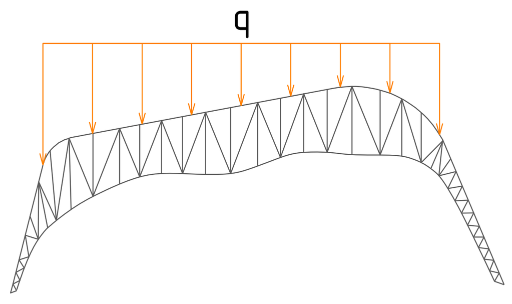
Predimensioning of Crussed Beam



*we consider roof pitch = 10º for the entire roof.

ELU: Factored Load
Purlin type: Trussed beam
Span: 70m
Roof pitch: 10°
Bandwidth: 6,6m

H Area (+x)	TOTAL
ELU-1	-1,75KN/m²
ELU-2	-2,01KN/m²
ELU-3	-1,71KN/m²
ELU-4	+0,19KN/m²

H Area (-x)	TOTAL
ELU-1	-1,75KN/m²
ELU-2	-1,89KN/m²
ELU-3	-1,52KN/m²
ELU-4	+0,97KN/m²

Upper and lower chord

*biarticulated (distributed load)

$M_{ed} = q \cdot L^2/8 \qquad f = (5/384)\cdot(q \cdot L^4/E \cdot I_{yy'})$

$M_{ed} = 2{,}01kN/m^2 \cdot 6{,}6m \cdot (70m)^2/8 = 8.125{,}4KNm$

H= 70m/25 = 2,8m

$F_{ed} = M_{ed}/H = 8125{,}4/2{,}80m = 2.901{,}91\ kN$

$F_{rd} > F_{ed}$

$F_{rd} > A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \cdot f_{yd}$

$A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \geq F_{ed}\ /\ f_{yd} = 2.901{,}91 \cdot 10^3\ /262N/mm^2 = 11.072{,}51mm^2$

$L_{yy'}=4m\ ;\ L_{zz'}=4m$

Cheking metallic tubular profile's catalogues, we choose a RHS-250-16 for the upper chord / ∅ CHS-355,6-12,5 for the lower chord

Steel S-275-JR Properties

$f_y = 275N/mm^2$
$\Upsilon_{m0} = 1{,}05$
$f_{yd} = 262N/mm^2$
E: 210.000N/mm²
G: 81.000N/mm²
α: 0,00012ºC⁻¹
p: 78,5KN/m³

ELS: Not Factored Load
Purlin type: Continuous
Span: 70m
Roof pitch: 10°
Bandwidth: 6,6m

H Area (-x)	TOTAL
ELS-1	-1,25KN/m²
ELS-2	-1,64KN/m²
ELS-3	-1,39KN/m²
ELS-4	+0,42KN/m²

H Area (+x)	TOTAL
ELS-1	-1,25KN/m²
ELS-2	-1,43KN/m²
ELS-3	-1,48KN/m²
ELS-4	-0,10KN/m²

$q_{ed} = (6{,}6 \cdot 1{,}64) = 10{,}82KN/m$

Deflection= 70.000mm/300 = 233.33mm

$f = (5/384)\cdot(q \cdot L^4/E \cdot I_{yy'})$

$233.33mm = (5/384)\cdot(q \cdot L^4/E \cdot I_{yy'})$

$Iyy' = 5 \cdot q \cdot L^4/384 \cdot E \cdot 233{,}33mm)$

$Iyy' = 5 \cdot 10{,}82N/mm \cdot 70.000^4/384 \cdot 210.000N/mm^2 \cdot 233{,}33mm) = 6.903.485 \cdot 10^4 mm^4$

$A_s \geq 2 \cdot I_{yy'}/H^2$

$A_s \geq 2 \cdot 6.903.485 \cdot 10^4 mm^4/4000^2 = 8.629{,}35mm^2$

$A_s \geq 2 \cdot 6.903.485 \cdot 10^4 mm^4/4000^2 = 8.629{,}35mm^2$

Steel S-275-JR Properties

$f_y = 275N/mm^2$
$\Upsilon_{m0} = 1{,}05$
$f_{yd} = 262N/mm^2$
E: 210.000N/mm²
G: 81.000N/mm²
α: 0,00012ºC⁻¹
p: 78,5KN/m³

