|
| $h_{eff,v}$                        | 22.35 mm                  | $b_{eff,v}$  | 37.00 mm |
| $h_{eff2,v}$                       | 44.65 mm                  | $b_{eff2,v}$ | 37.00 mm |
| $z_{plu}$                          | 77.50 mm                  | $\psi$       | -1.000   |
| $z_{eff}$                          | 77.50 mm                  | $b_f$        | 74.42 mm |
| $I_{eff,v}$                        | 7940588.8 mm <sup>4</sup> | $b_c$        | 74.42 mm |
| $W_{eff,v,com}$                    | 99257.4 mm <sup>3</sup>   | $t_{red}$    | 5.00 mm  |
| $W_{eff,v,ten}$                    | 99257.4 mm <sup>3</sup>   |              |          |
| $\lambda_y$ druklens               | 0.38                      |              |          |
| $\lambda_y$ lip                    | 0.38                      |              |          |
| $\lambda_y$ randverstijving        | 0.58                      |              |          |

Profiel fysisch mogelijk

Output geldig

**Project:** BI7934 Interboat - Schipperskerk  
**Onderdeel:** Bijlage 3 - Verificaties  
**Datum:** 12/07/2023  
**Auteur:** A.Akyel

**Versie Rekenblad:** 1.1  
**Gecontroleerd door:** [REDACTED]  
**Datum:** 18/07/2023  
**Pagina's:** 9

**Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]**

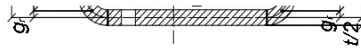
**Input,output - Rekensheet Bouwen Met Staal - C-M<sub>z</sub>**

<https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

| Profielafmetingen                                 |        | Materiaaleigenschappen                 |                                               |  | INPUT |
|---------------------------------------------------|--------|----------------------------------------|-----------------------------------------------|--|-------|
| $h$                                               | 160 mm | $E$                                    | 210000 N/mm <sup>2</sup>                      |  |       |
| $b$                                               | 100 mm | $\nu$                                  | 0.3                                           |  |       |
| $c$                                               | 35 mm  | $f_{yb}$                               | 355 N/mm <sup>2</sup>                         |  |       |
| $t$                                               | 5 mm   | $Y_{MO}$                               | 1                                             |  |       |
| $r$                                               | 8 mm   | $Y_{MI}$                               | 1.25                                          |  |       |
| Invl. afrondingsstralen mag niet worden genegeerd |        |                                        |                                               |  |       |
| Profiel fysisch mogelijk                          |        |                                        |                                               |  |       |
| <b>Voorwaarde voor de berekening</b>              |        |                                        |                                               |  |       |
| <u>Plaatafdikte</u>                               |        | $1 \leq 5.00 \leq 8$                   | Voldoet                                       |  |       |
| <u>Geometrie van profiel</u>                      |        | plaatdeel 1 $h/t$ $32.00 \leq 500$     | Voldoet                                       |  |       |
|                                                   |        | plaatdeel 2 $b/t$ $20.00 \leq 60$      | Voldoet                                       |  |       |
|                                                   |        | plaatdeel 3 [lip] $c/t$ $7.00 \leq 50$ | Voldoet                                       |  |       |
|                                                   |        | $c/b$ $0.35 \geq 0.2$                  | De lip mag worden meegenomen in de berekening |  |       |
|                                                   |        | $c/b$ $0.35 \leq 0.6$                  |                                               |  |       |
| afrondingsstraal                                  |        | $r \leq 0.04 * t * E / f_y$            |                                               |  |       |
|                                                   |        | $8 \leq 118.3$                         | Voldoet                                       |  |       |
|                                                   |        |                                        |                                               |  |       |

| Eigenschappen effectieve doorsnede |                           |              |          |  | OUTPUT |  |  |
|------------------------------------|---------------------------|--------------|----------|--|--------|--|--|
| $y_{init}$                         | 36.59 mm                  | $h_{eff1,v}$ | 67.00 mm |  |        |  |  |
|                                    |                           | $h_{eff2,v}$ | 67.00 mm |  |        |  |  |
| $b_t$                              | 56.33 mm                  | $b_{eff1,v}$ | 5.98 mm  |  |        |  |  |
| $b_c$                              | 33.52 mm                  | $b_{eff2,v}$ | 20.11 mm |  |        |  |  |
| $\psi$                             | -1.651                    | $b_{t,v}$    | 47.91 mm |  |        |  |  |
| $y_{eff}$                          | 36.59 mm                  | $c_v$        | 22.00 mm |  |        |  |  |
| $I_{eff,z}$                        | 2745688.3 mm <sup>4</sup> |              |          |  |        |  |  |
| $W_{eff,z,com}$                    | 70233.6 mm <sup>3</sup>   |              |          |  |        |  |  |
| $W_{eff,z,tot}$                    | 45080.5 mm <sup>3</sup>   |              |          |  |        |  |  |
| $\lambda_p$ druklens               | 0.64 -                    |              |          |  |        |  |  |
| $\lambda_p$ lijf                   | 0.12 -                    |              |          |  |        |  |  |
| Profiel fysisch mogelijk           |                           |              |          |  |        |  |  |
| Output geldig                      |                           |              |          |  |        |  |  |

Input,output - Rekensheet Bouwen Met Staal - C-M<sub>z</sub>



**Project:** BI7934 Interboat - Schipperskerk  
**Onderdeel:** Bijlage 3 - Verificaties  
**Datum:** 12/07/2023  
**Auteur:** A.Akyel

**Versie Rekenblad:** 1.1  
**Gecontroleerd door:** [Redacted]  
**Datum:** 18/07/2023  
**Pagina's:** 9

**Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]**

**Input,output - Rekensheet Bouwen Met Staal - C-M<sub>z2</sub>**

<https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

| Profielafmetingen |        | Materiaaleigenschappen |                          |
|-------------------|--------|------------------------|--------------------------|
| $h$               | 160 mm | $E$                    | 210000 N/mm <sup>2</sup> |
| $b$               | 100 mm | $\nu$                  | 0.3                      |
| $c$               | 35 mm  | $f_{yb}$               | 355 N/mm <sup>2</sup>    |
| $t$               | 5 mm   | $Y_{M0}$               | 1                        |
| $r$               | 8 mm   | $Y_{M1}$               | 1.25                     |

**Invl. afrondingsstralen mag niet worden genegeerd**

**Profiel fysisch mogelijk**

**Voorwaarde voor de berekening**

| Plaatsdikte       | 1 ≤   | 5.00 ≤ 8               | Voldoet                                       |
|-------------------|-------|------------------------|-----------------------------------------------|
| plaatdeel 1       | $h/t$ | 32.00 ≤ 500            | Voldoet                                       |
| plaatdeel 2       | $b/t$ | 20.00 ≤ 60             | Voldoet                                       |
| plaatdeel 3 [lip] | $c/t$ | 7.00 ≤ 50              | Voldoet                                       |
|                   | $c/b$ | 0.35 ≥ 0.2             | De lip mag worden meegenomen in de berekening |
|                   | $c/b$ | 0.35 ≤ 0.6             |                                               |
| afrondingsstraal  | $r$   | ≤ 0.04 * $t * E / f_y$ |                                               |
|                   | 8     | ≤ 118.3                | Voldoet                                       |

INPUT

| Eigenschappen effectieve doorsnede |                             |               |          |
|------------------------------------|-----------------------------|---------------|----------|
| $y_{init}$                         | 36.59 mm                    |               |          |
| $b_t$                              | 33.52 mm                    | $b_{eff,t,v}$ | 14.71 mm |
| $b_c$                              | 56.33 mm                    | $b_{eff2,v}$  | 33.20 mm |
| $\psi$                             | -0.606                      | $b_{t,v}$     | 26.09 mm |
| $y_{eff}$                          | 36.59 mm                    | $c_{eff,v}$   | 22.00 mm |
| $I_{eff,z}$                        | 2745688.277 mm <sup>4</sup> | $t_{red}$     | 5.00 mm  |
| $W_{eff,z,com}$                    | 45080.5 mm <sup>3</sup>     |               |          |
| $W_{eff,z,ten}$                    | 70233.6 mm <sup>3</sup>     |               |          |
| $\lambda_{p,lijf}$                 | 0.20 -                      |               |          |
| $\lambda_{p,lip}$                  | 0.36 -                      |               |          |
| $\lambda_{p,randverstijving}$      | 0.59 -                      |               |          |

**Profiel fysisch mogelijk**

**Output geldig**

OUTPUT

|                                                                |
|----------------------------------------------------------------|
| Input,output - Rekensheet Bouwen Met Staal - C-M <sub>z2</sub> |
|                                                                |



**Project:** BI7934 Interboat - Schipperskerk  
**Onderdeel:** Bijlage 3 - Verificaties  
**Datum:** 12/07/2023  
**Auteur:** A.Akyel

**Versie Rekenblad:** 1.1  
**Gecontroleerd door:**  
**Datum:** 18/07/2023  
**Pagina's:** 9

**Toetsing doorsnedecapaciteit en stabiliteit van koudgewalst C - Profiel [Hoofdligger]**

**Input,output - Rekensheet Bouwen Met Staal - C - N: Input**

<https://www.bouwenmetstaal.nl/tools/berekenen/koudgevormde-profielen>

| Profielafmetingen                                 |        | Materiaaleigenschappen |                               |             | INPUT   |
|---------------------------------------------------|--------|------------------------|-------------------------------|-------------|---------|
| h                                                 | 160 mm | E                      | 210000 N/mm <sup>2</sup>      |             |         |
| b                                                 | 100 mm | v                      | 0.3                           |             |         |
| c                                                 | 35 mm  | f <sub>yb</sub>        | 355 N/mm <sup>2</sup>         |             |         |
| t                                                 | 5 mm   | Y <sub>M0</sub>        | 1                             |             |         |
| r                                                 | 8 mm   | Y <sub>M1</sub>        | 1.25                          |             |         |
| Invl. afrondingsstralen mag niet worden genegeerd |        |                        |                               |             |         |
| Profiel fysisch mogelijk                          |        |                        |                               |             |         |
| Voorwaarde voor de berekening                     |        |                        |                               |             |         |
| Plaatdikte                                        |        | 1 ≤                    | 5.00 ≤ 8                      | Voldoet     |         |
| Geometrie van profiel                             |        | plaatdeel 1            | h/t                           | 32.00 ≤ 500 | Voldoet |
|                                                   |        | plaatdeel 2            | b/t                           | 20.00 ≤ 60  | Voldoet |
|                                                   |        | plaatdeel 3 [lip]      | c/t                           | 7.00 ≤ 50   | Voldoet |
|                                                   |        | plaatdeel 3 [lip]      | c/b                           | 0.35 ≥ 0.2  |         |
|                                                   |        |                        | c/b                           | 0.35 ≤ 0.6  |         |
| De lip mag worden meegenomen in de berekening     |        |                        |                               |             |         |
| afrondingsstraal                                  | r      | ≤                      | 0.04 * t * E / f <sub>y</sub> |             |         |
|                                                   | 8      | ≤                      | 118.3                         | Voldoet     |         |
|                                                   |        |                        |                               |             |         |

| Eigenschappen effectieve doorsnede |                         |  | OUTPUT |
|------------------------------------|-------------------------|--|--------|
| h <sub>eff1,v</sub>                | 67.00 mm                |  |        |
| h <sub>eff2,v</sub>                | 67.00 mm                |  |        |
| b <sub>eff1,v</sub>                | 37.00 mm                |  |        |
| b <sub>eff2,v</sub>                | 37.00 mm                |  |        |
| c <sub>eff,v</sub>                 | 22.00 mm                |  |        |
| t <sub>red</sub>                   | 5.00 mm                 |  |        |
| A <sub>eff</sub>                   | 1959.87 mm <sup>2</sup> |  |        |
| y <sub>eff</sub>                   | 36.59 mm                |  |        |
| y <sub>g</sub>                     | 36.59 mm                |  |        |
| e <sub>Nz</sub>                    | 0.00 mm                 |  |        |
| λ <sub>p</sub> flens               | 0.38 -                  |  |        |
| λ <sub>p</sub> lip                 | 0.36 -                  |  |        |
| λ <sub>a</sub> randverstijving     | 0.63 -                  |  |        |
| Profiel fysisch mogelijk           |                         |  |        |
| Output geldig                      |                         |  |        |

