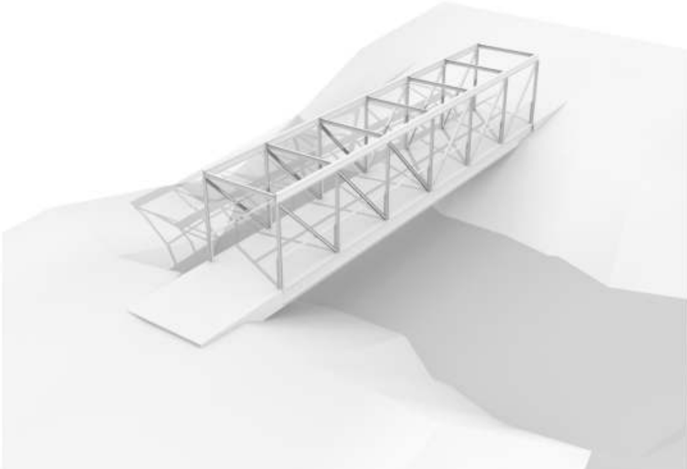
LTL PEDESTRIAN FOOTBRIDGE

POLITECNICO DI TORINO
Dipartimento di Architettura e Design

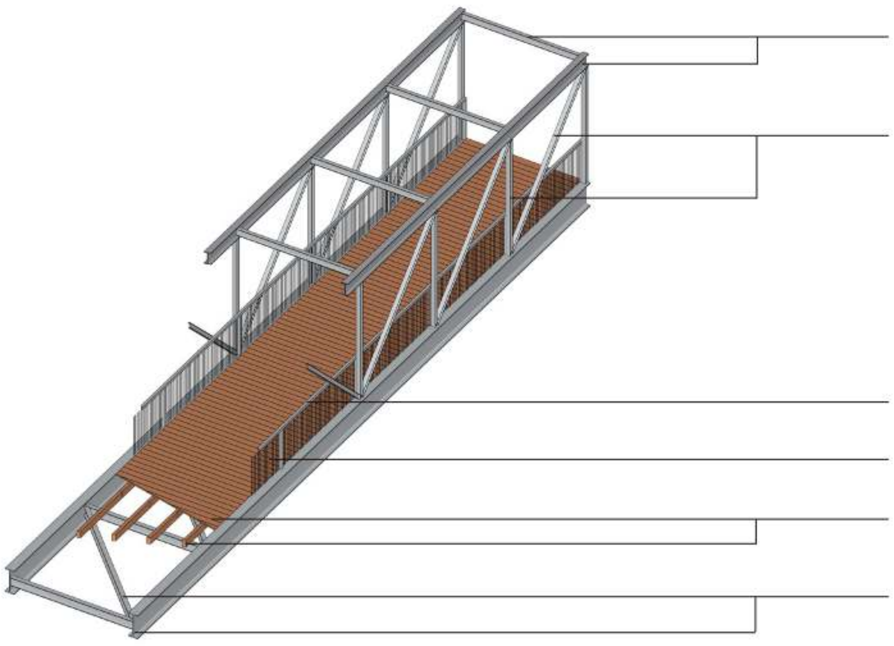
Project location: Longtan Lake park,Beijing,China

Our design site is located in Longtan Lake Park in Beijing. In 2019, the Beijing Municipal Government began to expand and renovate Longtan Lake Park and built several small artificial islands. Our design is to build a pedestrian bridge connecting the artificial island to the main island.

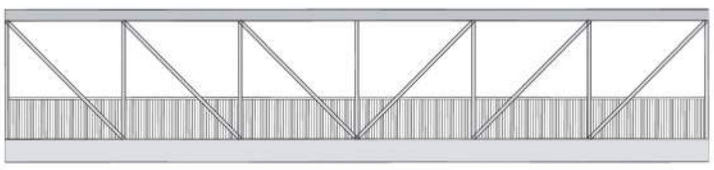


Structural concept

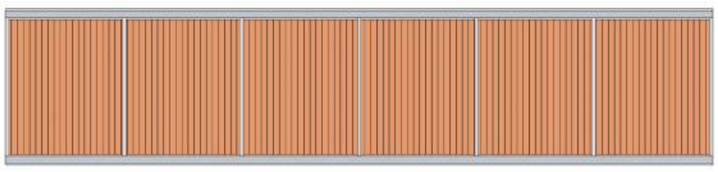
The total length of the bridge is 18m and usable widths is 3m,The Pratt truss is a classic typology in the world of structures,The choice of the truss typology provides a great transparency to the crossing and allows pedestrians to fully enjoy the views that result from the neces-sary elevation of the path, we want to provide pedestrians and cyclists a special user experience with a highly effective and very low mainte-nance structure, which, along with a careful selection of the materials