RHS-250-16 area ⟶ 14.701mm² > 8.629,35mm²
CHS-355,6-12,5 area ⟶ 13.474mm² > 8.629,35mm²

Studs and diagonals

H Area (+x)	TOTAL
ELU-1	-1,75KN/m²
ELU-2	-2,01KN/m²
ELU-3	-1,71KN/m²
ELU-4	+0,19KN/m²

$q_{ed} = (6{,}6 \cdot 2{,}01kN/m^2) = 13{,}26KN/m$

$R_{1,Ed} = R_{2Ed} = 13{,}26KN/m \cdot 70m\ /2 = 464KN$

$F_{stud,Ed} = 464KN$ (compression) L=2,8-6m

$F_{diag,Ed} = 464KN/sin60°$ (tension) = 646,2KN

Stud

$F_{stud,Ed} = 464KN$ (compression) L=2,8-6m

$F_{Rd} > F_{stud,Ed}$

$F_{Rd} = A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \cdot f_{yd}$

$A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \geq \cdot f_{yd} = 464 \cdot 10^3 N/262N/mm^2$

$A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) = 1.771mm^2$

Cheking metallic profile's catalogues, we choose ∅ **CHS 139,7-6** (2,8m) and **CHS-168,3-10** (6m) metallic tubular profiles

*To avoid buckling, when the element the stud/diagonal is compressed and it has a higher lenght we will increase the thickness.

Diagonal

$F_{stud,Ed} = 646KN$ (tension) L=3-7m

$F_{Rd} > F_{stud,Ed}$

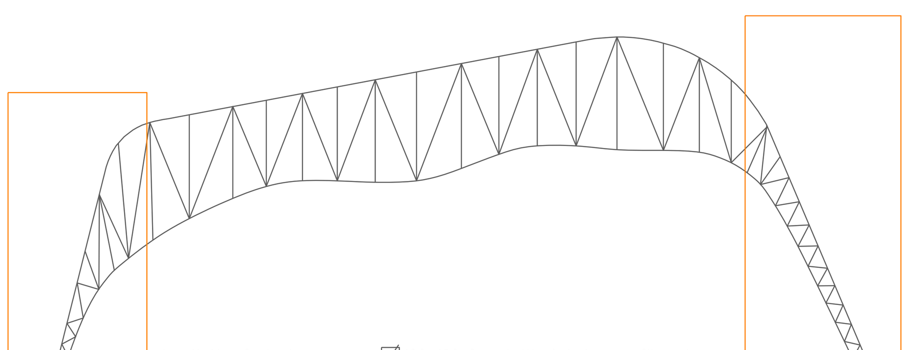
$F_{Rd} = A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \cdot f_{yd}$

$A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) \geq \cdot f_{yd} = 646 \cdot 10^3 N/262N/mm^2$

$A_s \cdot min\ (x_{yy'}\ ;\ x_{zz'}) = 2466.4mm^2$

Cheking metallic profile's catalogues, we choose ∅ **114,3-8** metallic tubular profile

Predimensioning of column's frame



*In all the fachades we use 180x180x8 metallic tubular profiles due to the fact they will suport envelope (Fy) and wind pression/suction (Fx)

h = 15m
$\beta_{yy'} = 1{,}5$
$L_{p,yy'} = 37{,}5$
$\beta_{yy'} = 1{,}5$
$L_{p,yy'} = 37{,}5$
$i_{yy'} \geq 35.000/200 = 187{,}5$
$i_{zz'} \geq 12500/200 = 62{,}5$

*To do the predimensioning we use an **HEM 360** to calculate the required profile instead of the tubular structure because of the complexity.