## Single Pile Tool

Tool version 0,9 - date: 1/9/2022  
Validation report BG3816-101-119



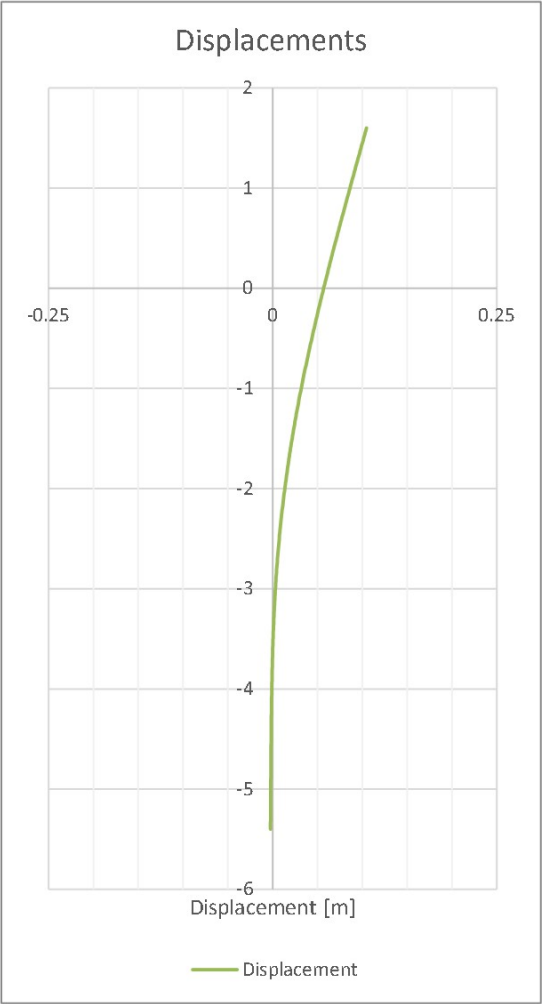
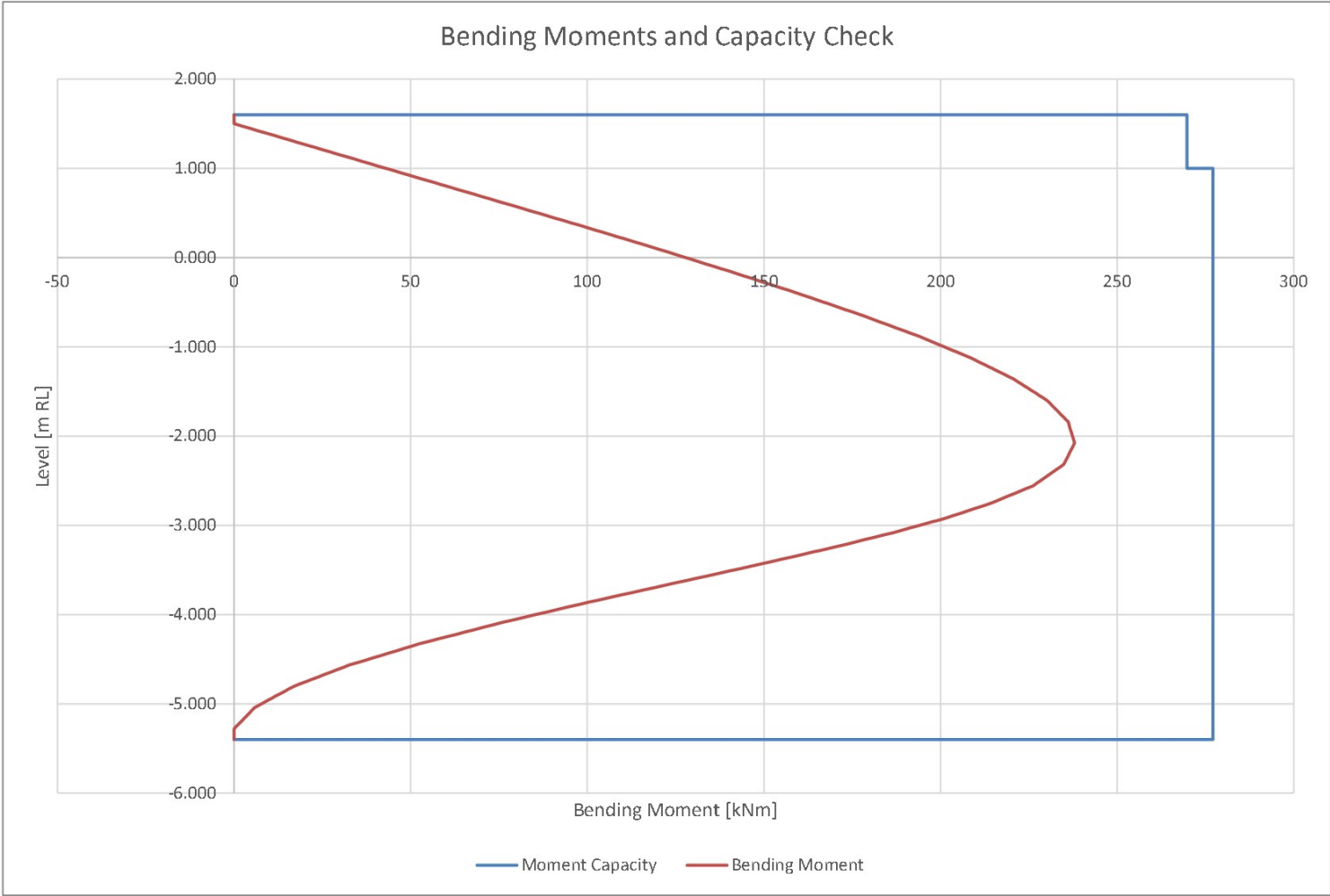
|                 |                    |           |         |
|-----------------|--------------------|-----------|---------|
| Project:        | Inter Boat Marinas | Date:     | 7/18/23 |
| Part:           | AW0                | Version:  | 1.0     |
| Project number: | BI7934             | Designer: | AA      |

[illegible]

| Gresnigt Zones                | Top Level [m NAP] |
|-------------------------------|-------------------|
| - Zone 2 - Empty              | -2.677            |
| - Zone 2 - Filled (5 mpa)     | -3.323            |
| - Zone 3 - Filled (10 mpa)    | -3.969            |
| Top of Sand Layer Inside Pile | -3.000            |

| Pile Properties           |      |
|---------------------------|------|
| Unit Weight Steel [kg/m3] | 7850 |
| Total Weight [kg]         | 644  |
| Pile Length [m]           | 7.00 |

| Steel properties                                 |        |
|--------------------------------------------------|--------|
| Modulus of Elasticity [N/mm2]                    | 210000 |
| Partial factor on steel properties $\gamma_{M0}$ | 1.00   |
| Partial factor on steel properties $\gamma_{M1}$ | 1.10   |
| Partial factor on steel properties $\gamma_{M2}$ | 1.25   |



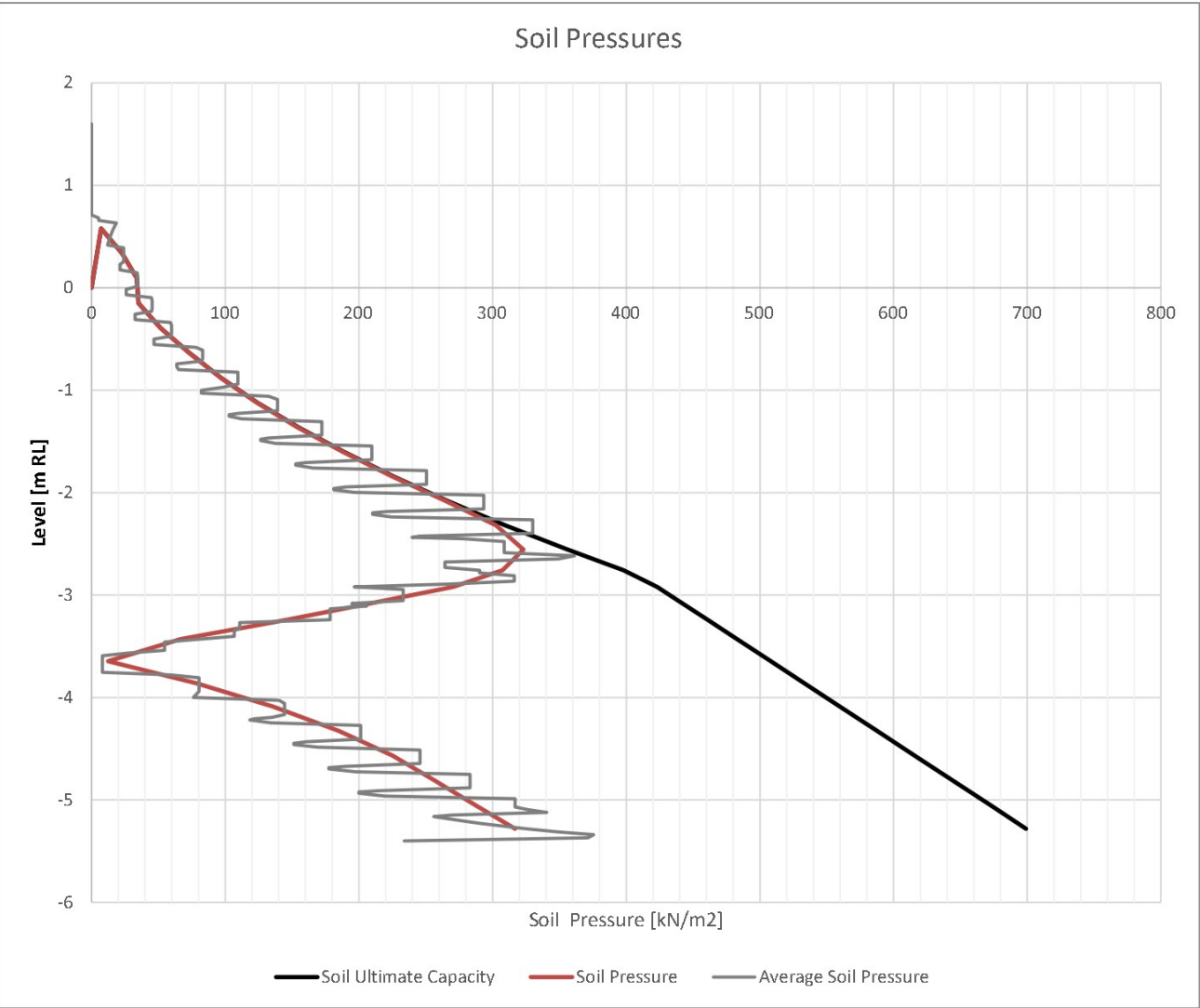
Level reference system used: NAP

**Other results**

|                  |      |     |
|------------------|------|-----|
| Absorbed Energy  | 4    | kNm |
| Top displacement | 105  | mm  |
| Tip displacement | -2.5 | mm  |

**Soil**

|                                     |     |       |
|-------------------------------------|-----|-------|
| Soil pressure tip                   | 317 | kN/m2 |
| Soil pressure ultimate              | 699 | kN/m2 |
| Utilisation of soil pressure at tip | 45% | -     |



PROJECT **Inter Boat Marinas**

SUBJECT **AW0 Section check C3-EC**

PROJECT No. **BI7934** FILE Ref **C3-EC** REV **1.0**

PREPARED **AA** DATE **18/07/2023**



| REF.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | OUTPUT.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------|-----------------|----------|-------|----------------|------------------------|-------|-------|------|----------------|----------------|-------|-------|----|----------------|---|------|------|----|----------------------|-----|-------|-------|-----------------|-------------|---|----|----|------|-------------------|---|-----------|-------|-----------------|-----------------|---|-----------|-------|-----------------|-----------------|---|-----------|-------|-----------------|-----------------------------------|---|-------|-------|----|
| <b>LOCAL BUCKLING IN ACCORDANCE WITH EC3-1-6 BS EN 1993-1-6:2007+A1:2017</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| <b>A.1 TUBULAR CROSS-SECTION PROPERTIES</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Uncorroded pile outer diameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | d = <b>323</b> mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Uncorroded pile wall thickness                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | t = <b>12</b> mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Corrosion loss of the section (Internal faces)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | = <b>0</b> mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Corrosion loss of the section (External faces)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | = <b>0.6</b> mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Modify fyk for material thickness<br>Apply <b>FALSE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| <table border="1"> <thead> <tr> <th>Properties</th> <th>Symbols</th> <th>Uncorroded</th> <th>Corroded</th> <th>Unit</th> </tr> </thead> <tbody> <tr> <td>Outer diameter</td> <td>d</td> <td>323.0</td> <td>321.8</td> <td>mm</td> </tr> <tr> <td>Inner diameter</td> <td>di</td> <td>299.0</td> <td>299.0</td> <td>mm</td> </tr> <tr> <td>Wall thickness</td> <td>t</td> <td>12.0</td> <td>11.4</td> <td>mm</td> </tr> <tr> <td>Cross-sectional area</td> <td>A</td> <td>11724</td> <td>11117</td> <td>mm<sup>2</sup></td> </tr> <tr> <td>Tube weight</td> <td>W</td> <td>92</td> <td>87</td> <td>Kg/m</td> </tr> <tr> <td>Moment of Inertia</td> <td>I</td> <td>1.420E+08</td> <td>#####</td> <td>mm<sup>4</sup></td> </tr> <tr> <td>Elastic Modulus</td> <td>Z</td> <td>8.790E+05</td> <td>#####</td> <td>mm<sup>3</sup></td> </tr> <tr> <td>Plastic Modulus</td> <td>S</td> <td>1.161E+06</td> <td>#####</td> <td>mm<sup>3</sup></td> </tr> <tr> <td>Radius of cylinder middle surface</td> <td>r</td> <td>155.5</td> <td>155.2</td> <td>mm</td> </tr> </tbody> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Properties             | Symbols        | Uncorroded      | Corroded | Unit  | Outer diameter | d                      | 323.0 | 321.8 | mm   | Inner diameter | di             | 299.0 | 299.0 | mm | Wall thickness | t | 12.0 | 11.4 | mm | Cross-sectional area | A   | 11724 | 11117 | mm <sup>2</sup> | Tube weight | W | 92 | 87 | Kg/m | Moment of Inertia | I | 1.420E+08 | ##### | mm <sup>4</sup> | Elastic Modulus | Z | 8.790E+05 | ##### | mm <sup>3</sup> | Plastic Modulus | S | 1.161E+06 | ##### | mm <sup>3</sup> | Radius of cylinder middle surface | r | 155.5 | 155.2 | mm |
| Properties                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Symbols                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Uncorroded             | Corroded       | Unit            |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Outer diameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | d                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 323.0                  | 321.8          | mm              |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Inner diameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | di                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 299.0                  | 299.0          | mm              |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Wall thickness                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | t                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 12.0                   | 11.4           | mm              |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Cross-sectional area                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 11724                  | 11117          | mm <sup>2</sup> |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Tube weight                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | W                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 92                     | 87             | Kg/m            |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Moment of Inertia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.420E+08              | #####          | mm <sup>4</sup> |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Elastic Modulus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Z                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 8.790E+05              | #####          | mm <sup>3</sup> |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Plastic Modulus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | S                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.161E+06              | #####          | mm <sup>3</sup> |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Radius of cylinder middle surface                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | r                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 155.5                  | 155.2          | mm              |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| <b>A.2 MATERIAL PROPERTIES</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| EC3-1-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Design yield stress fyd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Table 3.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Ultimate Yield Strength                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| 3.2.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Modulus of Elasticity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Poisson's ratio (elastic range)                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Shear Modulus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| EC3-1-6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Coefficient of linear thermal expansion                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| D.1.2.2(2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Fabrication quality p End 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Table D.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Classification of the section:                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | = (235/φψδ)0.5 = <b>0.81</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| EC3-1-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Table 5.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| (sheet 3 of 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <table border="1"> <thead> <tr> <th colspan="2">d/t ratio</th> <th>Uncorroded</th> <th>Corroded</th> </tr> <tr> <th>Class</th> <th>d/t limit</th> <th colspan="2">Section classification</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>33.1</td> <td><b>CLASS 1</b></td> <td><b>CLASS 1</b></td> </tr> <tr> <td>2</td> <td>46.3</td> <td>-</td> <td>-</td> </tr> <tr> <td>3</td> <td>59.6</td> <td>-</td> <td>-</td> </tr> <tr> <td>4</td> <td>N/A</td> <td>-</td> <td>-</td> </tr> </tbody> </table> | d/t ratio              |                | Uncorroded      | Corroded | Class | d/t limit      | Section classification |       | 1     | 33.1 | <b>CLASS 1</b> | <b>CLASS 1</b> | 2     | 46.3  | -  | -              | 3 | 59.6 | -    | -  | 4                    | N/A | -     | -     |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| d/t ratio                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Uncorroded             | Corroded       |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| Class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | d/t limit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Section classification |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 33.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>CLASS 1</b>         | <b>CLASS 1</b> |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 46.3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | -                      | -              |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 59.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | -                      | -              |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | -                      | -              |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                        |                |                 |          |       |                |                        |       |       |      |                |                |       |       |    |                |   |      |      |    |                      |     |       |       |                 |             |   |    |    |      |                   |   |           |       |                 |                 |   |           |       |                 |                 |   |           |       |                 |                                   |   |       |       |    |



PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.         |                                                                                                        | OUTPUT.      |
|--------------|--------------------------------------------------------------------------------------------------------|--------------|
|              | <b>A.3 MEMBER LENGTH AND BOUNDARY CONDITIONS</b>                                                       |              |
|              | Length of cylinder between boundary conditions $l =$ <b>6460</b> m                                     |              |
|              | Member end 1 boundary condition $=$ <b>2</b>                                                           |              |
|              | Member end 2 boundary condition $=$ <b>2</b>                                                           |              |
|              | <b>A.4 PARTIAL SAFETY FACTORS</b>                                                                      |              |
|              | Partial safety factor for cross sections $\gamma_{M0} =$ <b>1.00</b>                                   |              |
| EC3-1-6      | Partial safety factor for member instability $\gamma_{M1} =$ <b>1.10</b>                               |              |
| 6.2.2 (1)    | Partial safety factor for cross sections in tension $\gamma_{M2} =$ <b>1.25</b>                        |              |
| equation 6.1 | Design value of resistance, $f_{eq,Rd} = f_{yd} = f_{yk}/\gamma_{M1} =$ <b>355.0</b> N/mm <sup>2</sup> |              |
|              | <b>A.5 STRESS COMPUTATION AND CONDITION METHODS</b>                                                    |              |
|              | Stress computation method $=$ <b>TRUE</b>                                                              |              |
|              | If TRUE buckling verification is based on Appendix A Shell expressions                                 |              |
|              | If FALSE buckling verification is based on ELASTIC section properties                                  |              |
|              | Ignore special Long Cylinder condition (if applicable) $=$ <b>TRUE</b>                                 |              |
|              | If TRUE the calculations ignore the long cylinder special condition D.1.2.2(4)                         |              |
|              | If FALSE the calculations include the long cylinder special condition D.1.2.2(4)                       |              |
|              | <b>A.6 CO-EXISTING ULTIMATE DESIGN FORCES</b>                                                          |              |
|              | Design Maximum Axial Force $N_{Ed} =$ <b>0</b> kN (-ve for tension)                                    |              |
|              | Design Maximum Shear $V_{Z,Ed} =$ <b>0</b> kN                                                          |              |
|              | Design Maximum Shear $V_{Y,Ed} =$ <b>114</b> kN                                                        |              |
|              | Resultant Shear $V_{Ed} =$ <b>114</b> kN                                                               |              |
|              | Design Maximum Torsion $M_{xEd} =$ <b>0</b> kNm                                                        |              |
|              | Design Max Bending Moment $M_{Z,Ed} =$ <b>238</b> kNm                                                  |              |
|              | Design Max Bending Moment $M_{Y,Ed} =$ <b>0</b> kNm                                                    |              |
|              | Design Resultant Bending moment $M_{Ed} =$ <b>238</b> kNm                                              | Design Value |
|              | Internal Friction $=$ N/A kN/m <sup>2</sup>                                                            |              |
|              | Circumferential Pressure $=$ <b>376</b> kN/m <sup>2</sup>                                              |              |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



REF.

OUTPUT.

## B SUMMARY OF LOCAL BUCKLING DESIGN RESULTS

(LS1) Limit State

$$\sigma_{\theta,Ed} / \phi_{\theta} \sigma_{\theta,Rd} = 0.78 = \text{OK}$$

OK

(LS3) Stress Limitation - Meridional buckling

$$\sigma_{x,Ed} \leq \sigma_{x,Rd} = 0.86 = \text{OK}$$

OK

(LS3) Stress Limitation - Circumferential buckling

$$\sigma_{\theta,Ed} \leq \sigma_{\theta,Rd} = 0.03 = \text{OK}$$

OK

(LS3) Stress Limitation - Shear buckling

$$\tau_{q,Ed} \leq \tau_{q,Rd} = 0.11 = \text{OK}$$

OK

(LS3) EC3-1-6 8.5.3 (3) Eqn 8.19 Buckling Interaction Verification

$$(\sigma_{x,Ed} / \sigma_{x,Rd})^{k_x} + k_1 (\sigma_{x,Ed} / \sigma_{x,Rd}) (\sigma_{\theta,Ed} / \sigma_{\theta,Rd}) + (\sigma_{\theta,Ed} / \sigma_{\theta,Rd})^{k_{\theta}} + (\tau_{q,Ed} / \tau_{q,Rd})^{k_t} \leq 1.0$$

$$= 0.75 = \text{OK}$$

OK

Interaction eqn 8.19 using conservative Buckling Interaction parameters

$$= 0.76 = \text{OK}$$

OK

|                                                                            | Utilisation | % Contribution |
|----------------------------------------------------------------------------|-------------|----------------|
| Component of Meridional utilisation factor                                 | 0.74        | 98.8%          |
| Component of Meridional / Circumferential cross product utilisation factor | -0.01       | -1.0%          |
| Component of Circumferential utilisation factor                            | 0.00        | 0.4%           |
| Component of Shear utilisation factor                                      | 0.01        | 1.8%           |
| <b>UTILISATION FACTOR</b>                                                  | <b>0.75</b> | <b>100.0%</b>  |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



REF.

OUTPUT.

C DESIGN CALCULATIONS

C.1 DERIVATION OF STRESSES

| Stressess          | Appendix A | Section properties | Unit  |
|--------------------|------------|--------------------|-------|
| Axial              | 0.0        | 0.0                | N/mm2 |
| Mz                 | -          | 285.6              | N/mm2 |
| My                 | -          | 0.0                | N/mm2 |
| Mresultant         | 275.8      | 285.6              | N/mm2 |
| Axial + Mresultant | 275.8      | 285.6              | N/mm2 |
| Torsion            | 0.0        | 0.0                | N/mm2 |
| Vz                 | -          | 0.0                | N/mm2 |
| Vy                 | -          | 20.6               | N/mm2 |
| Vresultant         | 20.6       | 20.6               | N/mm2 |

EC3-1-6

Annex A,A.2 C.2 UNSTIFFENED CYLINDRICAL SHELLS

|       |                                               |                           |                 |       |             |
|-------|-----------------------------------------------|---------------------------|-----------------|-------|-------------|
| A.2.1 | Uniform axial load from Fx, meridional stress | $\sigma_{\xi v} =$        | 0.0             | N/mm2 |             |
| A.2.2 | Axial load from M, meridional stress          | $\sigma_{\xi \beta} =$    | 275.8           | N/mm2 |             |
|       | Meridional stress                             | $\sigma_{\xi E \delta} =$ | 275.8           | N/mm2 |             |
|       | $n_x, E_d \max = sxt$ (compression)           | $n_x =$                   | 3144.4          | N/mm2 |             |
| A.2.3 | Internal Friction                             | $=$                       | not implemented |       |             |
| A.2.3 | Circumferential Pressure                      | $\theta, E \delta =$      | 5.1             | N/mm2 | Compressive |
|       | $n_q = s q, E_d, t$                           |                           | 58.3            | N/mm2 |             |
| A.2.6 | Uniform Shear from Torsion                    | $t_q =$                   | 0.0             | N/mm2 |             |
|       | $n_q, E_d \max = t_q, t$                      | $n_q =$                   | 0.0             | N/mm2 |             |
| A.2.7 | Shear from Transverse Force                   | $t \max =$                | 20.6            | N/mm2 |             |
|       | $n_{xq} = t \max, t$                          | $n_{xq} =$                | 234.7           | N/mm2 |             |
|       |                                               | $x_q, E_d =$              | 20.6            | N/mm2 |             |

EC3-1-6

6 C.3 PLASTIC LIMIT STATE (LS1)

6.2.1 (1) Elastic stress design - lower bound theorem

6.2.1 (5) Equivalent design stress

$$s_{eq}, E_d = 1/t \sqrt{(n^2 x, E_d + n^2 q, E_d - n x, E_d, n_q, E_d + 3 n^2 x_q, E_d)} = 275.6 \text{ N/mm2}$$



PROJECT **Inter Boat Marinas**

SUBJECT **AW0 Section check C3-EC**

PROJECT No. **BI7934** FILE Ref **C3-EC** REV **1.0**

PREPARED **AA** DATE **18/07/2023**



| REF.            |                                                                                                                                                                                                                                                                            | OUTPUT.                   |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| 6.2.3 (1)       | <b>Stress Limitation</b>                                                                                                                                                                                                                                                   |                           |
| equation 6.6    | $\sigma_{\epsilon\theta}, E\delta \delta \phi_{\epsilon\theta}, P\delta$ $\sigma_{\epsilon\theta}, E\delta = 275.6 \text{ N/mm}^2$<br>$f_{eq}, R_d = 355.0 \text{ N/mm}^2$<br>$\sigma_{\epsilon\theta}, E\delta \delta \phi_{\epsilon\theta}, P\delta = \text{OK}$         | <b>OK</b>                 |
| EC3-1-6         | <b>C.4 BUCKLING LIMIT STATE (LS3)</b>                                                                                                                                                                                                                                      |                           |
| 8               |                                                                                                                                                                                                                                                                            |                           |
| 8.5             | Stress Design                                                                                                                                                                                                                                                              |                           |
| 8.5.2           | Design Resistance (Buckling Strength)                                                                                                                                                                                                                                      |                           |
| 8.5.2 (1)       | Meridional Buckling Resistance $s_{x,Rd} = s_{x,Rk} / \gamma_{M1}$<br>Circumferential Buckling Resistance $\sigma_{\theta}, P\delta = \sigma_{\theta}, P_{\kappa} / \gamma_{M1}$<br>Shear buckling resistance $t_{q,Rd} = t_{q,Rk} / \gamma_{M1}$                          |                           |
| 8.5.2 (3)       | Characteristic Buckling Stress<br>Characteristic Meridional Buckling Stress $s_{x,Rk} = c_x \cdot f_{yk}$<br>Characteristic Circumferential Buckling Stress $s_{q,Rk} = c_q \cdot f_{yk}$<br>Characteristic Shear Buckling Stress $t_{q,Rk} = c_t \cdot f_{yk} / \sqrt{3}$ |                           |
| EC3-1-6         | <b>C.5 MERIDIONAL BUCKLING</b>                                                                                                                                                                                                                                             |                           |
| D1.2            |                                                                                                                                                                                                                                                                            |                           |
| D.1.2.2 (5)     | Meridional shell buckling check requirem $r / t \leq 0.03 \cdot (E / f_{yk})$ Check Not Required<br>$r / t = 13.6$<br>$0.03 \cdot (E / f_{yk}) = 17.7$                                                                                                                     | <b>Check Not Required</b> |
| D.1.2.1 (2)     | Length of Shell segment<br>Dimensionless length parameter $\omega = \lambda / (\sqrt{p\tau}) = 153579.8$                                                                                                                                                                   |                           |
| D.1.2.1         |                                                                                                                                                                                                                                                                            |                           |
| (4),(5),(6)     | Check Length of Cylinder                                                                                                                                                                                                                                                   |                           |
| equation D.3    | Medium : $1.7 \leq \omega \leq 0.5p/\tau$                                                                                                                                                                                                                                  |                           |
| equation D.5    | Short = $\omega \leq 1.7$                                                                                                                                                                                                                                                  |                           |
| equation D.7    | Long = $\omega > 0.5p/\tau$                                                                                                                                                                                                                                                |                           |
|                 | $0.5 r/t = 6.8$                                                                                                                                                                                                                                                            |                           |
|                 | Meridional Cylinder length classification = LONG                                                                                                                                                                                                                           |                           |
| D.1.2.1 (7)     | Check long cylinder special condition $r/t \leq 150$ = TRUE                                                                                                                                                                                                                |                           |
| equation D.11   | $\omega \leq 6(p/\tau)$ = FALSE                                                                                                                                                                                                                                            |                           |
|                 | $500 \leq E/f_{yk} \leq 1000$ = TRUE                                                                                                                                                                                                                                       |                           |
|                 | D.1.2.1 (7) eqn D.12 can be used = FALSE                                                                                                                                                                                                                                   |                           |
|                 | Exclude special long cylinder condition = TRUE                                                                                                                                                                                                                             | User override             |
| D.1.2.1 (4),(5) | Factor $C_x$                                                                                                                                                                                                                                                               |                           |
| equation D.4    | Medium $C_x =$ = FALSE                                                                                                                                                                                                                                                     |                           |
| equation D.6    | Short $C_x = 1.36 - 1.83/w + 2.07/w^2$ = FALSE                                                                                                                                                                                                                             |                           |
| D.1.2.1 (6)     |                                                                                                                                                                                                                                                                            |                           |
| equation D.8    | D.1.2.1 (6) eqn D.8 long (1) $C_x = C_{xh}$ = 0.6                                                                                                                                                                                                                          |                           |
| equation D.9    | $C_{xN} = \max(0.6, 1 + 0.2/C_{xb} \cdot (1 - 2w(t/r)))$ = 0.6                                                                                                                                                                                                             |                           |
| equation D.10   | $1 + 0.2/C_{xb} \cdot (1 - 2w(t/r))$ = -4511.20                                                                                                                                                                                                                            |                           |
| Table D.1       | Effect of boundary conditions on meridional buckling $\chi_{xb}$ = 1                                                                                                                                                                                                       |                           |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023