Material diagram

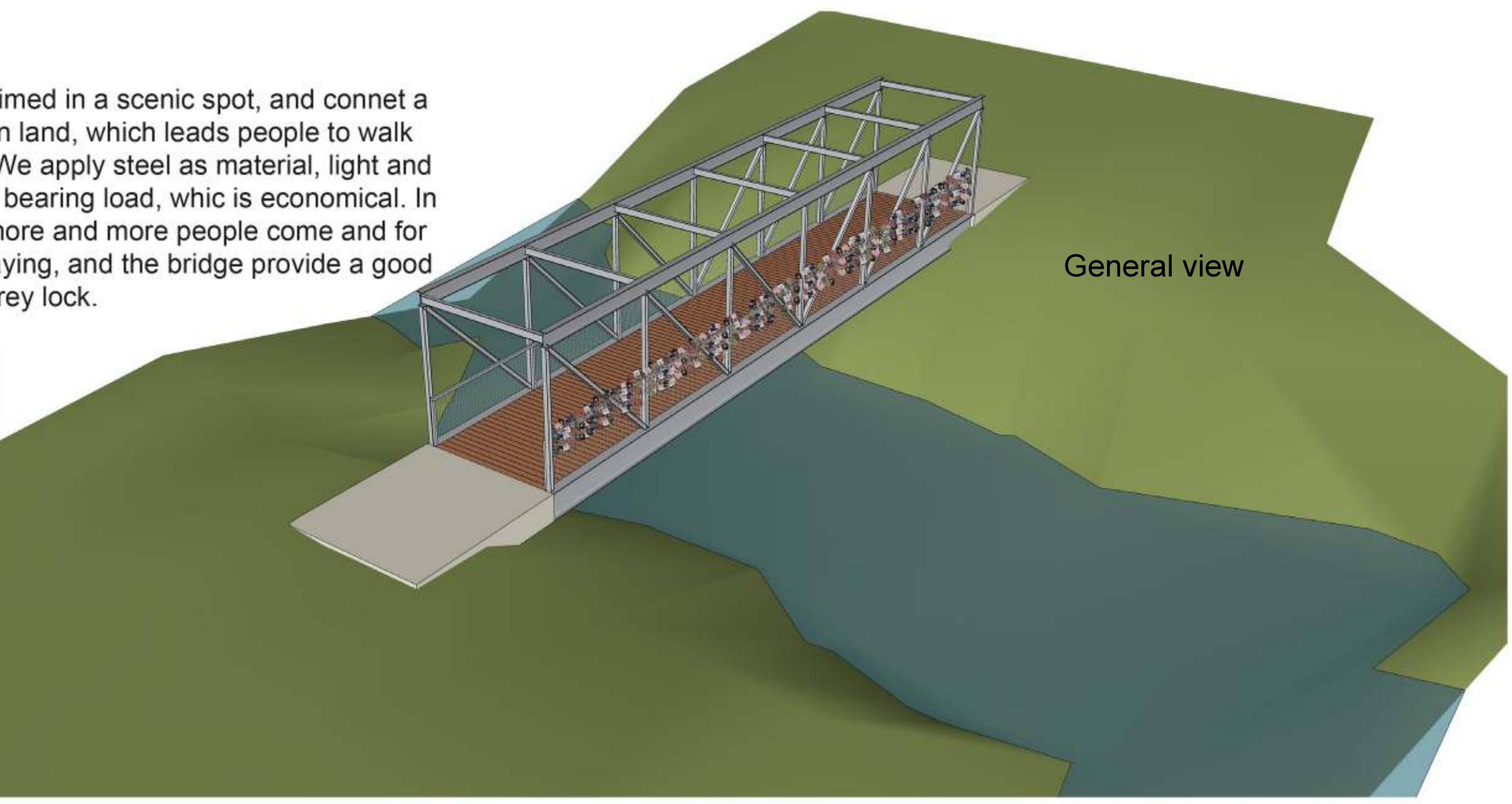


Elevation



Top-view

The bridge are aimed in a scenic spot, and connet a island to the main land, which leads people to walk in a wider area. We apply steel as material, light and high capacity for bearing load, whic is economical. In tourist season, more and more people come and for some activity praying, and the bridge provide a good carrier to hang prey lock.