$I_1 = 84.870 \cdot 10^4 mm^4$
$I_2 = As \cdot H^2/2 = 31800mm^2 \cdot 2000^2/2 = 3{,}6 \cdot 10^{10} mm^4$
L=70m
$k = (I_2/I_1)\cdot(h/L) = (3{,}6 \cdot 10^{10}/84.870 \cdot 104mm4)\cdot(15/70) = 9{,}08$
$p = 0{,}5KN/m2 \cdot L/2 \cdot h/2 \cdot c_{exp} = 315KN$

$M_b = M_c = -p \cdot L^2/(6 \cdot (k+2)$

$M_b = M_c = -2{,}01 \cdot 70^2/(6 \cdot (9.8+2) = 149{,}22KNm$

$M_b = -M_c = (p \cdot h/2)\cdot(3k/(6 \cdot (k+1)$

$M_b = -M_c = (315kN \cdot 15m/2)\cdot(3 \cdot 9.08/(6 \cdot (9.08+1) = 1039{,}5\ KNm$

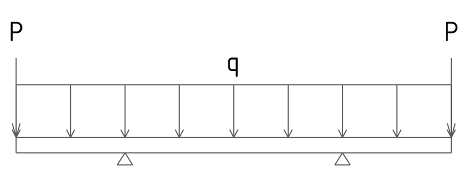
HEM 360 ⟶ $W_{yy'} = 4.297 \cdot 10^3 mm^3 > 3.969.10^3 mm^3$

$Wyy' \geq 1.039.500.000Nmm/(275/1{,}05) = 3.969 \cdot 10^3 mm^3$

Wineva's Results Review

	SW	DL	LL	Snow	Wind P	Wind S
	Gk,j	Gk,j	Qk	Qk	Qk	Qk
	-0,40KN/m²	-0,45KN/m²	-0,40KN/m²	-0,50KN/m²	-0,13KN/m²	1.,10KN/m²
Bandwidth: 3,3m	-1,76KN/m²	-1,76KN/m²	-1,98KN/m²	-2,20KN/m²	-0.57KN/m²	4,84KN/m²

Purlins



P= window

Wind on Facade

Slenderness on X: 24m/78m = 0,31
$c_p = 0{,}7$
$c_s = -0{,}32$

$q_e = 0'5\ KN/m^2 \cdot 2{,}4 \cdot 0{,}7 = 0{,}84\ KN/m^2$
$q_e = 0'5\ KN/m^2 \cdot 2{,}4 \cdot -0{,}32 = -0{,}41\ KN/m^2$

$q_{wind\ pression}$: 0,84 KN/m² · Bandwidth = 5,5KN/m²
$q_{wind\ suction}$: -0,41 KN/m² · Bandwidth = 2,71KN/m₂

*To obtain the HEM 180 inertia with roof pitch=10°

$I_{yy',co} = \sqrt{(I_{yy'} \cdot cos10º)^2 + (I_{zz'} \cdot sin10º)^2}$

$I_{yy',co} = \sqrt{(7483 \cdot 10^4 mm^4 \cdot cos10º)^2 + (7483 \cdot 10^4 mm^4 \cdot sin10º)^2} = 7372 \cdot 10^4 mm^4$

Ground Properties (Hard Clay)

σ adm=1.8kg/cm²
Ck= (cohesion coefficient) =90KN/m²
μ (friction coefficient)= 0,4

We check the slide because we have important X reactions

Safety Slide Coefficient:

$C_{sd} = F_{est}/F_{des} > Y_R \qquad Y_R = 1{,}5$

Fdes= $(Rx)^2 + (Ry)^2 = (178KN)^2 + (779KN)^2 = 794KN$

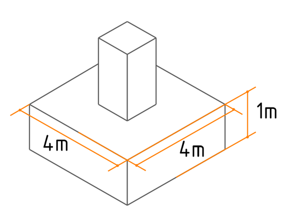
$1{,}5 = F_{est}/794KN \qquad Fest = 1191KN$

