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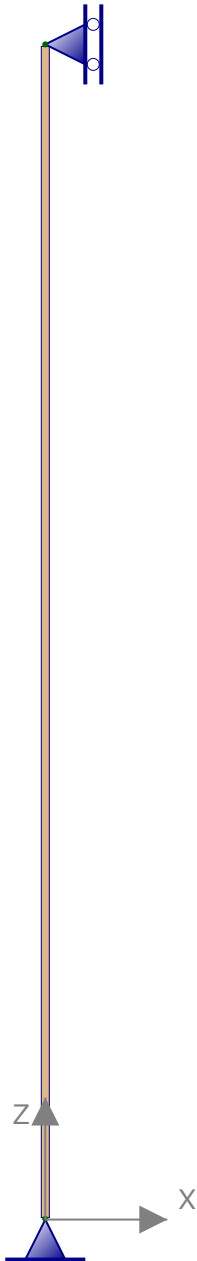
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Gehanteerde normen: : NEN-EN 1995-1-1+C1+A1:2011/NB:2013 nl

Gevolgklasse : CC1

Zwaartekrachtversnelling g : 9,81 m/s²

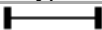
1 Invoergegevens



1.1 KNOPEN

| Knoopnummer | Coördinaten | | Opleggingen | | |
|-------------|-------------|--------|-------------|----|----|
| | X [mm] | Z [mm] | Tx | Tz | Ry |
| 1 | 0 | 0 | A | A | |
| 2 | 0 | 2700 | A | | |

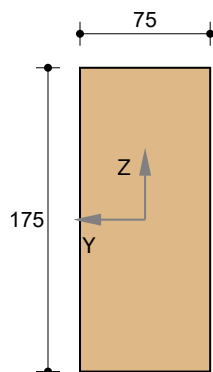
1.2 STAVEN

| Staaflnummer | Knoop | | Staaftype | Profiel | Lengte [mm] |
|--------------|-------|------|---|----------|-------------|
| | van | naar | | | |
| 1 | 1 | 2 |  | 75 x 175 | 2700 |

1.3 PROFIELEN

| Profielnummer | Naam | Gewicht [kg/m] | E [N/mm ²] | A [mm ²] | I _y [mm ⁴] | Wy;el_1 [mm ³] | Wy;el_2 [mm ³] |
|---------------|----------|----------------|------------------------|----------------------|-----------------------------------|----------------------------|----------------------------|
| 1 | 75 x 175 | 5,0 | 9000 | 1,3125E | 3,3496E7 | 3,8281E5 | 3,8281E5 |

75 x 175



Materiaalgegevens

Sterkteklasse

C18

Klimaatklasse

1

Materiaaltype

Gezaagd hout $\gamma_M = 1,30$ $k_{def} = 0,60$

Elasticiteitsmodulus

E = 9000 N/mm²

| Belastingsduurklasse | k _{mod} | f _{m,k} | f _{t,0,k} | f _{t,90,k} | f _{c,0,k} | f _{c,90,k} | f _{v,k} |
|----------------------|------------------|------------------|--------------------|---------------------|--------------------|---------------------|------------------------|
| | | Blijvend | 0,60(0,50) | 18,00 | 11,00 | 0,40 | 18,00 |
| Middellang | 0,80(0,65) | 8,31 | 5,08 | 0,15 | 8,31 | 1,02 | 1,57 N/mm ² |
| Kort | 0,90(0,80) | 11,08 | 6,77 | 0,20 | 11,08 | 1,35 | 2,09 |
| | | 12,46 | 7,62 | 0,25 | 12,46 | 1,52 | 2,35 |

Volumieke massa

 $\rho_{mean} =$ 380 kg/m³ $\rho_k =$ 320 kg/m³

Elasticiteitsmodulus

E_{0,mean} =9000 N/mm²E_{90,mean} =300 N/mm²

Elasticiteitsmodulus (kruip)