| REF.           |                                                                                                      | OUTPUT.                  |
|----------------|------------------------------------------------------------------------------------------------------|--------------------------|
|                | (LONG cylinders only)                                                                                |                          |
|                | D.1.2.1 (7) eqn D.12 long (2)                                                                        |                          |
|                | $C_x = C_x N \cdot (s_{x,E}, N / s_{x,E}) + (s_{x,E}, M / s_{x,E}) =$                                | 1.00                     |
|                | $\sigma_{\xi,E} = \sigma_{\xi} =$                                                                    | 275.8 N/mm <sup>2</sup>  |
|                | $\sigma_{\xi,E,N} = \sigma_{\xi v} =$                                                                | 0.0 N/mm <sup>2</sup>    |
|                | $\sigma_{\xi,E,M} = \sigma_{\xi \mu} =$                                                              | 275.8 N/mm <sup>2</sup>  |
|                | Meridional Design Value of $C_x$                                                                     | $C_x = 0.60$             |
|                | Elastic Critical Meridional Buckling Stress $\sigma_{\xi,P\chi\rho} =$                               | 5599.4 N/mm <sup>2</sup> |
| 8.5.2 (6)      | $\sigma_{\xi,P\chi\rho} = 0.605 E X_{\xi} \tau / \rho$                                               |                          |
| equation 8.17  | Relative Slenderness of the Shell $\lambda_x = \sqrt{\sigma_{yk} / s_{x,Rcr}} =$                     | 0.25                     |
| D.1.2.2 (3)    |                                                                                                      |                          |
| equation D.16  | Meridional squash limit slenderness <b>BS EN 1993-1-6:2007+A1:2017</b>                               |                          |
|                | Short, medium cylinder $\lambda_{x0} =$                                                              | 0.2                      |
|                | Long cylinder $\lambda_{x0} = 0.20 + 0.10(s_{x,E}, M / s_{x,E}) =$                                   | FALSE                    |
|                | Design value adopted $\lambda_{x0} =$                                                                | 0.20                     |
| equation D.14c | Plastic range factor <b><math>b_x = 1 - (0.95 / (1 + 1.2 \cdot (D_{wk}/t)))</math></b>               | <b>0.06</b>              |
| equation D.14d | Interaction exponent <b><math>\eta_{\xi} = 5.4 / (1 + 4.6 \cdot (\Delta \sigma_k / \tau))</math></b> | <b>5.10</b>              |
| D.1.2.2(1)     | Quality Class $B =$                                                                                  | 25                       |
| equation D.15  | Characteristic buckling amplitude <b><math>D_{wk} = 1/Q \sqrt{(r/t)}</math></b>                      | <b>0.15</b> mm           |
| equation D.14a | Meridional elastic buckling factor <b><math>a_{xG} = 0.83</math></b>                                 | <b>0.83</b>              |
| equation D.14b | <b><math>a_{xI} = 1 / (1 + 2.2 \cdot (D_{wk}/t) \cdot 0.88)</math></b>                               | <b>0.95</b>              |
| equation D.14  | <b><math>a_x = a_{xG} \cdot a_{xI}</math></b>                                                        | <b>0.79</b>              |
|                | Hardening limit <b><math>c_{sh} =</math></b>                                                         | <b>1.00</b>              |
| 8.5.2 (5)      | Plastic limit relative slenderness                                                                   |                          |
| equation 8.16  | $\lambda_{xp} = \sqrt{a/(1-b)} =$                                                                    | 0.92                     |
| 8.5.2 (4)      | Meridional Shell Buckling Parameter <b><math>\chi_{\xi} =</math></b>                                 | <b>0.995</b>             |
| equation 8.13  | $\chi_{\xi} \leq \lambda_{x0} =$                                                                     | FALSE                    |
| equation 8.14  | <b><math>\lambda_{x0} &lt; \chi_{\xi} &lt; \lambda_{xp}</math></b>                                   | TRUE                     |
| equation 8.15  | $\lambda_{xp} \leq \lambda_x =$                                                                      | FALSE                    |
| 8.5.2 (2)      | Meridional Buckling Stress $s_{x,Rk} = c_x \cdot \sigma_{yk} =$                                      | 353.35 N/mm <sup>2</sup> |
| 8.5.2 (1)      | Meridional Buckling Resistance $s_{x,Rd} = s_{x,Rk} / \gamma_{M1} =$                                 | 321.23 N/mm <sup>2</sup> |
| 8.5.3 (2)      | Buckling Stress Limitation $s_{x,Ed} \leq s_{x,Rd} =$                                                | TRUE                     |



PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023

| REF.                       |                                                                                               | OUTPUT.               |
|----------------------------|-----------------------------------------------------------------------------------------------|-----------------------|
| <b>EC3-1-6</b>             | <b>C.6 CIRCUMFERENTIAL BUCKLING</b>                                                           |                       |
| <b>D.1.3</b>               |                                                                                               |                       |
| <b>D.1.3.2 (3)</b>         | Circumferential shell buckling check requirement                                              |                       |
|                            | $r/t \leq 0.21 \cdot \sqrt{E/f_yk}$ Check Required                                            | <b>Check Required</b> |
|                            | $r/t = 13.61$                                                                                 |                       |
|                            | $0.21 \cdot \sqrt{E/f_yk} = 5.11$                                                             |                       |
| <b>D.1.3.1 (2)</b>         | Length of Shell segment                                                                       |                       |
|                            | Dimensionless length parameter $w = l/(\sqrt{rt}) = #####$                                    |                       |
| <b>D.1.3.1 (3),(5),(7)</b> | Check Length of Cylinder: condition                                                           |                       |
| equation D.20              | Medium $= 20 \leq w / C\theta \leq 1.63 r / t$                                                |                       |
| equation D.22              | Short $= w / C\theta_s < 20$                                                                  |                       |
| equation D.24              | Long $= w / C\theta > 1.63 * r / t$                                                           |                       |
|                            | Check Length of Cylinder: stress                                                              |                       |
|                            | Medium $0.92 * E (C\theta / w) (t/r) = 0.1$ N/mm2                                             |                       |
|                            | Short $0.92 * E (C\theta_s / w) (t/r) = 0.1$ N/mm2                                            |                       |
|                            | Long $E (t/r)^2 [0.275 + 2.03 (C\theta / w * r/t)^4] = 311.6$ N/mm2                           |                       |
|                            | Circumferential Cylinder length classification $= LONG$                                       |                       |
| <b>8.5.2 (6)</b>           | Elastic Critical Circumferential Buckling Stress $\sigma_{\theta, P\chi\phi} = 311.6$ N/mm2   |                       |
| equation 8.17              | Slenderness of the Shell $\lambda_{\theta} = \sqrt{f_yk / \sigma_{\theta, P\chi\phi}} = 1.07$ |                       |
| <b>D1.3.2 (2)</b>          | Circumferential squash limit slenderness                                                      |                       |
| equation D.26              | Short, medium, long cylinder $\lambda_{\theta 0} = 0.40$                                      |                       |
| equation D.26              | Plastic range factor $\beta = 0.60$                                                           |                       |
| equation D.26              | Interaction exponent $\eta = 1.00$                                                            |                       |
| <b>Table D.5</b>           | Quality Class $= B$                                                                           |                       |
| <b>8.5.2 (5)</b>           | Circumferential elastic imperfection factor $\alpha_{\theta} = 0.65$                          |                       |
| equation 8.16              | Plastic limit relative slenderness $\lambda_{qp} = \sqrt{a/(1-b)} = 1.27$                     |                       |
| <b>8.5.2 (4)</b>           | Circumferential Shell Buckling Parameter $\chi_{\theta} = 0.54$                               |                       |
| equation 8.13              | $\lambda_{\theta} \leq \chi_{\theta 0} = FALSE$                                               |                       |
| equation 8.14              | $\lambda_{\theta 0} < \chi_{\theta} < \lambda_{qp} = TRUE$                                    |                       |
| equation 8.15              | $\lambda_{qp} \leq \lambda_{\theta} = FALSE$                                                  |                       |
| <b>8.5.2 (2)</b>           | Characteristic Circumferential Buckling Stress $= 192.5$ N/mm2                                |                       |
| <b>8.5.2 (1)</b>           | Circumferential Buckling Resistance $= 175.0$ N/mm2                                           |                       |
| <b>8.5.3 (2)</b>           | Buckling Stress Limitation $= TRUE$                                                           |                       |
|                            | <b>BS EN 1993-1-6:2007+A1:2017</b>                                                            |                       |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023

| REF.                       |                                                                                                           |                                                                       | OUTPUT.                          |
|----------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------|
| <b>EC3-1-6 C.7</b>         | <b>SHEAR BUCKLING</b>                                                                                     |                                                                       |                                  |
| <b>D.1.4</b>               |                                                                                                           |                                                                       |                                  |
| <b>D.1.4.2 (3)</b>         | Shear shell buckling check requirement                                                                    |                                                                       |                                  |
|                            | $r / t \leq 0.16 \cdot (E / f_{yk})^{0.67}$                                                               | = Check Required                                                      | <b>Check Required</b>            |
|                            | $r / t$                                                                                                   | = 13.6                                                                |                                  |
|                            | $0.16 \cdot (E / f_{yk})^{0.67}$                                                                          | = 11.52                                                               |                                  |
| <b>D.1.4.1 (2)</b>         | Length of Shell segment                                                                                   |                                                                       |                                  |
|                            | Dimensionless length parameter                                                                            | $\omega = \lambda / (\sqrt{\rho} \tau) = 153579.8$                    |                                  |
| <b>D.1.4.1 (4),(5),(6)</b> | Check Length of Cylinder: condition                                                                       |                                                                       |                                  |
| equation D.33              | Medium                                                                                                    | $10 \leq \omega \leq 8.7 r / t$                                       |                                  |
| equation D.35              | Short                                                                                                     | $\omega < 10$                                                         |                                  |
| equation D.24              | Long                                                                                                      | $\omega > 8.7 * r / t$                                                |                                  |
|                            | Check Length of Cylinder: value of Ct                                                                     |                                                                       |                                  |
|                            | Medium                                                                                                    | $C_t = 1.0$                                                           |                                  |
|                            | Short                                                                                                     | $C_t = \sqrt{1 + (42 / \omega^3)} = 1.0$                              |                                  |
|                            | Long                                                                                                      | $C_t = 1 / 3 \cdot \sqrt{\omega \cdot t / r} = 35.4$                  |                                  |
|                            | Shear Cylinder length classification                                                                      | = LONG                                                                |                                  |
|                            |                                                                                                           | $C_t = 35.404$                                                        |                                  |
|                            | Elastic Critical Shear Buckling Stress                                                                    |                                                                       |                                  |
| 8.5.2 (6)                  | $\tau_{\xi \theta, P_{\chi p}} = 0.75 \cdot E \cdot X_{\tau} \cdot \sqrt{(1 / \omega)} \cdot \tau / \rho$ | = 1045.2 N/mm <sup>2</sup>                                            |                                  |
| equation 8.17              | Slenderness of the Shell                                                                                  | $\lambda_t = \sqrt{(f_{yk} / \sigma_3)} / t_{xq, R_c} = 0.44$         |                                  |
| <b>D1.4.2 (2)</b>          | Shear squash limit slenderness                                                                            |                                                                       |                                  |
| equation D.39              | Short, medium, long cylinder                                                                              | $\lambda_{t0} = 0.4$                                                  |                                  |
| equation D.39              | Plastic range factor                                                                                      | $\beta = 0.6$                                                         |                                  |
| equation D.39              | Interaction exponent                                                                                      | $\eta = 1.0$                                                          |                                  |
| Table D.6                  | Shear elastic imperfection factor                                                                         | $\alpha_{\tau} = 0.65$                                                |                                  |
| equation 8.16              | Plastic limit relative slenderness                                                                        | $\lambda_{tp} = \sqrt{(a / (1 - b))} = 1.27$                          |                                  |
| 8.5.2 (4)                  | Shear Shell Buckling Parameter                                                                            | $\chi_{\tau} = 0.97$                                                  |                                  |
| equation 8.13              |                                                                                                           | $\lambda_t \leq \lambda_{t0} = \text{FALSE}$                          |                                  |
| equation 8.14              |                                                                                                           | $\lambda_{t0} < \lambda_t < \lambda_{tp} = \text{TRUE}$               |                                  |
| equation 8.15              |                                                                                                           | $\lambda_{tp} \leq \lambda_t = \text{FALSE}$                          |                                  |
| 8.5.2 (2)                  | Shear Buckling Stress                                                                                     | $t_{xq, R_k} = c_t \cdot f_{yk} / \sqrt{3} = 198.9$ N/mm <sup>2</sup> |                                  |
| 8.5.2 (1)                  | Shear Buckling Resistance                                                                                 | $t_{q, R_d} = t_{xq, R_k} / \gamma_{M1} = 180.9$ N/mm <sup>2</sup>    |                                  |
| 8.5.3 (2)                  | Stress Limitation                                                                                         | $t_{q, E_d} \leq t_{xq, R_d} = \text{TRUE}$                           |                                  |
|                            | (Buckling strength verification)                                                                          |                                                                       |                                  |
| equation D.50              | Length Parameters;                                                                                        |                                                                       |                                  |
| equation D.51              |                                                                                                           | $IR = \min \{0.1 L, 0.16 r \sqrt{(r/t)} = 92$ mm                      | Limiting local buckling boundary |
| equation D.52              |                                                                                                           | $l_f = L - 2 IR = 6459817$ mm                                         | Local buckling free length       |
| equation D.53              |                                                                                                           | $l_{int} = 1.3 r \sqrt{(r/t)} = 744$ mm                               | Long cylinder zone within $l_f$  |
|                            | <b>BS EN 1993-1-6:2007+A1:2017</b>                                                                        |                                                                       |                                  |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                                    | OUTPUT.                                                                                                                                                                                                                    |
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| <b>EC3-1-6 C.8 SATISFYING CONDITION</b> |                                                                                                                                                                                                                            |
| equation 8.19                           | $(\sigma_{x,Ed} / \sigma_{x,Rd})k_x - k_i (\sigma_{x,Ed} / \sigma_{x,Rd}) (\sigma_{\theta,Ed} / \sigma_{\theta,Rd}) + (\sigma_{\theta,Ed} / \sigma_{\theta,Rd})k_{\theta} + (t_{x\theta,Ed} / t_{x\theta,Rd})k_t \leq 1.0$ |
| Appendix D                              | Appendix D buckling interaction parameters                                                                                                                                                                                 |
| equation D.46                           | $k_x = 1.25 + 0.75 c_x = 2.00$                                                                                                                                                                                             |
| equation D.47                           | $k_{\theta} = 1.25 + 0.75 c_{\theta} = 1.66$                                                                                                                                                                               |
| equation D.48                           | $k_t = 1.75 + 0.25 c_t = 1.99$                                                                                                                                                                                             |
| equation D.49                           | $k_i = (c_x \cdot c_{\theta})^2 = 0.29$                                                                                                                                                                                    |
|                                         | Conservative buckling interaction parameters                                                                                                                                                                               |
| equation 8.20                           | $k_x = 1.0 + c_x^2 = 1.99$                                                                                                                                                                                                 |
| equation 8.21                           | $k_{\theta} = 1.0 + c_{\theta}^2 = 1.29$                                                                                                                                                                                   |
| equation 8.22                           | $k_t = 1.50 + 0.5 c_t^2 = 1.97$                                                                                                                                                                                            |
| equation 8.23                           | $k_i = (c_x \cdot c_{\theta})^2 = 0.29$                                                                                                                                                                                    |
| <b>C.9 SUMMARY OF THE CALCULATIONS</b>  |                                                                                                                                                                                                                            |
| Meridional Buckling factor              | $\chi_x^E = 1.00$                                                                                                                                                                                                          |
| Circumferential Buckling factor         | $\chi_{\theta}^E = 0.54$                                                                                                                                                                                                   |
| Shear Buckling factor                   | $\chi_{\tau}^E = 0.97$                                                                                                                                                                                                     |
| Meridional Design Resistance            | $s_{x,Rd} = 321.2 \text{ N/mm}^2$                                                                                                                                                                                          |
| Meridional Design Stress                | $s_{x,Ed} = 275.8 \text{ N/mm}^2$                                                                                                                                                                                          |
| Circumferential Design Resistance       | $s_{q,Rd} = 175.0 \text{ N/mm}^2$                                                                                                                                                                                          |
| Circumferential Design Stress           | $s_{q,Ed} = 5.1 \text{ N/mm}^2$ Compressive                                                                                                                                                                                |
| Shear Design Resistance                 | $t_{q,Rd} = 180.9 \text{ N/mm}^2$                                                                                                                                                                                          |
| Shear Design Stress                     | $t_{q,Ed} = 20.6 \text{ N/mm}^2$                                                                                                                                                                                           |
| 8.5.3 (3)                               | Interaction eqn 8.19 using Appendix D buckling interaction parameters = 0.75 - hoop tension is excluded 8.5.3 (4)                                                                                                          |
| 8.5.3 (3)                               | Interaction eqn 8.19 using conservative buckling interaction parameters = 0.76 - hoop tension is excluded 8.5.3 (4)                                                                                                        |
|                                         | % Contribution                                                                                                                                                                                                             |
| Appendix D                              | Component of Meridional Utilisation factor = 0.74 98.8%                                                                                                                                                                    |
| 8.19                                    | Component of Meridional / Circumferential Utilisation cross product Utilisation factor = -0.01 -1.0%                                                                                                                       |
|                                         | Component of Circumferential Utilisation Factor = 0.00 0.4%                                                                                                                                                                |
|                                         | Component of Shear Utilisation Factor = 0.01 1.8%                                                                                                                                                                          |
|                                         | Summation = 0.75 100.0%                                                                                                                                                                                                    |



PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                              |                                                                                   |                      | OUTPUT. |
|-----------------------------------|-----------------------------------------------------------------------------------|----------------------|---------|
|                                   | <b>MEMBER BUCKLING IN ACCORDANCE WITH EC3-1-1</b>                                 |                      |         |
|                                   | <b>A INPUT</b>                                                                    |                      |         |
|                                   | <b>A.1 Uncorroded Pile Dimensions</b>                                             |                      |         |
|                                   | Outer Diameter (d)                                                                | = 323 mm             | Class 1 |
|                                   | Wall Thickness (t)                                                                | = 12.0 mm            |         |
|                                   | <b>A.2 Corroded Pile Dimensions</b>                                               |                      |         |
|                                   | Corrosion loss of the section (External faces)                                    | = 0.6 mm             |         |
|                                   | Corrosion loss of the section (Internal faces)                                    | = 0 mm               |         |
|                                   | Outer Diameter (d)                                                                | = 321.8 mm           |         |
|                                   | Wall Thickness (t)                                                                | = 11.4 mm            |         |
|                                   | Inside Diameter (di)                                                              | 299 mm               |         |
|                                   | <b>A.3 Material Properties</b>                                                    |                      |         |
|                                   | Design Yield Stress (fy)                                                          | = 355 N/mm2          |         |
|                                   | Young's Modulus                                                                   | = 210000 N/mm2       |         |
|                                   | Cross Section Limits                                                              | = Cold Formed        |         |
|                                   | <b>A.4 Eurocode Partial Factors</b>                                               |                      |         |
| BS EN 1993-5: 2007<br>Cl 5.1.1(4) | Partial Factor for resistance of cross section                                    | $\gamma_{M0}$ = 1.00 |         |
|                                   | Partial Factor for resistance of members to instability assessed by member checks | $\gamma_{M1}$ = 1.10 |         |
|                                   | <b>A.5 Pile Length</b>                                                            |                      |         |
| BS EN 1993-5: 2007<br>Figure 5.8  |                                                                                   |                      |         |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.          |                                                            | OUTPUT. |
|---------------|------------------------------------------------------------|---------|
|               | Length of Pile From Soffit to Fixity Level (H) = 3.5845 m  |         |
|               | Length Factor (k) = 2.00                                   |         |
|               | Buckling Length = $l_{cr} = k \times H$                    |         |
|               | $= 2 \times 3.58$                                          |         |
|               | $l_{cr} = 7.17 \text{ m}$                                  |         |
|               | <b>A.6.2 Co-Existing Axial Forces and Bending Moment</b>   |         |
|               | Design Axial Force (NEd) = 0 kN                            |         |
|               | Design Shear (VED) = 114 kN                                |         |
| Refer section | Design Torsion (TEd) = 0 kNm                               |         |
| B.11.3 and    | Design Bending Moment at top in y-y axis (My,Ed) = 0 kNm   |         |
| table B.3 of  | Design Bending Moment at top in z-z axis (Mz,Ed) = 238 kNm |         |
| this Sheet    | Design Resultant Bending Moment (MEd) = 238 kNm            |         |
|               | <b>A.6.6 Equivalent Uniform Moment Factor</b>              |         |
|               | Equivalent uniform moment factor $C_m = 1.00$              |         |
|               | <b>B STRUCTURAL CALCULATIONS</b>                           |         |
|               | <b>B.1 Parameters for Structural Calculations</b>          |         |
|               | Outer Diameter (d) = 321.8 mm                              |         |
|               | Wall Thickness (t) = 11.4 mm                               |         |
|               | Inner Diameter (di) = 299 mm                               |         |
|               | Diameter/wall thickness (d/t) = 28.23                      |         |
|               | Pile Area = 11117 mm <sup>2</sup>                          |         |
|               | Moment of Inertia (I) = 1.3E+08 mm <sup>4</sup>            |         |
|               | Radius of Gyration (i) = 110 mm                            |         |
|               | Elastic Section Modulus (Wel) = ##### mm <sup>3</sup>      |         |
|               | Plastic Section Modulus (Wpl) = ##### mm <sup>3</sup>      |         |
|               | Shear Area (Av) = 7077.12 mm <sup>2</sup>                  |         |



PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                                  |                                                                                                                                                                            | OUTPUT. |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
|                                       | <b>B.2 Classification of Cross Section</b>                                                                                                                                 |         |
| BS EN 1993-1-1: 2005<br>Table 5.2     | $\epsilon = \quad = 0.81$ $50 \epsilon^2 = 33.10$ $70 \epsilon^2 = 46.34$ $90 \epsilon^2 = 59.58$ $d/t = 28.2 \leq 50 \epsilon^2$ $\text{Classification} = \text{Class 1}$ |         |
|                                       | <b>B.11 Buckling Resistance of Members</b>                                                                                                                                 |         |
|                                       | <b>B.11.1 Uniform Members in Compression</b>                                                                                                                               |         |
| BS EN 1993-1-1: 2005<br>Cl 6.3.1.1(1) | <p>A compression member should be verified against buckling as follows:</p> $\leq 1.0$                                                                                     |         |
|                                       | $N_{Ed} = 0 \text{ kN}$ <p>Nb,Rd = Design Buckling Resistance of the Compression Member</p> $=$                                                                            |         |
| BS EN 1993-1-1: 2005<br>Cl 6.3.1.1(3) | $\chi = \text{Reduction Factor for the Relevant Buckling Mode}$                                                                                                            |         |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                             | OUTPUT.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                |      |      |      |   |   |                       |      |      |      |      |      |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------|------|------|---|---|-----------------------|------|------|------|------|------|
| BS EN 1993-1-1: 2005<br>Eq 6.49  | $\chi = \leq 1.0$<br><br>$=$<br><br>$=$ Non-dimensional slenderness ratio                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                |      |      |      |   |   |                       |      |      |      |      |      |
| BS EN 1993-1-1: 2005<br>Eq 6.50  | $=$<br><br>$=$<br><br>$L_{cr} =$ Buckling Length $= 7.169$ m<br>$i = 110$ mm (Radius of Gyration)<br><br>$\lambda_1 = = 93.9$ $\epsilon$ 76<br><br>$\lambda_1 = 93.9 \times 0.81 = 76.40$<br>$= 0.85$                                                                                                                                                                                                                                                                                                                          |                |      |      |      |   |   |                       |      |      |      |      |      |
| BS EN 1993-5:2007<br>Cl 5.3.3(3) | <p>The Slenderness criterion for which overall buckling may be assumed to be satisfied is:</p> $\leq 0.1$<br><br><p>If this criteria is not met consideration should be given to buckling</p> $N_{cr} =$<br><br>$N_{cr} = 5405$ kN<br><br>$= 0.00 \leq 0.1$ OK                                                                                                                                                                                                                                                                 |                |      |      |      |   |   |                       |      |      |      |      |      |
|                                  | <p>For <math>= 0.85</math> <math>\chi</math> can be established from table 6.1, 6.2 and figure 6.4</p>                                                                                                                                                                                                                                                                                                                                                                                                                         |                |      |      |      |   |   |                       |      |      |      |      |      |
|                                  | <p>Table 6.1: Imperfection factors for buckling curves</p> <table border="1"> <thead> <tr> <th>Buckling curve</th> <th>a0</th> <th>a</th> <th>b</th> <th>c</th> <th>d</th> </tr> </thead> <tbody> <tr> <td>Imperfection Factor a</td> <td>0.13</td> <td>0.21</td> <td>0.34</td> <td>0.49</td> <td>0.76</td> </tr> </tbody> </table> <p>Cross section limits <math>=</math> Cold Formed<br/> Choose <math>\alpha = 0.49</math><br/><br/> <math>=</math> <math>= 1.025</math><br/><br/> <math>\chi = = 0.63 \leq 1.0</math> </p> | Buckling curve | a0   | a    | b    | c | d | Imperfection Factor a | 0.13 | 0.21 | 0.34 | 0.49 | 0.76 |
| Buckling curve                   | a0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | a              | b    | c    | d    |   |   |                       |      |      |      |      |      |
| Imperfection Factor a            | 0.13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0.21           | 0.34 | 0.49 | 0.76 |   |   |                       |      |      |      |      |      |

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SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                                     | OUTPUT.                                                                                                                                                                                                                                                                                                               |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use c = 0.63                             |                                                                                                                                                                                                                                                                                                                       |
| BS EN 1993-1<br>-1:2005<br>Table 6.2     |                                                                                                                                                                                                                                                                                                                       |
| BS EN 1993-1<br>-1:2005<br>Figure 6.4    |                                                                                                                                                                                                                                                                                                                       |
| $\chi = 0.628$                           |                                                                                                                                                                                                                                                                                                                       |
| Nb,Rd =                                  |                                                                                                                                                                                                                                                                                                                       |
| = 2253 kN                                |                                                                                                                                                                                                                                                                                                                       |
| = 0.00 ≤ 1.0 OK                          | OK                                                                                                                                                                                                                                                                                                                    |
| <b>B.11.2 Uniform Members in Bending</b> |                                                                                                                                                                                                                                                                                                                       |
| BS EN 1993-1:2005<br>Cl 6.3.2.1 (2)      | Beams with sufficient restraint to the compression flange are not susceptible to lateral-torsional buckling. In addition, beams with certain types of cross sections, such as square or circular hollow sections, fabricated circular tubes or square box sections are not susceptible to lateral-torsional buckling. |

PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                                               | OUTPUT.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                    | Therefore it is not necessary to consider the effects of lateral-torsional buckling for steel tubular members                                                                                                                                                                                                                                                                                                                                                       |
|                                                    | <b>B.11.3 Uniform Members in Bending and Axial Compression</b>                                                                                                                                                                                                                                                                                                                                                                                                      |
| BS EN 1993-1-1:2005<br>Cl 6.3.3 (4) & Eq 6.61/6.62 | Members which are subjected to combined bending and axial compression should satisfy:<br>$\leq 1.0$                                                                                                                                                                                                                                                                                                                                                                 |
|                                                    | This equation shown is a simplification for a tubular section and consideration of uni-axial bending but using a resultant bending moment if applicable.                                                                                                                                                                                                                                                                                                            |
| BS EN 1993-1-1:2005<br>Table 6.7                   | $\Delta M_{y,z,Ed} = 0$ Symmetrical cross section, therefore shift in centroidal axis not applicable.<br>$\chi_{LT} = 0$ Tubular sections not prone to lateral torsional buckling.                                                                                                                                                                                                                                                                                  |
|                                                    | The buckling interaction equation can therefore be further simplified to:-                                                                                                                                                                                                                                                                                                                                                                                          |
| BS EN 1993-1-1:2005<br>Cl 6.3.2.1 (2)              | $\leq 1.0 \quad k = \text{Buckling Interaction factor}$                                                                                                                                                                                                                                                                                                                                                                                                             |
| BS EN 1993-1-1:2005<br>Table 6.7                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                    | $NR_k = f_y A = 355 \times 11117 \times 10^{-3}$ $= 3946 \text{ kN}$ <p>Type of Class = Class 1</p> <p>Use</p> $W_y = W_z = W = W_{pl}$ $MR_k = f_y \times W_{pl}$ $= 355 \times 1098863$ $= 3.9E+08 \text{ Nmm}$ $= 390 \text{ kNm}$ <p>Method 2 shall be used to calculate k factors. In accordance with Steel Construction Institute advice, circular hollow sections can be used in this approach even though reference is only made to I and RHS sections.</p> |







PROJECT Inter Boat Marinas

SUBJECT AW0 Section check C3-EC

PROJECT No. BI7934 FILE Ref C3-EC REV 1.0

PREPARED AA DATE 18/07/2023



| REF.                                                     | OUTPUT.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                          | <p>Equivalent uniform moment factor adopted</p> <p><math>C_m = 1.00</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <div>BS EN 1993-1-1:2005<br/>Annex B<br/>Table B.1</div> | <p>Table B.1 gives the following formulas to calculate Interaction factor k for different cross section.<br/>(Tubular members are not susceptible to torsional deformations)</p> <p>This equation are simplified for a tubular section and consideration of uni-axial</p> <p>For Class 4 cross section:</p> <p><math>k = \quad \leq</math></p>                                                                                                                                                                                                              |
| <div>Refer section<br/>B.10.1 of this<br/>Sheet</div>    | <p>Classification = Class 1</p> <p><math>\alpha = 0.85</math></p> <p><math>N_{Ed} = 0 \text{ kN}</math></p> <p><math>N_{Rk} = 3946 \text{ kN}</math></p> <p><math>\chi = 0.63</math></p> <p><math>\chi \Delta T = 1.0</math> (Circular hollow sections not susceptible to lateral torsional buckling)</p> <p><math>g_{M1} = 1.1</math></p> <p><math>M_{Ed} = 238 \text{ kNm}</math></p> <p><math>\Delta M_{Ed} = 0 \text{ kNm}</math></p> <p><math>M_{Rk} = 390 \text{ kNm}</math></p> <p><math>k = 1.000</math></p> <p><math>= 0.67 \leq 1.0</math> OK</p> |
|                                                          | OK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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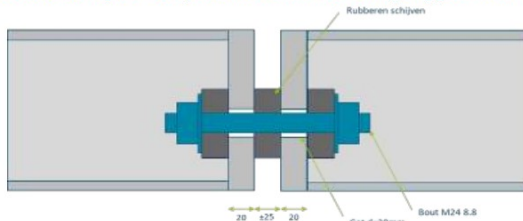
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## Toetsing semi-flexibele koppeling

### Omschrijving

In deze berekening wordt de capaciteit van de semi-flexibele koppeling geverifieerd



### Referenties:

NEN-EN 1993-1-8+C2 (nl)  
NEN-EN 1993-1-1-C2+A1-2011  
NEN-EN 1993-1-1+C2+A1:2016  
SCIA berekenings uitvoer

### Invoer

#### Geometrie

Afmeting  
Nominale boutdiameter  
Gatdiameter  
partiele factor voor de weerstand van dwarsdoorsneden  
partiele factor met betrekking tot breuktreksterkte  
boutklassen factor  
Boutoppervlakte  
Stuikweerstand factor  
Trekweerstand factor  
Vloeiingspanningsratio  
Plaatdikte  
Eindafstand

|                  |                        |
|------------------|------------------------|
| Afmeting         | M24                    |
| d                | 24.0 mm                |
| d <sub>0</sub>   | 28.0 mm                |
| Y <sub>M,0</sub> | 1.0                    |
| Y <sub>M,2</sub> | 1.25                   |
| α <sub>v</sub>   | 0.6                    |
| A <sub>b</sub>   | 353.0 mm <sup>2</sup>  |
| k <sub>1</sub>   | 2.5                    |
| k <sub>2</sub>   | 0.9                    |
| α <sub>b</sub>   | 0.4                    |
| t                | 20.0 mm                |
| e <sub>1</sub>   | 35.0 mm                |
| e <sub>2</sub>   | 35.0 mm                |
| W <sub>vel</sub> | 1357.2 mm <sup>3</sup> |

#### Materiaaleigenschappen kopplaat

|                  |                                         |
|------------------|-----------------------------------------|
| Staalklasse      | S235                                    |
| Vloeiingspanning | f <sub>yk</sub> 235.0 N/mm <sup>2</sup> |
| E-modulus        | E 210000 N/mm <sup>2</sup>              |
| Treksterkte      | f <sub>uk</sub> 360.0 N/mm <sup>2</sup> |

#### Materiaaleigenschappen bout

|                     |                                         |
|---------------------|-----------------------------------------|
| Boutklasse          | 8.8                                     |
| Vloeiingsgrens      | f <sub>yb</sub> 640.0 N/mm <sup>2</sup> |
| Uiterstetreksterkte | f <sub>ub</sub> 800.0 N/mm <sup>2</sup> |

#### Belastingen

Moment (scia uitvoer)  
Dwarskracht (scia uitvoer)  
Normaalkracht (scia uitvoer)

|                   |         |
|-------------------|---------|
| M <sub>Ed</sub>   | 0.4 kNm |
| F <sub>v,Ed</sub> | 30.7 kN |
| F <sub>t,Ed</sub> | 69.5 kN |

#### Afschuifweerstand

|                   |        |
|-------------------|--------|
| F <sub>v,Rd</sub> | 136 kN |
|-------------------|--------|

$$F_{v,Rd} = \frac{\alpha_s \cdot f_{vb} \cdot A}{\gamma_{M2}}$$

#### Stuik (dwars) -weerstand

|                   |        |
|-------------------|--------|
| F <sub>b,Rd</sub> | 144 kN |
|-------------------|--------|

$$F_{b,Rd} = \frac{k \cdot \alpha_s \cdot f_t \cdot d \cdot t}{\gamma_{M2}}$$

#### Trekweerstand

|                   |        |
|-------------------|--------|
| F <sub>t,Rd</sub> | 203 kN |
|-------------------|--------|

$$F_{t,Rd} = \frac{k_2 \cdot f_{tb} \cdot A_s}{\gamma_{M2}}$$

#### Buigweerstand

Momentweerstand  
Gereduceerde momentweerstand (door normaalspanning)

|                   |          |
|-------------------|----------|
| M <sub>Rd</sub>   | 1.30 kNm |
| M <sub>N,Rd</sub> | 1.09 kNm |

$$M_{N,Rd} = M_{Rd} \cdot \left(1 - \frac{F_{t,Ed}}{F_{t,Rd}}\right) \cdot \left(1 - \frac{F_{v,Ed}}{F_{v,Rd}}\right)$$

### Verificatie Resultaten

#### Toetsing van de Plaat

##### Verificatie Stuik (dwars) -weerstand plaat

|             |                     |      |                          |
|-------------|---------------------|------|--------------------------|
| Unity Check | UC <sub>Dets2</sub> | 0.21 | $F_{v,Ed} \leq F_{b,Rd}$ |
|-------------|---------------------|------|--------------------------|

#### Toetsing van de boutdoorsnede

##### Verificatie Afschuifweerstand

|             |                     |      |                          |
|-------------|---------------------|------|--------------------------|
| Unity Check | UC <sub>Dets1</sub> | 0.23 | $F_{v,Ed} \leq F_{v,Rd}$ |
|-------------|---------------------|------|--------------------------|

##### Verificatie Trekweerstand

|             |                     |      |                          |
|-------------|---------------------|------|--------------------------|
| Unity Check | UC <sub>Dets3</sub> | 0.34 | $F_{t,Ed} \leq F_{t,Rd}$ |
|-------------|---------------------|------|--------------------------|

##### Verificatie buigendmoment (incl reductie door normaal kracht)

|             |                     |      |                        |
|-------------|---------------------|------|------------------------|
| Unity Check | UC <sub>Dets4</sub> | 0.38 | $M_{Ed} \leq M_{N,Rd}$ |
|-------------|---------------------|------|------------------------|

##### Verificatie gecombineerde weerstand

|                                          |                     |      |                                                                                            |
|------------------------------------------|---------------------|------|--------------------------------------------------------------------------------------------|
| Afschuiving en normaalkracht             | UC <sub>Dets5</sub> | 0.47 | $\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 F_{t,Rd}} \leq 1.0$                       |
| Afschuiving, buigweerstand (gereduceerd) | UC <sub>Dets6</sub> | 0.20 | $\left[\frac{M_{Ed}}{M_{N,Rd}}\right]^2 + \left[\frac{F_{v,Ed}}{F_{v,Rd}}\right]^2 \leq 1$ |

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1  
  
3

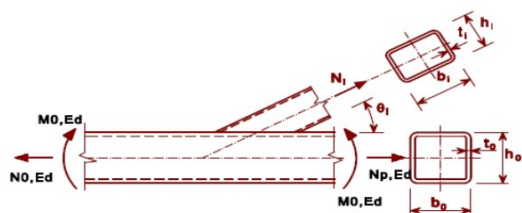
## Verificatie Verbinding Dwarsligger en Lassen

### Omschrijving

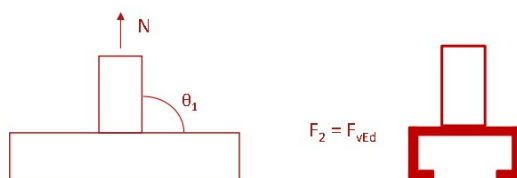
In deze verificatiesheet wordt de capaciteit van de vakwerkverbinding en de lassen getoetst. Hierbij is aangenomen dat de randstaaf als rechthoekige doorsnede mag worden vereenvoudigd.

### Referenties:

NEN-EN 1993-1-8+C2-2011  
SCIA berekeningsuitvoer



Definitieschets gelaste T, X, Y verbinding



Dwarsstaaf systeem schets

### Invoer

#### Geometrie

##### Profiel - Randstaaf - Hoofdligger

Hoogte (= in richting van verbinding)  
Breedte (=dwars op verbinding)  
Wanddikte

C-profiel als rechthoekige koker profiel

|    |       |    |
|----|-------|----|
| h0 | 100.0 | mm |
| b0 | 160.0 | mm |
| t0 | 5.00  | mm |

##### Profiel - Wandstaaf - Dwarsligger

Hoogte  
Breedte  
Wanddikte

Rechthoekige Koker profiel

|    |      |    |
|----|------|----|
| h1 | 60.0 | mm |
| b1 | 60.0 | mm |
| t1 | 4.0  | mm |

#### Parameters

Hoek wandstaaf met randstaaf

$\theta_1$  90.0 °

Verhouding van breedte (b0 / b1)

$\sin(\theta_1)$  1.00

Slankheid van plaatdeel randstaaf (b0 / t0)

$\beta$  0.38

$\gamma$  32

$k_n$  1.00

$\eta$  0.6

Verhouding van hoogte (h0 / h1)

Meewerkende breedte van lijf wandstaaf

Meewerkende breedte van flens randstaaf

$b_{eff}$  0 mm [conservatief]

$b_{a,p}$  0 mm [conservatief]

#### Belastingen (SCIA uitvoer)

Normaal kracht (scia uitvoer)

$N_{Ed}$  66.3 kN

Dwars kracht (scia uitvoer)

$F_{v,Ed}$  8.0 kN

#### Materiaaleigenschappen profiel

|                          |               |        |                   |
|--------------------------|---------------|--------|-------------------|
| Staalkwaliteit Randstaaf | $f_{yk0}$     | S355   | N/mm <sup>2</sup> |
| Staalkwaliteit Wandstaaf | $f_{yk1}$     | S235   | N/mm <sup>2</sup> |
| E-modulus                | E             | 210000 | N/mm <sup>2</sup> |
| Vloegrens Randstaaf      | $f_{y0}$      | 355    | N/mm <sup>2</sup> |
| Vloegrens Wandstaaf      | $f_{y1}$      | 235    | N/mm <sup>2</sup> |
| Partiëlefactor           | $\gamma_{M5}$ | 1      |                   |

#### Materiaaleigenschappen las - EN1993-1-8 tba 4.1

|                    |               |                                                     |
|--------------------|---------------|-----------------------------------------------------|
| Moedemateriaal las | $S235$        | N/mm <sup>2</sup>                                   |
| Vloegrens          | $f_y$         | 235 N/mm <sup>2</sup>                               |
| Uiterste vloegrens | $f_u$         | 360 N/mm <sup>2</sup>                               |
| Correlatiefactor   | $\beta_w$     | 0.80                                                |
| Partiëlefactor     | $\gamma_{M2}$ | 1.25                                                |
|                    | $f_{vwd}$     | 360 N/mm <sup>2</sup> $f_u / (\beta_w \gamma_{M2})$ |
|                    | $f_{twd}$     | 259 N/mm <sup>2</sup> $0.9 f_u / \gamma_{M2}$       |