Fest= (N+Pad Weight)·μ + (c·B)

c= Ck/2
B=Footing area

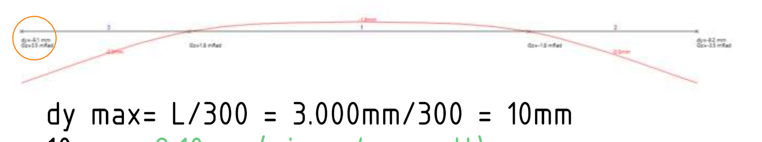
1191KN= (779KN+B·(concrete density)·0,4 + (45·B)

B= 15.98m²



Pad dimensions
4mx4mx1m

Deformation ELS-1

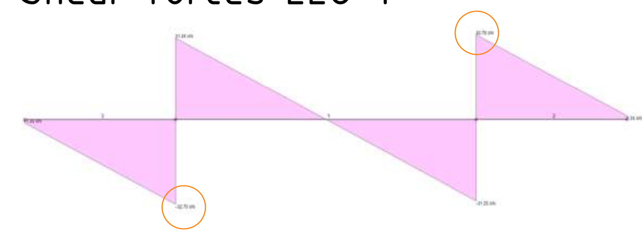


dy max= L/300 = 3.000mm/300 = 10mm
10mm > 9,10mm (wineva's result)

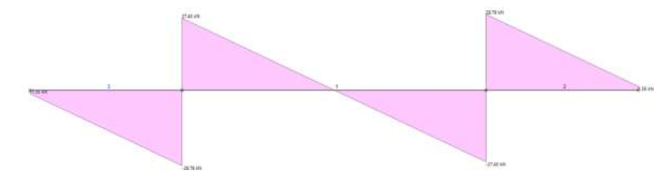
Deformation ELS-2

Deformation ELS-3

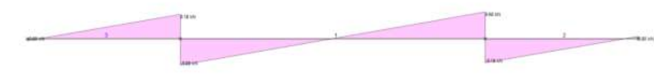
Shear forces ELU-1



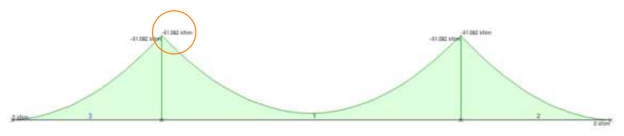
Shear forces ELU-2



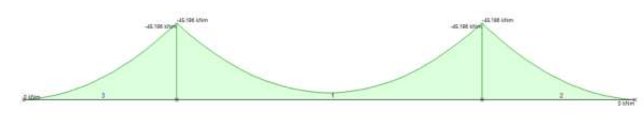
Shear forces ELU-3



Moments ELU-1



Moments ELU-2



Moments ELU-3

Self Weight Reactions

Dead Loads Reactions

Live Loads

Dead Loads Reactions

Live Loads Reactions

Wind Pression Reactions

Wind Sucion Reactions

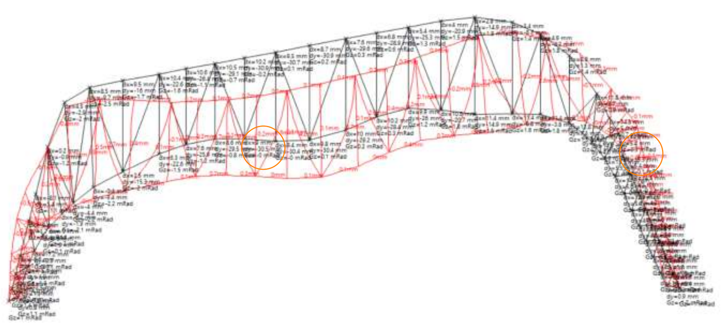
*These are the reactions used in Wineva's program to calculate the trussed beam's deformations

Trussed Beam (wind X direction)

Trussed Beam (wind -X direction)