E_{0,fin} =5625 N/mm²E_{90,fin} =188 N/mm²

Elasticiteitsmodulus

E_{0,05} =6000 N/mm²E_{0,d} =6923 N/mm²

Afschuifmodulus

G_{mean} =560 N/mm²G_{0,05} =380 N/mm²

Doorsnedegegevens

Maximale coördinaat

y_{max} =

37,5 mm

Z_{max} =

87,5 mm

Minimale coördinaat

y_{min} =

-37,5 mm

Z_{min} =

-87,5 mm

Zwaartelijns

Z_s =

0,0 mm

y_s =

0,0 mm

Oppervlak / Gewicht

A =

13125,0 mm²

G =

5,0 kg/m

Statisch moment

S_y =287109 mm³S_z =123047 mm³

Traagheidsmoment

I_y =33496094 mm⁴I_z =6152344 mm⁴

Traagheidsstraal

i_y =

50,5 mm

i_z =

21,7 mm

Elastisch weerstandsmoment

W_{y;el} =382813 mm³W_{z;el} =164063 mm³

Centrifugaalmoment

C_{yz} =0 mm³

hoek =

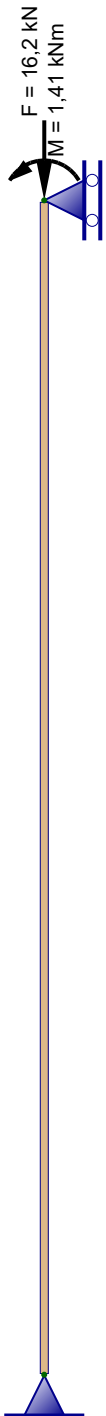
0,00 graden

| | | | | | | |
|------------------|------------|---|--------------------------|------------|---|-------------------------|
| Traagheidsmoment | I_{\max} | = | 33496094 mm ⁴ | I_{\min} | = | 6152344 mm ⁴ |
| Traagheidsstraal | i_{\max} | = | 50,5 mm | i_{\min} | = | 21,7 mm |

1.4 BELASTINGSGEVALLEN

| Nr. | Omschrijving | Type | ψ_0 | ψ_1 | ψ_2 |
|-----|--------------|-------------------------------|----------|----------|----------|
| 1 | Permanent | Permanent incl. eigen gewicht | 1,00 | 1,00 | 1,00 |
| 2 | Veranderlijk | H:daken | 0,00 | 0,00 | 0,00 |
| 3 | Wind | Wind | 0,00 | 0,20 | 0,00 |

1.5 BELASTINGSGEVAL 1 Permanent INCL. eigen gewicht

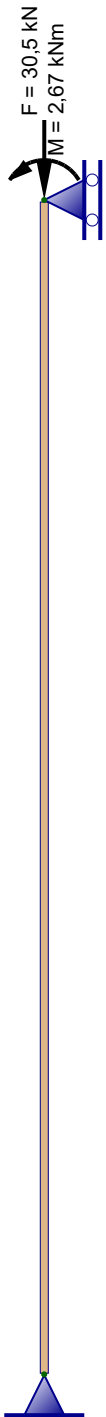


*) Belastingen a.g.v. eigen gewicht worden niet getekend!
Totaal eigen gewicht: : 0 kg.

1.5.1 Knoopbelastingen

| Knoop-nummer | Fx [kN] | Fz [kN] | My [kNm] |
|--------------|---------|---------|----------|
| 2 | | -16,200 | 1,410 |

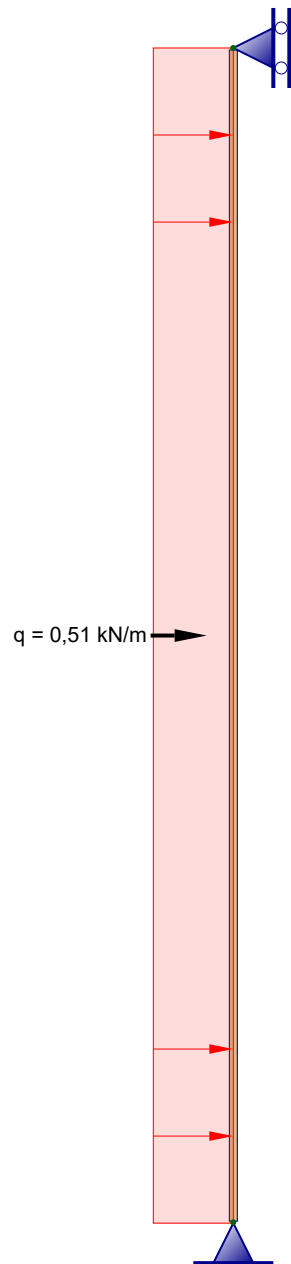
1.6 BELASTINGSGEVAL 2 Veranderlijk




1.6.1 Knoopbelastingen

| Knoop-nummer | Fx [kN] | Fz [kN] | My [kNm] |
|--------------|---------|---------|----------|
| 2 | | -30,500 | 2,670 |