### Verificatie Verbinding Y of T knoop

Geldigheidsgebied voor toetsen van gelaste Y en T verbindingen conform EN1993-1-8 tab 7.8

|                   |       |        |      |
|-------------------|-------|--------|------|
| $b/b_0 \leq 0.25$ | 0.375 | $\geq$ | 0.25 |
| $b_0/t_0 \leq 35$ | 32    | $\leq$ | 35   |
| $b_0/t_0 \leq 35$ | 32    | $\leq$ | 35   |
| $b/t_1 \leq 35$   | 15.00 | $\leq$ | 35   |
| $h/t_1 \leq 35$   | 15.00 | $\leq$ | 35   |
| $b/t_1 \leq 35$   | 15.00 | $\leq$ | 35   |
| $h/t_1 \leq 35$   | 15.00 | $\leq$ | 35   |

**Project:**  
**Onderdeel:**  
**Datum:**  
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BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
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**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum:**  
**Pagina's**

1  
18/07/2023  
3

## Verificatie Verbinding Dwarsligger en Lassen

Rekenwaarden van de weerstanden tegen normaalkracht van gelaste T en Y verbindingen conform EN1993-1-8 tab 7.11

### Verificatie vloeien van de flens van de randstaaf

Vloeien van de flens van de randstaaf (lijf van C-Profiel)  
Unity Check

|              |      |    |
|--------------|------|----|
| $N_{1,Rd}$   | 62   | kN |
| $UC_{bets1}$ | 1.07 | -  |

### Verificatie bezwijken van de wandstaaf

Ponsen van de flens van de randstaaf  
Unity Check

|              |      |    |
|--------------|------|----|
| $N_{1,Rd}$   | 123  | kN |
| $UC_{bets2}$ | 0.68 | -  |

### Verificatie ponsen

Bezwijken van de wandstaaf  
Unity Check

|              |      |    |
|--------------|------|----|
| $N_{1,Rd}$   | 98   | kN |
| $UC_{bets3}$ | 0.54 | -  |

## Verificatie Las Sterkte - Hoeklas

### Lasgegevens

Lastype  
Aantal gelaste zijdes (boven en onder zijde profiel)  
Lasdikte  
Laslengte  
Plaatdikte

|             | Hoeklas |    |
|-------------|---------|----|
| a           | 2       | -  |
| $l_{eff}$   | 4       | mm |
| $l_{plaat}$ | 52      | mm |
|             | 4       | mm |

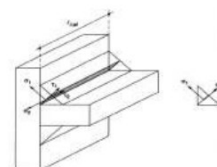


Fig. 33.9: Stresses on the collar cross section of a fillet weld (indices 1=L and 2=H)  
[ref. Overlappende staal - Constructies A]

### Controle hoeklas verbinding

#### Basisgeval 1

|                                 |       |                   |
|---------------------------------|-------|-------------------|
| F3                              | 66.3  | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 112.7 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0   | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{F_{s,d}/2}{4a_{eff}}; \quad \tau_2 = 0$$

#### Basisgeval 2

|                                 |      |                   |
|---------------------------------|------|-------------------|
| F2                              | 8.0  | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 13.6 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0  | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{F_{s,d}/2}{4a_{eff}}; \quad \tau_2 = 0$$

#### Basisgeval 3

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| F1                              | 0.0 | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\tau_2 = \frac{F_{s,d}}{2a_{eff}} \quad \text{indien } l_{eff} \leq 150a; \quad \sigma_1 = \tau_1 = 0$$

#### Basisgeval 4

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M5                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{M_{s,d}}{\sqrt{2}a_{eff}b^*} \quad \text{met } b^* = b + \frac{2}{3}a\sqrt{2}; \quad \tau_2 = 0$$

#### Basisgeval 5

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M4                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{2,12M_{s,d}}{a_{eff}^2} \quad (\text{in A en B}); \quad \tau_2 = 0$$

$$\sigma_1 = \tau_1 = 0 \quad (\text{in C}); \quad \tau_2 = 0$$

#### Basisgeval 6

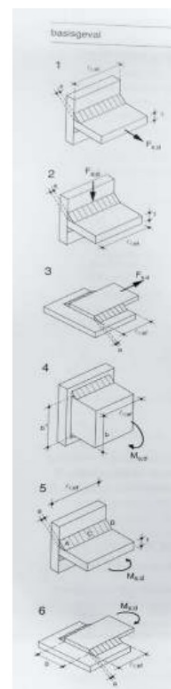
|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M6                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

(a) twee-krachtenmethode (indien  $l_{eff} \leq 2b$  en  $l_{eff} \leq 150a$ )

$$\tau_2 = \frac{F_{s,d}}{a_{eff}} \quad \text{met } F_{s,d} = \frac{M_{s,d}}{b^*} \quad \text{en } b^* = b + \frac{2}{3}a\sqrt{2}; \quad \sigma_1 = \tau_1 = 0$$

(b) twee-momentenmethode (indien  $l_{eff} > 2b$  en  $l_{eff} \leq 150a$ )

$$\sigma_1 = \tau_1 = \frac{2,12M_{s,d}}{a_{eff}^2}; \quad \tau_2 = 0$$



**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
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**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
[Redacted]  
18/07/2023  
3

### Verificatie Verbinding Dwarsligger en Lassen

Verificatie van de las met gecombineerde spanningen methode EN-1993-1-8 art 4.5.3.2

**Voorwaarde 1**

|                  |      |                   |                                                                                                       |
|------------------|------|-------------------|-------------------------------------------------------------------------------------------------------|
| $\sigma_{w,E;d}$ | 253  | N/mm <sup>2</sup> | $[\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} \leq f_v / (\beta_w \gamma_{M2})$ |
| $f_{v,w;d}$      | 360  | N/mm <sup>2</sup> |                                                                                                       |
| $UC_{bets4}$     | 0.70 | -                 |                                                                                                       |

**Voorwaarde 2**

|                      |      |                   |                                             |
|----------------------|------|-------------------|---------------------------------------------|
| $\sigma_{\perp,tot}$ | 126  | N/mm <sup>2</sup> | $\sigma_{\perp} \leq 0.9 f_v / \gamma_{M2}$ |
| $f_{t,w;d}$          | 259  | N/mm <sup>2</sup> |                                             |
| $UC_{bets5}$         | 0.49 | -                 |                                             |

**Maatgevende verificatie**

|              |      |   |             |
|--------------|------|---|-------------|
| $UC_{bets5}$ | 0.70 | - | Las Voldoet |
|--------------|------|---|-------------|



**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
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**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
18/07/2023  
3

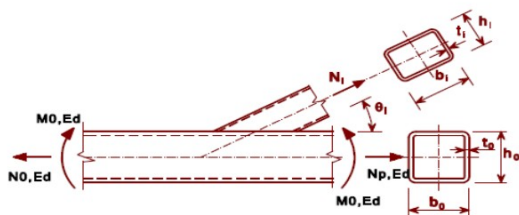
## Verificatie Verbinding Schoorstaaf en Lassen

### Omschrijving

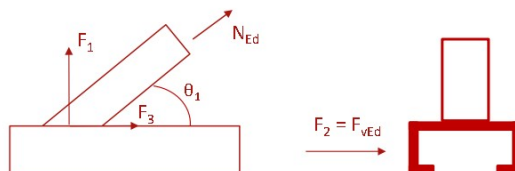
In deze verificatie sheet wordt de capaciteit van de vakwerk verbinding en de lassen getoetst  
Hierbij is aangenomen dat de randstaaf als Rechthoekige doorsnede mag worden vereenvoudigd

### Referenties:

NEN-EN 1993-1-8+C2-2011  
SCIA berekenings uitvoer



Definitie schets gelaste T, X, Y verbinding



Schoorstaaf systeem schets

### Invoer

#### Geometrie

##### Profiel - Randstaaf - Hoofdligger

Hoogte (= in richting van verbinding)  
Breedte (=dwars op verbinding)  
Wanddikte

##### Rechthoekige Koker profiel

|    |       |    |
|----|-------|----|
| h0 | 100.0 | mm |
| b0 | 160.0 | mm |
| t0 | 5.00  | mm |

##### Profiel - Wandstaaf - Schoorstaaf

Hoogte  
Breedte  
Wanddikte

##### Rechthoekige Koker profiel

|    |      |    |
|----|------|----|
| h1 | 60.0 | mm |
| b1 | 60.0 | mm |
| t1 | 5.0  | mm |

#### Parameters

Hoek wandstaaf met randstaaf

|            |      |   |
|------------|------|---|
| $\theta_1$ | 39.0 | ° |
|------------|------|---|

Verhouding van breedte ( $b_0 / b_1$ )  
Slankheid van plaatdeel randstaaf ( $b_0 / t_0$ )

|                  |      |    |
|------------------|------|----|
| $\sin(\theta_1)$ | 0.63 |    |
| $\beta$          | 0.38 |    |
| $\gamma$         | 32   |    |
| $k_n$            | 1.00 |    |
| $\eta$           | 0.6  |    |
| $b_{off}$        | 0    | mm |
| $b_{e,p}$        | 0    | mm |

Verhouding van hoogte ( $h_0 / h_1$ )  
Meewerkende breedte van lijf wandstaaf  
Meewerkende breedte van flens randstaaf

#### Belastingen (SCIA uitvoer)

Normaal kracht (scia uitvoer)  
Dwars kracht (scia uitvoer)

|            |       |    |
|------------|-------|----|
| $N_{Ed}$   | 110.2 | kN |
| $F_{v,Ed}$ | 0.1   | kN |

#### Materiaal eigenschappen profiel

|                          |               |        |                   |
|--------------------------|---------------|--------|-------------------|
| Staalkwaliteit Randstaaf | $f_{yk0}$     | S355   | N/mm <sup>2</sup> |
| Staalkwaliteit Wandstaaf | $f_{yk1}$     | S235   | N/mm <sup>2</sup> |
| E-modulus                | E             | 210000 | N/mm <sup>2</sup> |
| Vloegrens Randstaaf      | $f_{y0}$      | 355    | N/mm <sup>2</sup> |
| Vloegrens Wandstaaf      | $f_{y1}$      | 235    | N/mm <sup>2</sup> |
| Partiële factor          | $\gamma_{M5}$ | 1      |                   |

#### Materiaal eigenschappen las - EN1993-1-8 tba 4.1

|                      |               |      |                   |
|----------------------|---------------|------|-------------------|
| Moeder materiaal las |               | S235 | N/mm <sup>2</sup> |
| Vloei grens          | $f_y$         | 235  | N/mm <sup>2</sup> |
| Uiterste vloegrens   | $f_u$         | 360  | N/mm <sup>2</sup> |
| Correlatiefactor     | $\beta_w$     | 0.80 |                   |
| Partiële factor      | $\gamma_{M2}$ | 1.25 |                   |
|                      | $f_{vwd}$     | 360  | N/mm <sup>2</sup> |
|                      | $f_{twd}$     | 259  | N/mm <sup>2</sup> |

$f_u / (\beta_w \gamma_{M2})$   
 $0.9 f_u / \gamma_{M2}$

### Verificatie Verbinding Y of T knoop

Geldigheidsgebied voor toetsen van gelaste Y en T verbindingen conform EN1993-1-8 tab 7.8

|      |                     |       |        |      |
|------|---------------------|-------|--------|------|
|      | $b_0/b_1 \leq 0.25$ | 0.375 | $\geq$ | 0.25 |
|      | $b_0/t_0 \leq 35$   | 32    | $\leq$ | 35   |
|      | $b_0/t_0 \leq 35$   | 32    | $\leq$ | 35   |
| Druk | $b_1/t_1 \leq 35$   | 12.00 | $\leq$ | 35   |
| Druk | $h_1/t_1 \leq 35$   | 12.00 | $\leq$ | 35   |
| Trek | $b_1/t_1 \leq 35$   | 12.00 | $\leq$ | 35   |
| Trek | $h_1/t_1 \leq 35$   | 12.00 | $\leq$ | 35   |

**Project:**  
**Onderdeel:**  
**Datum:**  
**Auteur:**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
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**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum:**  
**Pagina's**

1  
18/07/2023  
3

## Verificatie Verbinding Schoorstaaf en Lassen

Rekenwaarden van de weerstanden tegen normaalkracht van gelaste T en Y verbindingen conform EN1993-1-8 tab 7.11

### Verificatie vloeien van de flens van de randstaaf (lijf C-profiel)

Vloeien van de flens van de randstaaf (lijf van C-Profiel)  
Unity Check

|               |      |    |
|---------------|------|----|
| $N_{1,Rd}$    | 114  | kN |
| $UC_{betst1}$ | 0.96 | -  |

### Verificatie bezwijken van de wandstaaf

Ponsen van de flens van de randstaaf  
Unity Check

|               |      |    |
|---------------|------|----|
| $N_{1,Rd}$    | 311  | kN |
| $UC_{betst2}$ | 0.94 | -  |

### Verificatie ponsen

Bezwijken van de wandstaaf  
Unity Check

|               |      |    |
|---------------|------|----|
| $N_{1,Rd}$    | 118  | kN |
| $UC_{betst3}$ | 0.35 | -  |

## Verificatie Las Sterkte - Hoeklas

### Lasgegevens

Lastype  
Aantal gelaste zijdes (boven en onder zijde profiel)  
Lasdikte  
Laslengte  
Dikte plaat

|             | Hoeklas |    |
|-------------|---------|----|
| a           | 2       | -  |
| l           | 4       | mm |
| Lasdikte    | 65      | mm |
| Laslengte   | 5       | mm |
| Dikte plaat |         |    |

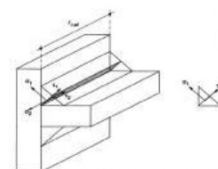


Fig 33.9: Stresses on the roller cross section of a fillet weld (indices 1=1, and 2=0)  
(ref. Overspanning slaai- Construeren A)