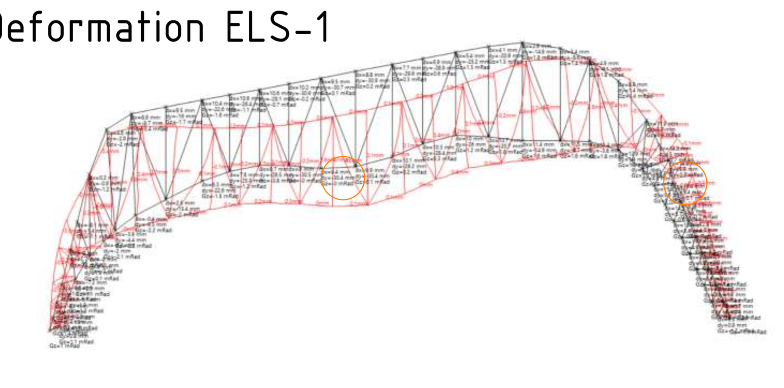
*We only calculate one trussed beam, and we consider all of them similar to do the procedure.
*We choose the trussed beam with the haviest loads.

Deformation ELS-1



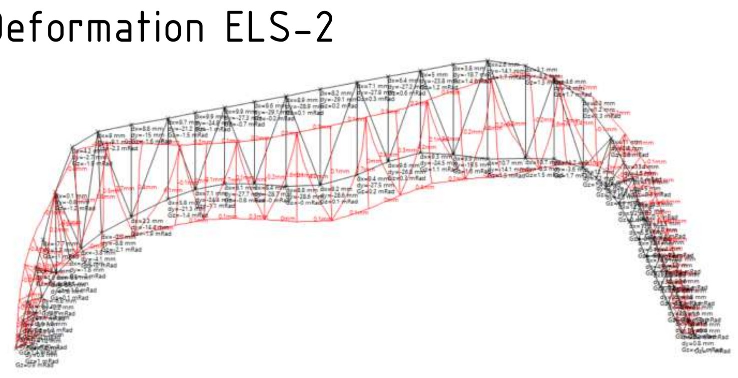
dy max= L/300 = 70.000mm/300 = 233,33mm
233,33mm > 30,5mm (wineva's result)
dx max= L/250 = 20.000mm/250= 80mm
80mm > 15,30mm (wineva's result)

Deformation ELS-1

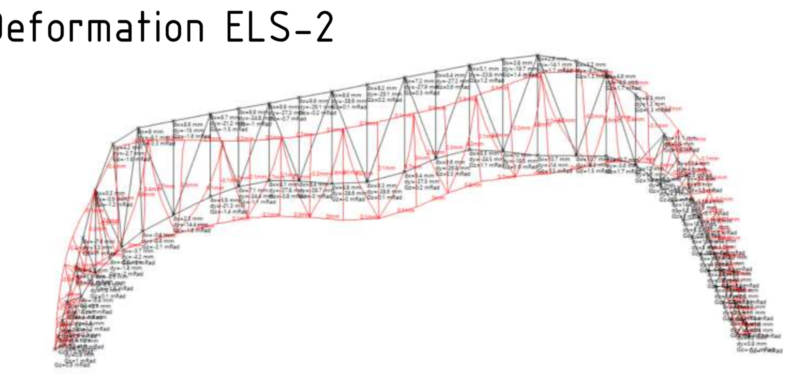


dy max= L/300 = 70.000mm/300 = 233,33mm
233,33mm > 30,4mm (wineva's result)
dx max= L/250 = 20.000mm/250= 80mm
80mm > 15,50mm (wineva's result)