General view

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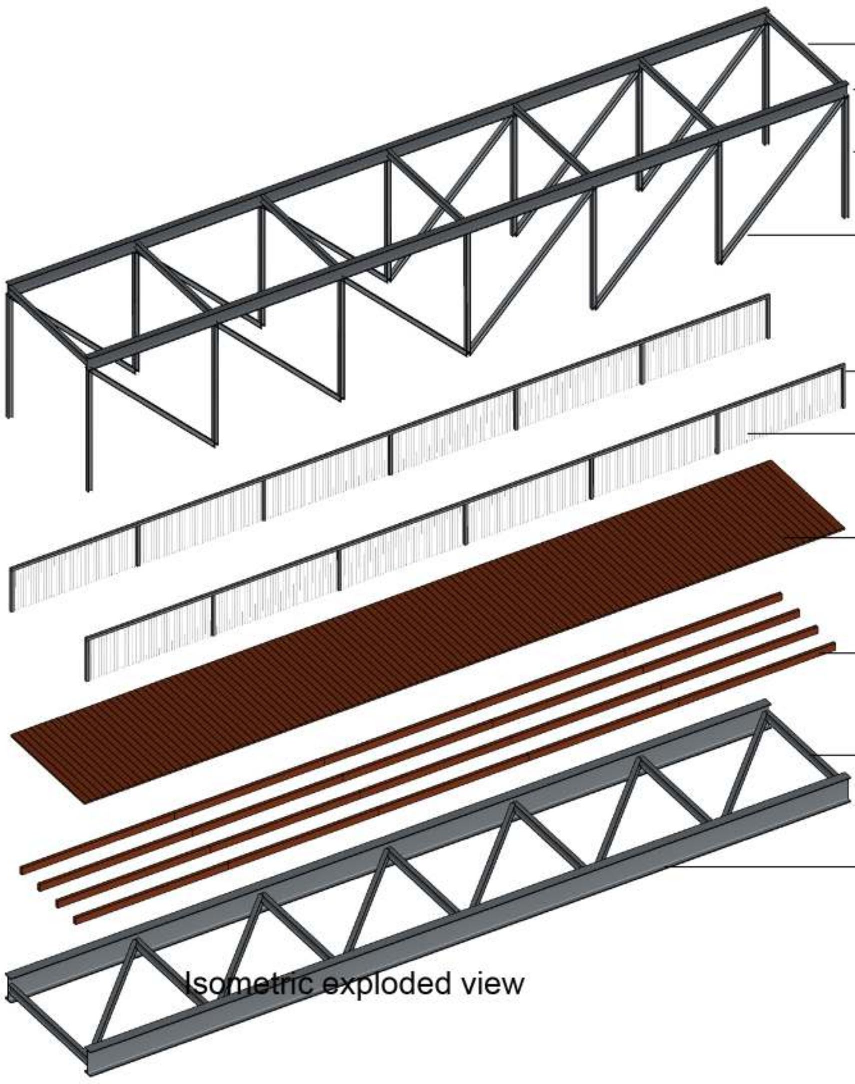
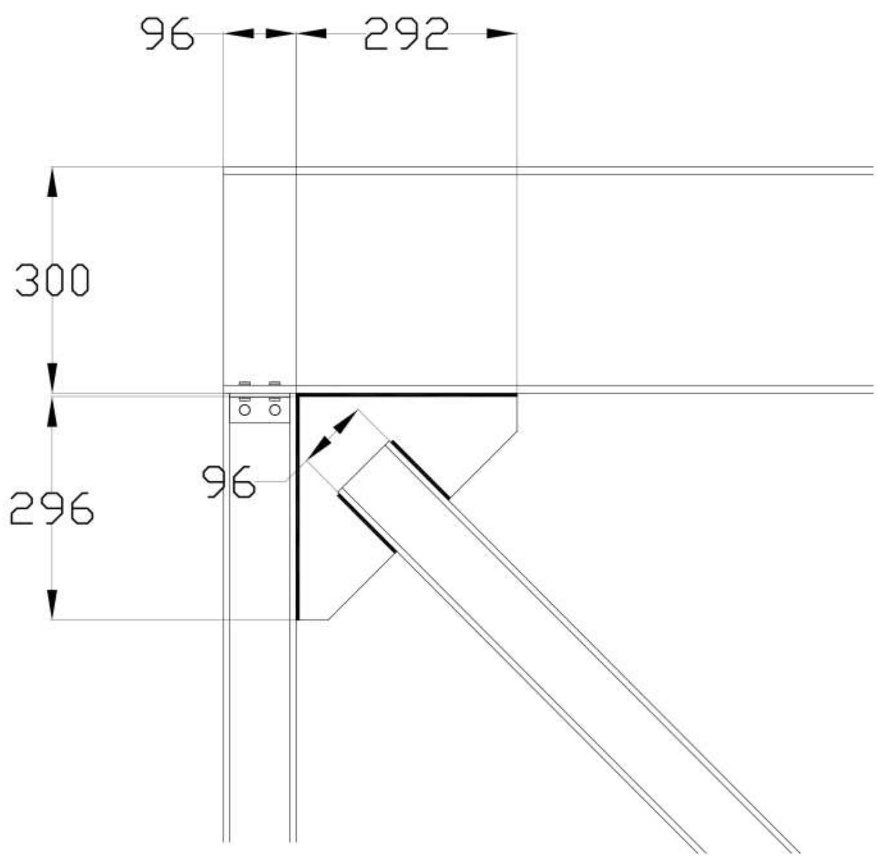
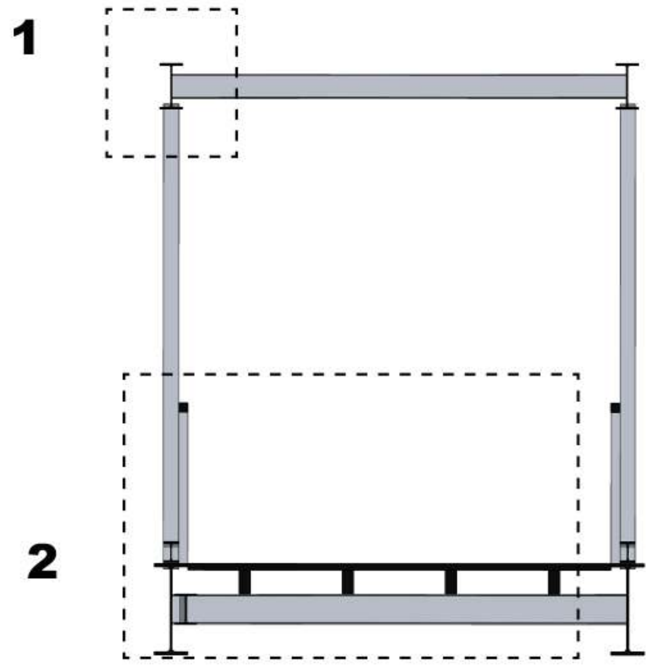