### Controle hoeklas verbinding

#### Basisgeval 1

|                                 |      |                   |
|---------------------------------|------|-------------------|
| F3                              | 69.4 | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 94.3 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0  | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{F_{s,d}/2}{4a l_{ref}}; \quad \tau_2 = 0$$

#### Basisgeval 2

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| F2                              | 0.1 | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.1 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{F_{s,d}/2}{4a l_{ref}}; \quad \tau_2 = 0$$

#### Basisgeval 3

|                                 |       |                   |
|---------------------------------|-------|-------------------|
| F1                              | 85.6  | kN                |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0   | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 164.7 | N/mm <sup>2</sup> |

$$\tau_2 = \frac{F_{s,d}}{2a l_{ref}} \quad \text{indien } l_{ref} \leq 150a; \quad \sigma_1 = \tau_1 = 0$$

#### Basisgeval 4

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M5                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{M_{s,d}}{\sqrt{2} a l_{ref} b^*} \quad \text{met } b^* = b + \frac{2}{3} a \sqrt{2}; \quad \tau_2 = 0$$

#### Basisgeval 5

|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M4                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

$$\sigma_1 = \tau_1 = \frac{2.12 M_{s,d}}{a l_{ref}^2} \quad (\text{in A en B}); \quad \tau_2 = 0$$

$$\sigma_1 = \tau_1 = 0 \quad (\text{in C}); \quad \tau_2 = 0$$

#### Basisgeval 6

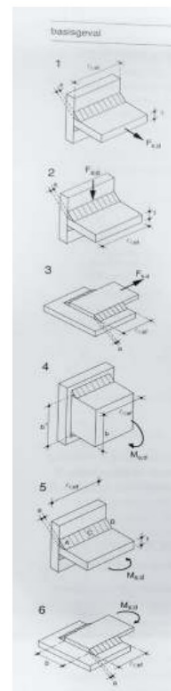
|                                 |     |                   |
|---------------------------------|-----|-------------------|
| M6                              | 0.0 | kNm               |
| $\sigma_{\perp} = \tau_{\perp}$ | 0.0 | N/mm <sup>2</sup> |
| $\tau_{\parallel}$              | 0.0 | N/mm <sup>2</sup> |

(a) twee-krachtenmethode (indien  $l_{ref} \leq 2b$  en  $l_{ref} \leq 150a$ )

$$\tau_2 = \frac{F_{s,d}}{a l_{ref}} \quad \text{met } F_{s,d} = \frac{M_{s,d}}{b^*} \quad \text{en } b^* = b + \frac{2}{3} a \sqrt{2}; \quad \sigma_1 = \tau_1 = 0$$

(b) twee-momentenmethode (indien  $l_{ref} > 2b$  en  $l_{ref} \leq 150a$ )

$$\sigma_1 = \tau_1 = \frac{2.12 M_{s,d}}{a l_{ref}^2}; \quad \tau_2 = 0$$



**Project:**  
**Onderdeel**  
**Datum**  
**Auteur**

BI7934 InterBoat - Schipperskerk  
Bijlage 3 - Verificaties  
12/07/2023  
A Akyel

**Versie Rekenblad:**  
**Gecontroleerd door:**  
**Datum**  
**Pagina's**

1  
18/07/2023  
3

### Verificatie Verbinding Schoorstaaf en Lassen

Verificatie van de las met gecombineerde spanningen methode EN-1993-1-8 art 4.5.3.2

**Voorwaarde 1**

|                      |      |                   |                                                                                                       |
|----------------------|------|-------------------|-------------------------------------------------------------------------------------------------------|
| $\sigma_{w,E;d}$     | 342  | N/mm <sup>2</sup> | $[\sigma_{\perp}^2 + 3 (\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} \leq f_v / (\beta_w \gamma_{M2})$ |
| $f_{v,w;d}$          | 360  | N/mm <sup>2</sup> |                                                                                                       |
| UC <sub>betst4</sub> | 0.95 | -                 |                                                                                                       |

**Voorwaarde 2**

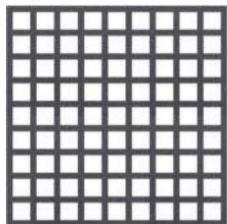
|                      |      |                   |                                             |
|----------------------|------|-------------------|---------------------------------------------|
| $\sigma_{\perp,tot}$ | 94   | N/mm <sup>2</sup> | $\sigma_{\perp} \leq 0.9 f_v / \gamma_{M2}$ |
| $f_{t,w;d}$          | 259  | N/mm <sup>2</sup> |                                             |
| UC <sub>betst5</sub> | 0.36 | -                 |                                             |

**Maatgevende verificatie**

|                      |      |   |             |
|----------------------|------|---|-------------|
| UC <sub>betst5</sub> | 0.95 | - | Las Voldoet |
|----------------------|------|---|-------------|

# Technical Information Sheet

## d<sup>2</sup> Dura Grating 23mm Mini Mesh



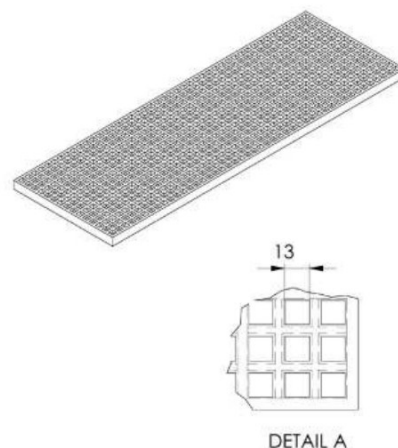
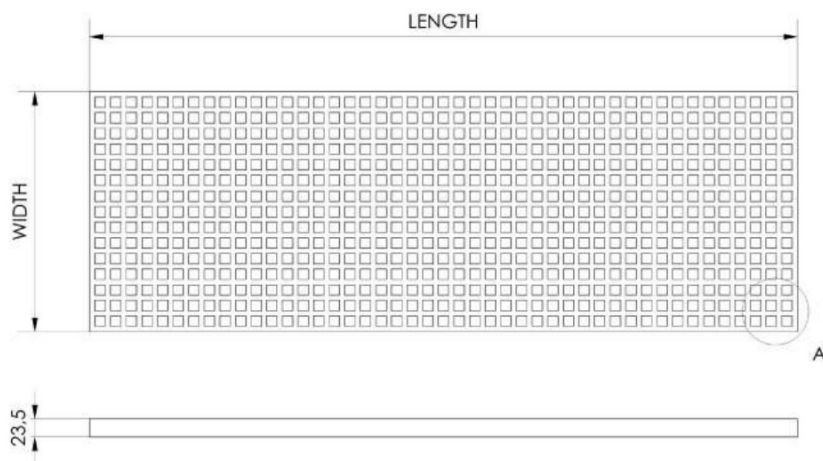
### Product Description

d<sup>2</sup> Dura Grating is a new patent pending GRP grating series that takes structural flooring to the next level. Available exclusively from Dura Composites, our Mini Mesh grating range achieves an industry-leading Class B fire rating according to BS EN 13501-1.

Designed, developed and manufactured by Dura Composites, d<sup>2</sup> Dura Grating's anti-slip surface is tested to over 1 million footfalls. It offers outstanding safety, performance and durability and is more cost-effective than traditional GRP grating in almost every scenario.

### Product Details

| Length (mm) | Width (mm) | Colours / Product Codes                                                                    | Panel Weight (kg) | Weight (kg/sqm) | Open Mesh Size (mm) |
|-------------|------------|--------------------------------------------------------------------------------------------|-------------------|-----------------|---------------------|
| 3012        | 1029       | Dark Grey (DG02309), Green (DG02315), Light Grey (DG02306), Sand (DG02303), Teak (DG02312) | 34.28             | 11.1            | 13 x 13             |
| 4033        | 1269       | Dark Grey (DG02308), Green (DG02314), Light Grey (DG02305), Sand (DG02302), Teak (DG02311) | 53.95             |                 |                     |
| 4033        | 1511       | Dark Grey (DG02307), Green (DG02313), Light Grey (DG02304), Sand (DG02301), Teak (DG02310) | 67.36             |                 |                     |



### Product Applications

Common applications for d<sup>2</sup> Dura Grating include walkways, gantries, gully covers, service risers, access platforms, stair treads, ramps, bund flooring, roof walkways, fencing, gates, trash screens, pontoons, mezzanines and low-rise balcony flooring.

### Packaging

Please see below for relevant packaging information for d<sup>2</sup> Dura Grating 23mm Mini Mesh.

| Packaging                   | Product Information |
|-----------------------------|---------------------|
| Maximum Products Per Pallet | 30                  |
| Pallet Dimensions (mm)      | 3010 x 1030 x 860   |
|                             | 4030 x 1270 x 860   |
|                             | 4030 x 1510 x 860   |
| Pallet Weight (kg)          | 1088                |
|                             | 1678                |
|                             | 2080                |

### Colours

Please see below for our d<sup>2</sup> Dura Grating RAL colours.

| Dura Colours | RAL Number |
|--------------|------------|
| Dark Grey    | 7043       |
| Green        | 6035       |
| Light Grey   | 7047       |
| Sand         | 1001       |
| Teak         | 8024       |



## Material

Glass Reinforced Polymer (GRP) d<sup>2</sup> Dura Grating is produced from glassfibres laminated together using an Orthophthalic Polyester Resin system and a gritted finish. It is resistant against a wide range of chemicals and temperature spectrums. Material samples are available on request, along with a copy of our chemical resistance data. Other resin types are available by special order.

## Test Performance Overview

| 4S Slider Pendulum Test    | BS EN 13501-1 | BS 4592   | European 20mm Ball Fall Test |
|----------------------------|---------------|-----------|------------------------------|
| PTV:<br>80 (dry), 77 (wet) | Class B       | Compliant | Compliant                    |

For more information please refer the Technical Installation Manual or speak to your Dura Composites Representative.

## Load and Deflection Data

Deflection is shown in millimetres (mm), with all columns denoting clear spans. Green/red cell colours indicate above and below L/100, which is the equivalent of 1% deflection. To view data for alternative standard load deflection such as L/200, or specific data for your project, visit [www.duracomposites.com/power-of-composites](http://www.duracomposites.com/power-of-composites).

### Point Load (PL)

|            | 200mm | 300mm | 400mm | 500mm | 600mm | 700mm |
|------------|-------|-------|-------|-------|-------|-------|
| 0.5 kN/ PL | 0.4   | 0.4   | 0.7   | 1.2   | 1.8   | 2.6   |
| 1.0 kN/ PL | 0.5   | 0.9   | 1.6   | 2.6   | 3.9   | 5.3   |
| 1.5 kN/ PL | 0.6   | 1.3   | 2.4   | 3.9   | 5.7   | 7.8   |
| 2.0 kN/ PL | 0.7   | 1.7   | 3.2   | 5.1   | 7.5   | 10.2  |
| 2.5 kN/ PL | 0.9   | 2.1   | 3.9   | 6.4   | 9.3   | 12.6  |
| 3.0 kN/ PL | 1.0   | 2.5   | 4.7   | 7.6   | 11.1  | 15.0  |

### Maximum Spans (mm)

| Load   | L/100 | L/200 |
|--------|-------|-------|
| 0.5 kN | 1460  | 940   |
| 1.0 kN | 940   | 480   |
| 1.5 kN | 630   | 340   |
| 2.0 kN | 490   | 270   |
| 2.5 kN | 400   | 220   |
| 3.0 kN | 340   | -     |

### Uniformly Distributed Loads (UDL)

|                           | 600mm | 700mm | 800mm | 900mm | 1000mm | 1100mm |
|---------------------------|-------|-------|-------|-------|--------|--------|
| 1.5 kN/m <sup>2</sup> UDL | 1.6   | 2.7   | 4.3   | 6.6   | 9.6    | 13.6   |
| 2.0 kN/m <sup>2</sup> UDL | 2.1   | 3.5   | 5.6   | 8.6   | 12.6   | 17.8   |
| 2.5 kN/m <sup>2</sup> UDL | 2.6   | 4.4   | 6.9   | 10.6  | 15.5   | 21.9   |
| 3.0 kN/m <sup>2</sup> UDL | 3.1   | 5.2   | 8.3   | 12.6  | 18.5   | 26.0   |
| 3.5 kN/m <sup>2</sup> UDL | 3.6   | 6.1   | 9.6   | 14.7  | 21.5   | 30.2   |
| 4.0 kN/m <sup>2</sup> UDL | 4.0   | 6.9   | 11.0  | 16.9  | 24.6   | 34.3   |

### Maximum Spans (mm)

| Load                  | L/100 | L/200 |
|-----------------------|-------|-------|
| 1.5 kN/m <sup>2</sup> | 1010  | 770   |
| 2.0 kN/m <sup>2</sup> | 910   | 690   |
| 2.5 kN/m <sup>2</sup> | 840   | 630   |
| 3.0 kN/m <sup>2</sup> | 790   | 590   |
| 3.5 kN/m <sup>2</sup> | 740   | 560   |
| 4.0 kN/m <sup>2</sup> | 700   | 530   |

Key: ● = Within limits ● = Out of limits

Overspanning van 700 mm is toegestaan

## Safety Information

Use diamond tipped tools for cutting and wear mask and goggles when cutting or grinding. Cover exposed parts of the body. Wear gloves when moving or lifting. Product itself is not considered a hazardous waste. Please ensure that you abide by local laws and procedures regarding disposal if you choose not to upcycle or re-use your product at the end of its initial lifecycle.

## Common Fixing Options

Some of the most common stainless steel fixing options are shown below. For a full list of fixings please see the d<sup>2</sup> Dura Grating brochure.



Small Dome Washer  
(BFX01005)



M Clip  
(BFX01013)



Channel Clamp  
(BFX01027)



Offset J Clamp  
(FX01128)

## Warranty

25 year limited warranty available. Please register your product with us within 30 days of your invoice date. Visit [www.duracomposites.com/warranty](http://www.duracomposites.com/warranty).