1.7 BELASTINGSGEVAL 3 Wind



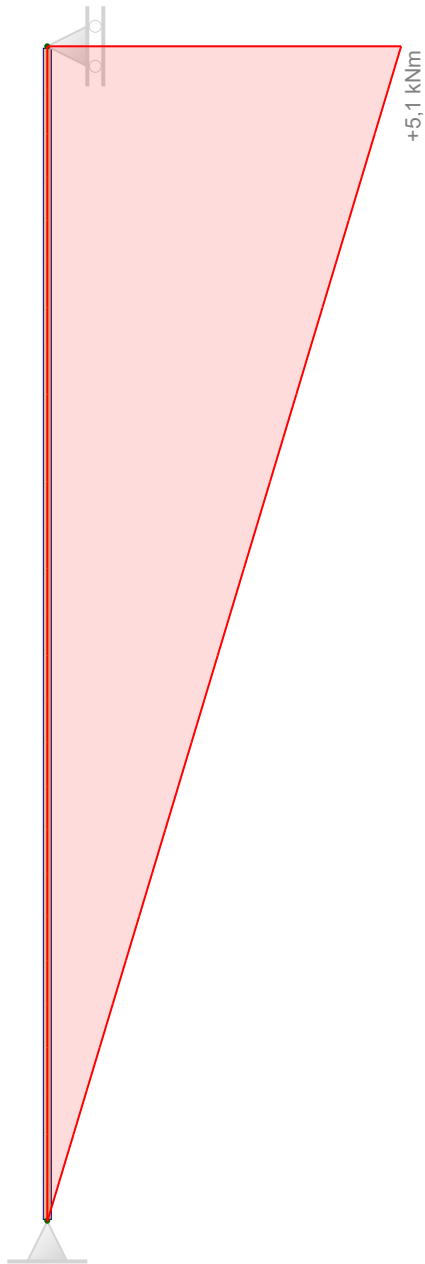
1.7.1 Staafbelastingen

| Staaf-nummer | Belasting | | | | Afstand van | | |
|--------------|---|-------------|-------------|------|-------------|--------|--------|
| | Type | q1 | q2 | Hoek | Knoop | a [mm] | L [mm] |
| 1 |  q | -0,510 kN/m | -0,510 kN/m | 0,0 | 1 | 0 | 2700 |

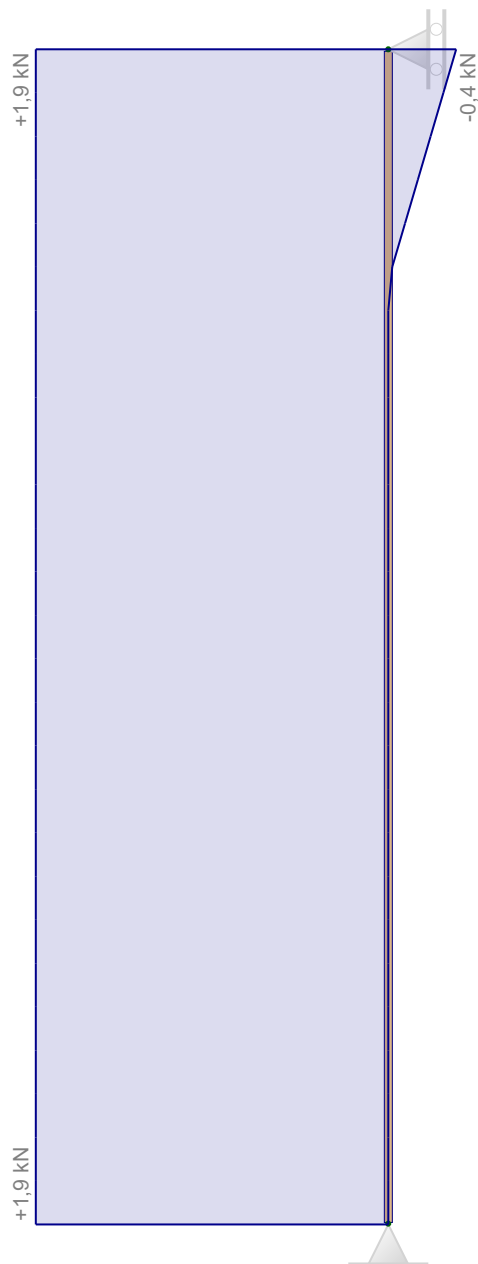
2 Berekeningsresultaten**2.1 UITERSTE GRENSTOESTANDEN (UGT)****2.1.1 Belastingscombinaties****(GNL) Geometrisch niet-lineaire krachtsverdeling**