Isometric exploded view

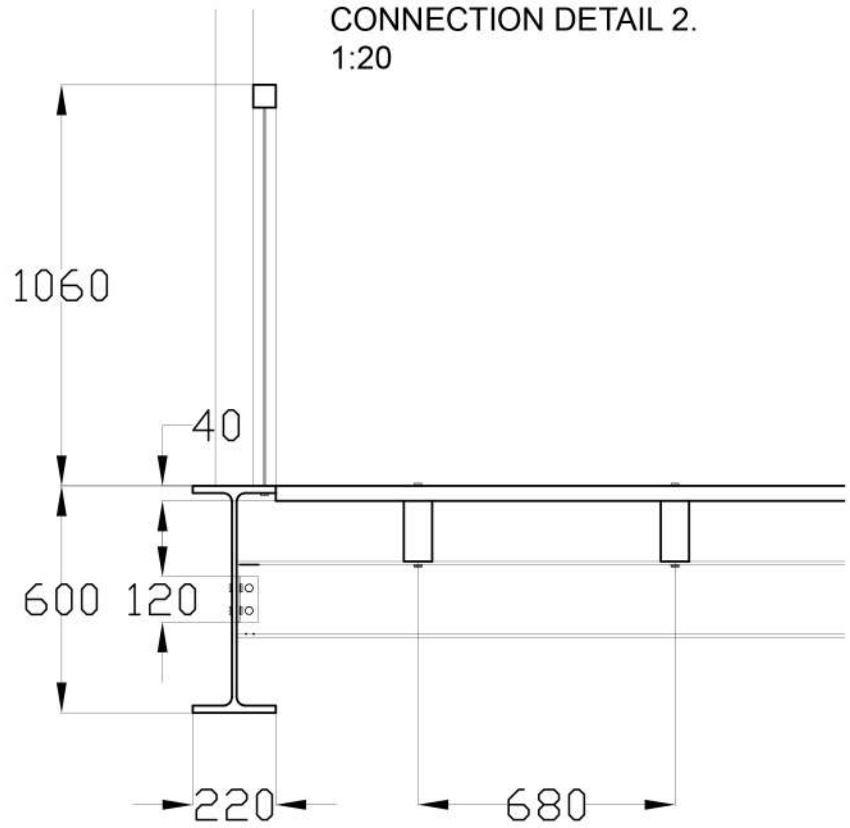


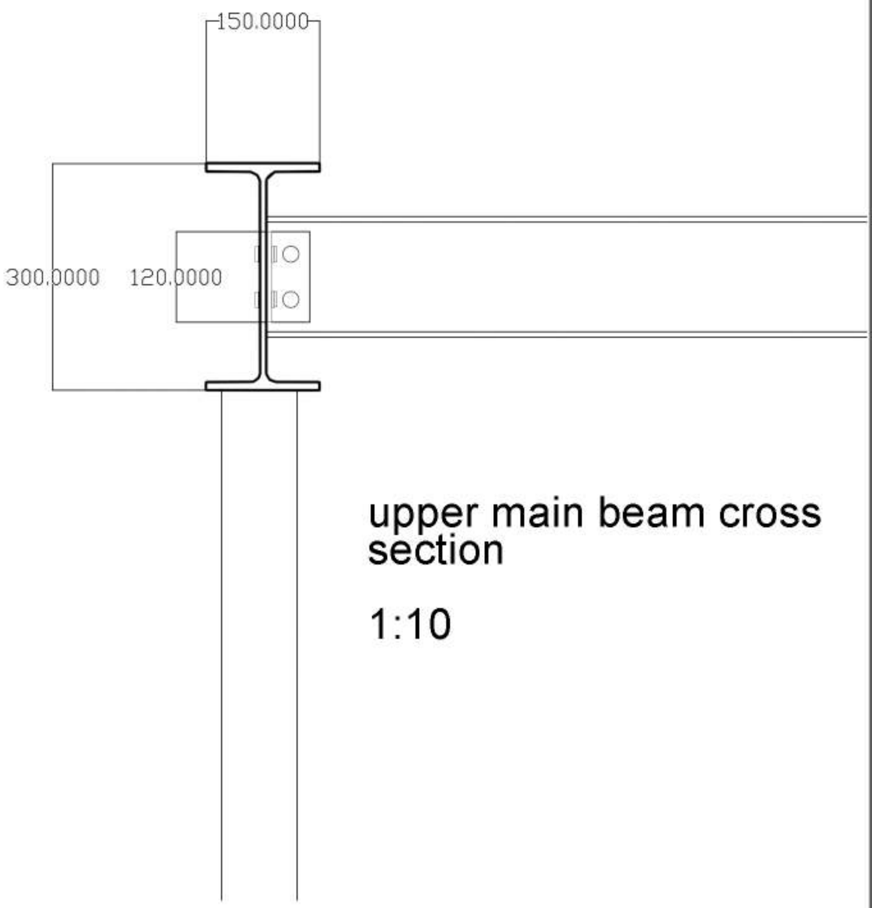
TRUSS CONNECTION DETAIL 1.
1:10



CROSS SECTION

CROSS BEAM AND DECKING
CONNECTION DETAIL 2.
1:20





upper main beam cross section

1:10

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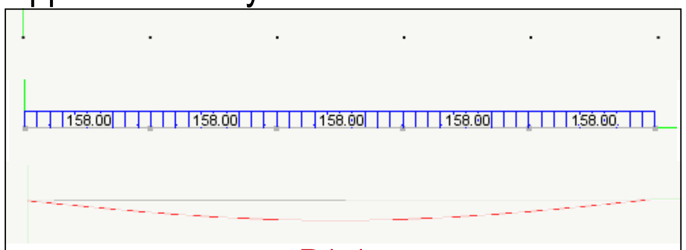
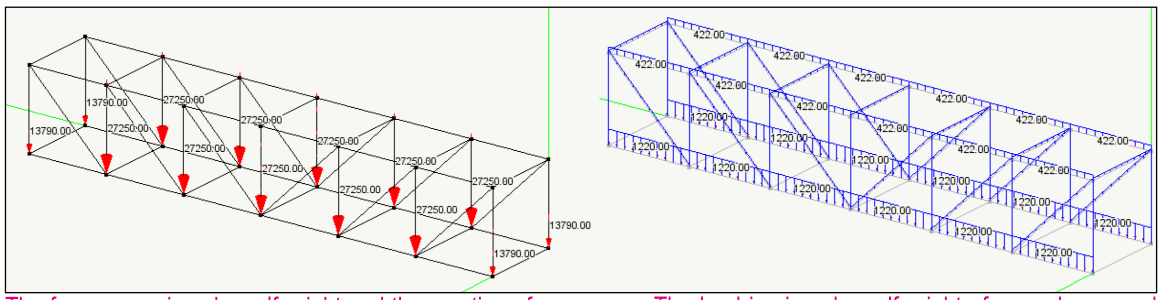
PROCESS 1