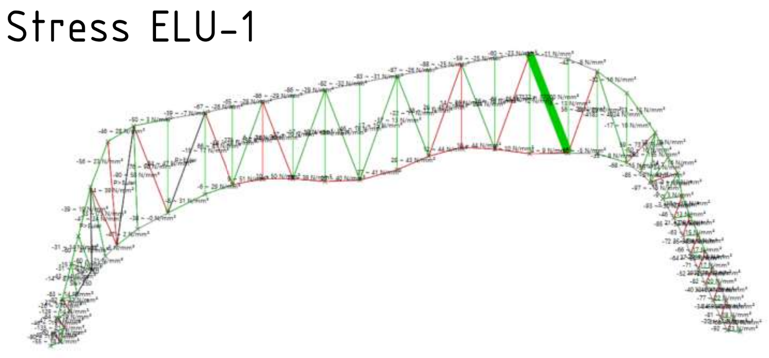
Deformation ELS-2



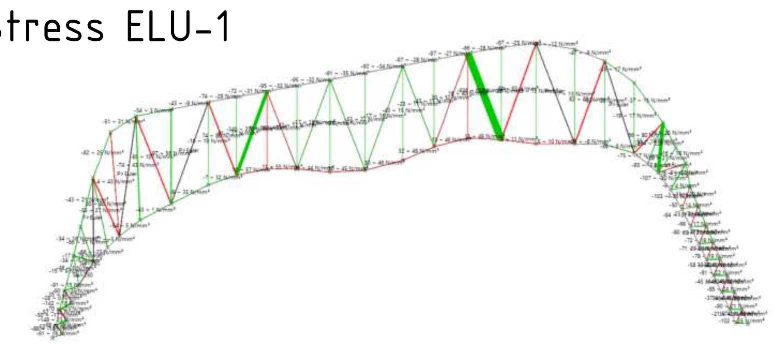
Deformation ELS-2



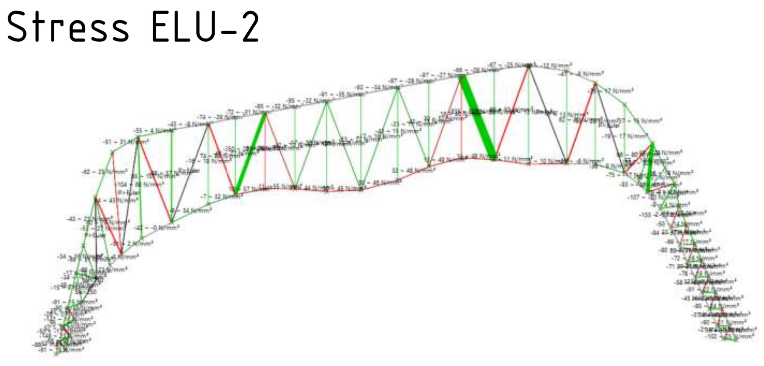
Stress ELU-1



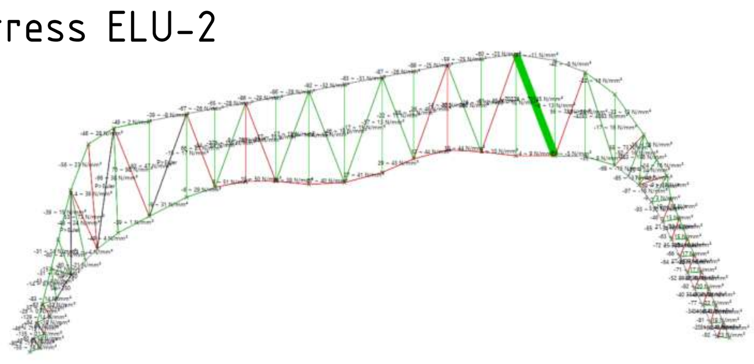
Stress ELU-1



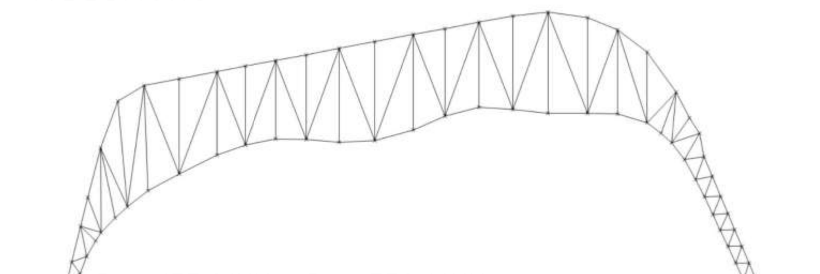
Stress ELU-2



Stress ELU-2



Reactions



Rx= 177,91KN ; Ry= 778,16KN

Reactions