| Combinatie nummer | Omschrijving | Type |
|-------------------|--------------|------|
| 1 | Veranderlijk | UGT |
| 2 | Permanent | UGT |
| 3 | Wind | UGT |

| Combinatie nummer | Belasting ($\psi \times \gamma$) | | | |
|-------------------|------------------------------------|-----------|-----------|--|
| | 1 | 2 | 3 | |
| 1 | 1,00x1,08 | 1,00x1,35 | | |
| 2 | 1,00x1,22 | | | |
| 3 | 1,00x1,08 | | 1,00x1,35 | |



Omhullende M-lijn



Omhullende D-lijn

2.1.2 Omhullende reactiekrachten

| Knoop-nummer | Combinatie nummer | Fx [kN] | Fz [kN] | My [kNm] |
|--------------|-------------------|---------------|---------------|----------|
| 1 | 1 | -1,899 | 58,671 | |
| | 2 | -0,637 | 19,764 | |
| | 3 | -1,493 | 17,496 | |
| 2 | 1 | 1,899 | | |
| | 3 | -0,365 | | |

| Knoop-nummer | Combinatie nummer | Fx [kN] | Fz [kN] | My [kNm] |
|-----------------------------|-------------------|---------------|---------------|----------|
| Minimale / maximale waarden | | | | |
| 1 | 1 | -1,899 | | |
| 2 | 1 | 1,899 | | |
| 1 | 3 | | 17,496 | |
| 1 | 1 | | 58,671 | |

2.1.3 Omhullende staafkrachten

| Staafl-nummer | Combinatie nummer | Knoop-nummer | x-lokaal [mm] | Nx-lokaal [kN] | Vz-lokaal [kN] | My-lokaal [kNm] |
|---------------|-------------------|--------------|---------------|----------------|----------------|-----------------|
| 1 | 1 | 1 | | 58,671 | 1,899 | 0,000 |
| | 2 | 1 | | 19,764 | 0,637 | 0,000 |
| | 3 | 1 | | 17,496 | 1,493 | 0,000 |
| | 3 | | 2169 | -17,496 | 0,000 | 1,620 |
| | 1 | 2 | | -58,671 | -1,899 | 5,127 |
| | 3 | 2 | | -17,496 | 0,365 | 1,523 |

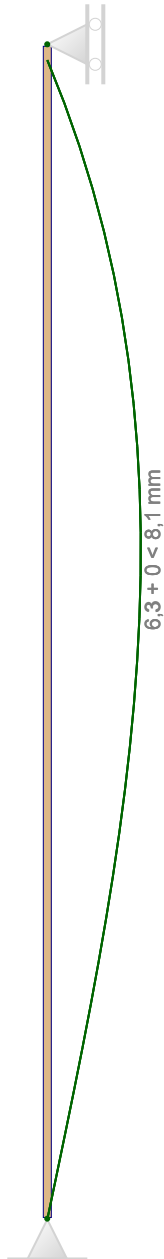
2.2 BRUIKBAARHEIDSGRENSTOESTANDEN (BGT)