Upper secondary beam IPE160 sw=158N/m



P1-1

Whole system upper and lower main beam for IPE300 and IPE600, truss for HEA100



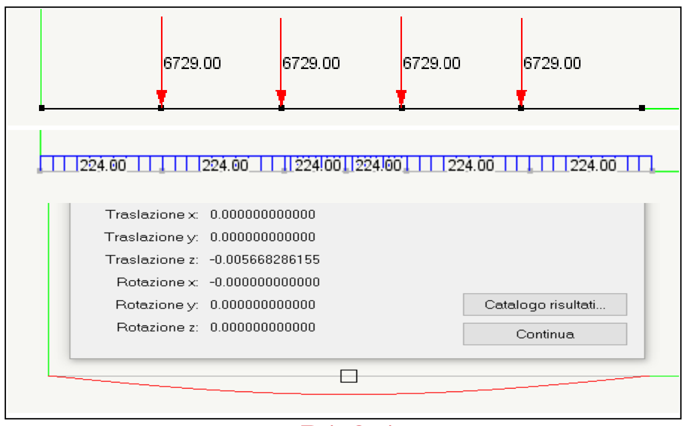
The forces are given by selfweight and the reaction of bottom secondary beam, which is got in Nolian. P1-4

P1-3

The load is given by selfweight of every beam and truss without lower secondary beam