2.2.1 Belastingscombinaties

(GNL) Geometrisch niet-lineaire krachtsverdeling

| Combinatie nummer | Omschrijving | Type |
|-------------------|--------------|------|
| 4 | Veranderlijk | BGT |
| 5 | Wind | BGT |

| Combinatie nummer | Belasting ($\psi \times \gamma$) | | | |
|-------------------|------------------------------------|-----------|-----------|--|
| | 1 | 2 | 3 | |
| 4 | 1,00x1,00 | 1,00x1,00 | | |
| 5 | 1,00x1,00 | | 1,00x1,00 | |



Omhullende verplaatsing

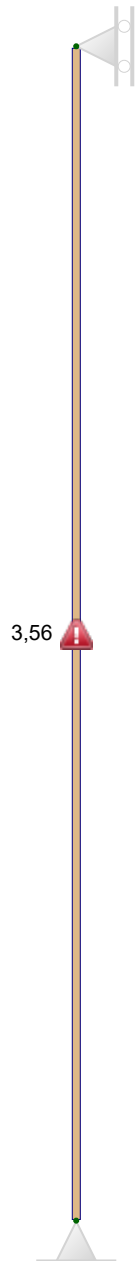
2.2.2 Omhullende knoopverplaatsingen

| Knoop-nummer | Combinatie nummer | dx [mm] | dz [mm] | dr [mrad] |
|-----------------------------|-------------------|---------|---------|-----------|
| 1 | 4 | 0,0 | 0,0 | -7,0 |
| | 5 | 0,0 | 0,0 | -3,6 |
| 2 | 4 | 0,0 | -1,1 | 13,2 |
| | 5 | 0,0 | -0,4 | 5,8 |
| Minimale / maximale waarden | | | | |

| Knoop-nummer | Combinatie nummer | dx [mm] | dz [mm] | dr [mrad] |
|--------------|-------------------|---------|---------|-----------|
| 2 | 4 | 0,0 | | |
| 1 | 4 | 0,0 | | |
| 2 | 4 | | -1,1 | |
| 1 | 5 | | 0,0 | |
| 1 | 4 | | | -7,0 |
| 2 | 4 | | | 13,2 |

2.3 EN1995 TOETSINGEN

De toetsing van de houtprofielen in de uiterste grenstoestand volgens EN 1995-1-1 is gebaseerd op een geometrische niet-lineaire krachtsverdeling (tweede orde analyse) inclusief de gegeven imperfecties volgens art.5.4.4.



| Staaflnummer | Profiel | Combinatienummer | Artikel | U.C. |
|--------------|----------|------------------|--------------|-------------|
| 1 | 75 x 175 | 1 | 6.1.4 | 0,40 |
| | | 1 | 6.1.7 | 0,10 |
| | | 1 | 6.2.4 | 1,37 |
| | | 1 | 6.3.2 | 2,94 |
| | | 1 | 6.3.3 | 3,56 |
| | | 4 | Doorbuiging | 0,78 |

| Staaf-nummer | Profiel | Combinatie nummer | Artikel | U.C. |
|--------------|----------|-------------------|-------------|------|
| 1 | 75 x 175 | 4 | Doorbuiging | 0,78 |

2.4 BEREKENING VAN UNITY CHECKS

2.4.1 Staaf 1 - 75 x 175 (C18 Klimaatklasse:1)

Druk evenwijdig aan de vezelrichting

art. 6.1.4

Combinatie : 1 x = 0 mm Nx = -58,671 kN Vz = 1,899 kN My = 0 kNm

Belastingsduurklasse : Middellang

$$\sigma_{c,0,d} = \frac{N_{c,Ed}}{A} = \frac{58671,0}{13125} = 4,5 \text{ N/mm}^2 < f_{c,0,d} = 11,1 \text{ N/mm}^2 \quad (6.2)$$

Afschuiving

art. 6.1.7

Combinatie : 1 x = 0 mm Nx = -58,671 kN Vz = 1,899 kN My = 0 kNm

Belastingsduurklasse : Middellang

$$\tau_d = \frac{V_{z,Ed} S}{b I_y} = \frac{1899,0 \times 287109}{75 \times 33496094} = 0,2 \text{ N/mm}^2 < f_{v,d} = 2,1 \text{ N/mm}^2 \quad (6.13)$$

Gecombineerde buig- en axiale drukspanningen

art. 6.2.4

Combinatie : 1 x = 2700 mm Nx = -58,671 kN Vz = 1,899 kN My = 5,127 kNm

Belastingsduurklasse : Middellang

$$\sigma_{c,0,d} = \frac{N_{c,Ed}}{A} = \frac{58671}{13125} = 4,5 \text{ N/mm}^2 \quad \sigma_{m,y,d} = \frac{M_{y,Ed}}{W_y} = \frac{5,127 \times 10^6}{383 \times 10^3} = 13,4 \text{ N/mm}^2$$

$$\left(\frac{\sigma_{c,0,d}}{f_{t,0,d}} \right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} = \left(\frac{4,5}{11,1} \right)^2 + \frac{13,4}{11,1} = 1,37 > 1,00 \text{ voldoet niet!} \quad (6.19)$$

Kolommen onderworpen aan druk of aan druk en buiging

art. 6.3.2

Combinatie : 1 x = 2700 mm Nx = -58,671 kN Vz = 1,899 kN My = 5,127 kNm

Belastingsduurklasse : Middellang

$$\lambda_y = \frac{L_{cr,y}}{i_y} = \frac{2700}{50,5} = 53,45 \quad \lambda_{rel,y} = \frac{\lambda_y}{\pi} \sqrt{\frac{f_{c,0,k}}{E_{0,005}}} = \frac{53,45}{\pi} \sqrt{\frac{18,0}{6000}} = 0,932 \quad (6.21)$$

$$\lambda_z = \frac{L_{cr,z}}{i_z} = \frac{2700}{21,7} = 124,71 \quad \lambda_{rel,z} = \frac{\lambda_z}{\pi} \sqrt{\frac{f_{c,0,k}}{E_{0,005}}} = \frac{124,71}{\pi} \sqrt{\frac{18,0}{6000}} = 2,174 \quad (6.22)$$

$$k_y = 0,5(1 + \beta_c (\lambda_{rel,y} - 0,3)) + \lambda_{rel,y}^2 = 0,5 \times (1 + 0,2 \times (0,932 - 0,3)) + 0,932^2 = 1,00 \quad (6.27)$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{1,00 + \sqrt{1,00^2 - 0,93^2}} = 0,74 \quad (6.25)$$

$$k_z = 0,5(1 + \beta_c (\lambda_{rel,z} - 0,3)) + \lambda_{rel,z}^2 = 0,5 \times (1 + 0,2 \times (2,174 - 0,3)) + 2,174^2 = 3,05 \quad (6.28)$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{3,05 + \sqrt{3,05^2 - 2,17^2}} = 0,19 \quad (6.26)$$

$$\sigma_{c,0,d} = \frac{N_{c,Ed}}{A} = \frac{58671}{13125} = 4,5 \text{ N/mm}^2$$

$$\sigma_{m,y,d} = \frac{M_{y,Ed}}{W_y} = \frac{5,127 \times 10^6}{383 \times 10^3} = 13,4 \text{ N/mm}^2$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{4,5}{0,74 \times 11,1} + \frac{13,4}{11,1} + 0,7 \times \frac{0,0}{12,7} = 1,76 > 1,00 \text{ voldoet niet!} \quad (6.23)$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{4,5}{0,19 \times 11,1} + 0,7 \times \frac{13,4}{11,1} + \frac{0,0}{12,7} = 2,94 > 1,00 \text{ voldoet niet!} \quad (6.24)$$

Liggers onderworpen aan druk of aan druk en buiging

art. 6.3.3

Combinatie : 1 x = 2700 mm Nx = -58,671 kN Vz = 1,899 kN My = 5,127 kNm
 Belastingsduurklasse : Middellang