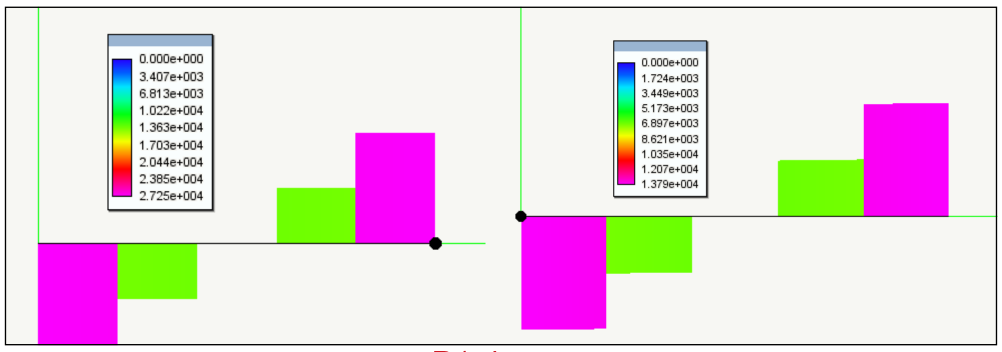
Lower secondary beam IPE200 sw=224N/m

Center beam



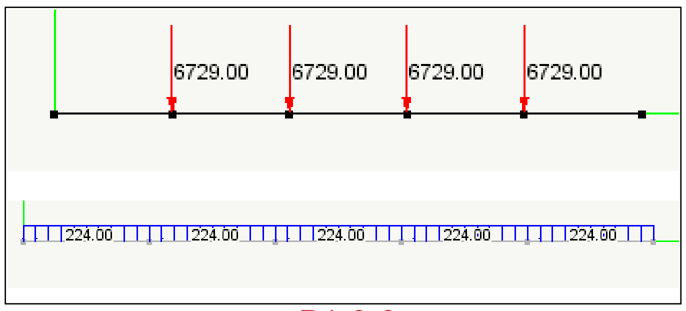
P1-2-1

Shear force of lower secondary beam

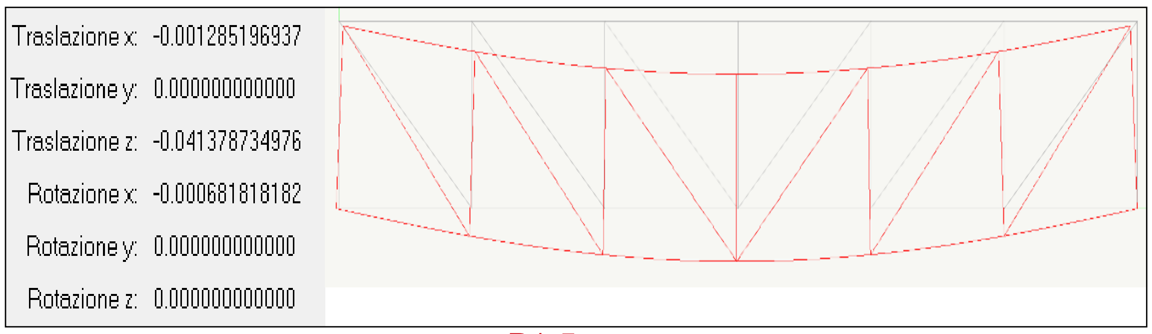


Center beam P1-4 Lateral beam

Lateral beam



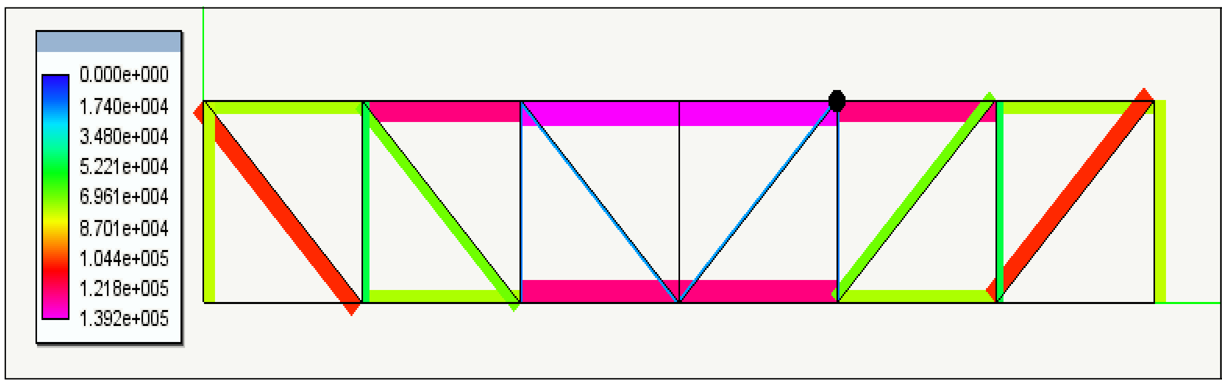
P1-2-2



P1-5

PROCESS 2

Axial force in main beam and truss



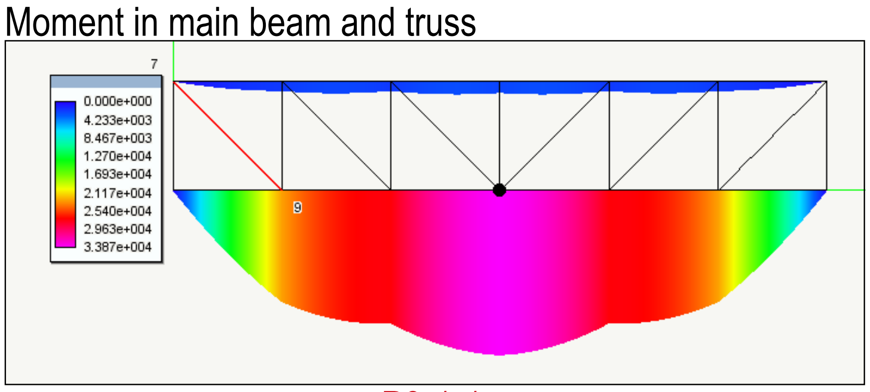
P2-1-1

Axial force in secondary beam

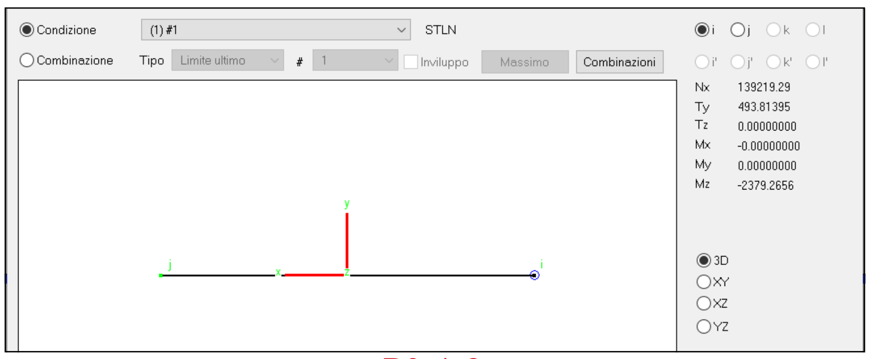
P2-1-2

PROCESS 3

Moment in main beam and truss

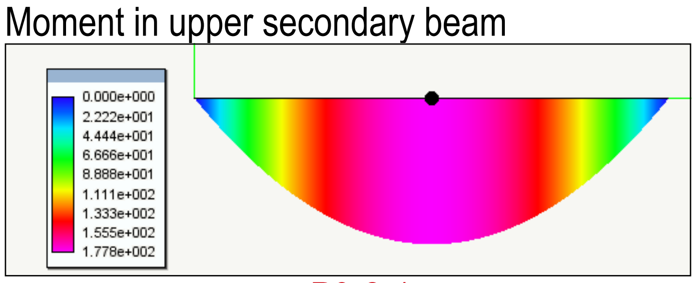


P3-1-1



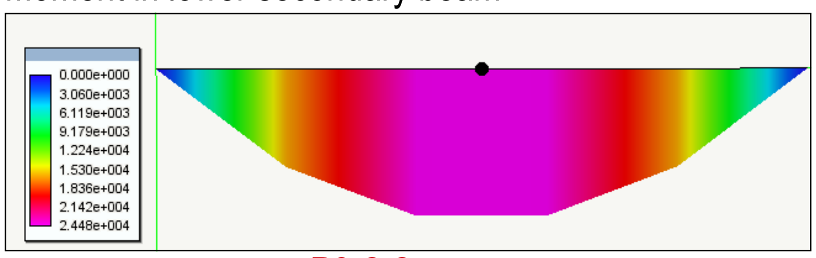
P3-1-2