Aantal kipsteunen: 0 Op twee steunpunten: Gelijkmatic verdelde belasting

$$\rightarrow l_{ef} = 0,9 \times l = 0,9 \times 2700 = 2430 \text{ mm}$$

$$\sigma_{m,crit} = \frac{0,78 b^2}{h l_{ef}} E_{0,05} = \frac{0,78 \times 75^2}{175 \times 2430} \times 6000 = 61,9 \text{ N/mm}^2 \quad (6.32)$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = \sqrt{\frac{18}{61,9}} = 0,539 < 0,75 \quad \rightarrow k_{crit} = 1,00 \quad (6.30)(6.34)$$

$$\sigma_{m,y,d} = \frac{M_{y,Ed}}{W_y} = \frac{5,127 \times 10^6}{383 \times 10^3} = 13,4 \text{ N/mm}^2 \quad \sigma_{c,0,d} = \frac{N_{c,Ed}}{A} = \frac{58671}{13125} = 4,5 \text{ N/mm}^2$$

$$\lambda_z = \frac{L_{cr,z}}{i_z} = \frac{2700}{21,7} = 124,71 \quad \lambda_{rel,z} = \frac{\lambda_z}{\pi} \sqrt{\frac{f_{c,0,k}}{E_{0,005}}} = \frac{124,71}{\pi} \sqrt{\frac{18,0}{6000}} = 2,174 \quad (6.22)$$

$$k_z = 0,5(1 + \beta_c (\lambda_{rel,z} - 0,3)) + \lambda_{rel,z}^2 = 0,5 \times (1 + 0,2 \times (2,174 - 0,3)) + 2,174^2 = 3,05 \quad (6.28)$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{3,05 + \sqrt{3,05^2 - 2,17^2}} = 0,19 \quad (6.26)$$

$$\left(\frac{\sigma_{m,d}}{k_{crit} f_{m,d}} \right)^2 + \frac{\sigma_{c,d}}{k_{c,d} f_{c,0,d}} = \left(\frac{13,4}{1,00 \times 11,1} \right)^2 + \frac{4,5}{0,19 \times 11,1} = 3,56 > 1,00 \text{ voldoet niet!} \quad (6.35)$$

Doorbuiging

Combinatie : 4 x = 1482,7 mm Nx = -46,7 kN Vz = 1,511 kN My = 2,241 kNm
 Belastingsduurklasse : Middellang

Lokale knoopverplaatsingen $d_{z1} = 0 \text{ mm}$ $d_{z2} = 0 \text{ mm}$

$$w_{eind,z} = w_z + k_{def} w_{BGT} \text{ Quasi blijvend,z} = -6,3 + 0,6 \times 0 = -6,3 \text{ mm}$$

$$\frac{|W_{\text{eind},z}|}{W_{\text{eind},z,\text{max}}} = \frac{|-6,3|}{2700 / 333} = \frac{|-6,3|}{8,1} = 0,78 < 1,0$$

$$W_{\text{bijk},z} = W_z - W_{\text{BGT Blijvend},z} = -6,3 - 0 = -6,3 \text{ mm}$$

$$\frac{|W_{\text{bijk},z}|}{W_{\text{bijk},z,\text{max}}} = \frac{|-6,3|}{2700 / 333} = \frac{|-6,3|}{8,1} = 0,78 < 1,0$$

Doorbuiging

Combinatie : 4 x = 1482,7 mm Nx = -46,7 kN Vz = 1,511 kN My = 2,241 kNm

Belastingsduurklasse : Middellang

Lokale knoopverplaatsingen $d_{z1} = 0 \text{ mm}$ $d_{z2} = 0 \text{ mm}$

$$W_{\text{eind},z} = W_z + k_{\text{def}} W_{\text{BGT Quasi blijvend},z} = -6,3 + 0,6 \times 0 = -6,3 \text{ mm}$$

$$\frac{|W_{\text{eind},z}|}{W_{\text{eind},z,\text{max}}} = \frac{|-6,3|}{2700 / 333} = \frac{|-6,3|}{8,1} = 0,78 < 1,0$$

$$W_{\text{bijk},z} = W_z - W_{\text{BGT Blijvend},z} = -6,3 - 0 = -6,3 \text{ mm}$$

$$\frac{|W_{\text{bijk},z}|}{W_{\text{bijk},z,\text{max}}} = \frac{|-6,3|}{2700 / 333} = \frac{|-6,3|}{8,1} = 0,78 < 1,0$$