Moment in upper secondary beam



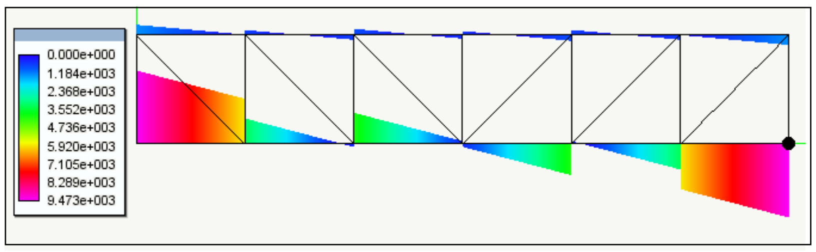
P3-2-1

Moment in lower secondary beam



P3-2-2

Shear force in main beam and truss



P3-3

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Course / Professor Fundamentals of structural analysis/BARPI FABRIZIO

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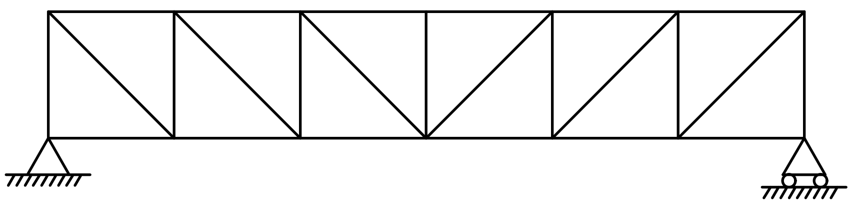

Rtot=2+1+2*{2*[(2-1)+(3-1)+(4-1)+(4-1)+(4-1)+(4-1)] +(3-1)+(5-1)}=75
Freedom(tot)=25*3=75
so the system is stable 75-75=0

Outside force = 648N/m^2*18m*3m+5000N/m^2*18 m*3m+3.6m^3*5000N/m^3 = 323000N

Snow load: 648N/m^2
Live load: 5000N/m^2
Timber load: 5000N/m^3
Timber volume: 3.6m^3
Bridge length: 18m
Bridge Width: 3m

Type of steel:
Top of secondary beam: IPE160 sw=158N/m
Top of main beam: IPE300 sw=422N/m
Truss: HEA100 sw=167N/m
Bottom secondary beam: IPE200 sw=224N/m
Bottom main beam: IPE600 sw=1220N/m

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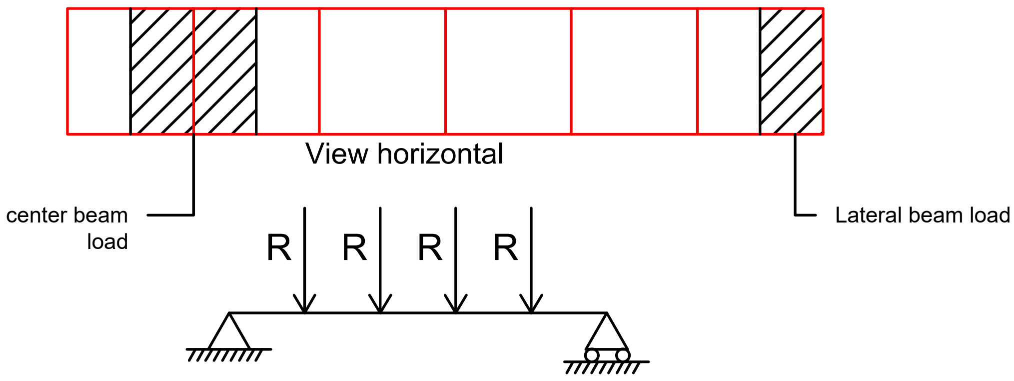
CALCULATION REPORT
(diagram in panel 3)

PROCESS 1

Max deflection of secondary beam =L/400=3/400=0.0075m
Max deflection of main beam =L/400=3/400=0.045m

1.Upper secondary beam:
Due to upper secondary beam only bear self weight so its deformation is surely satisfied. (Load and deformation as P1-1)

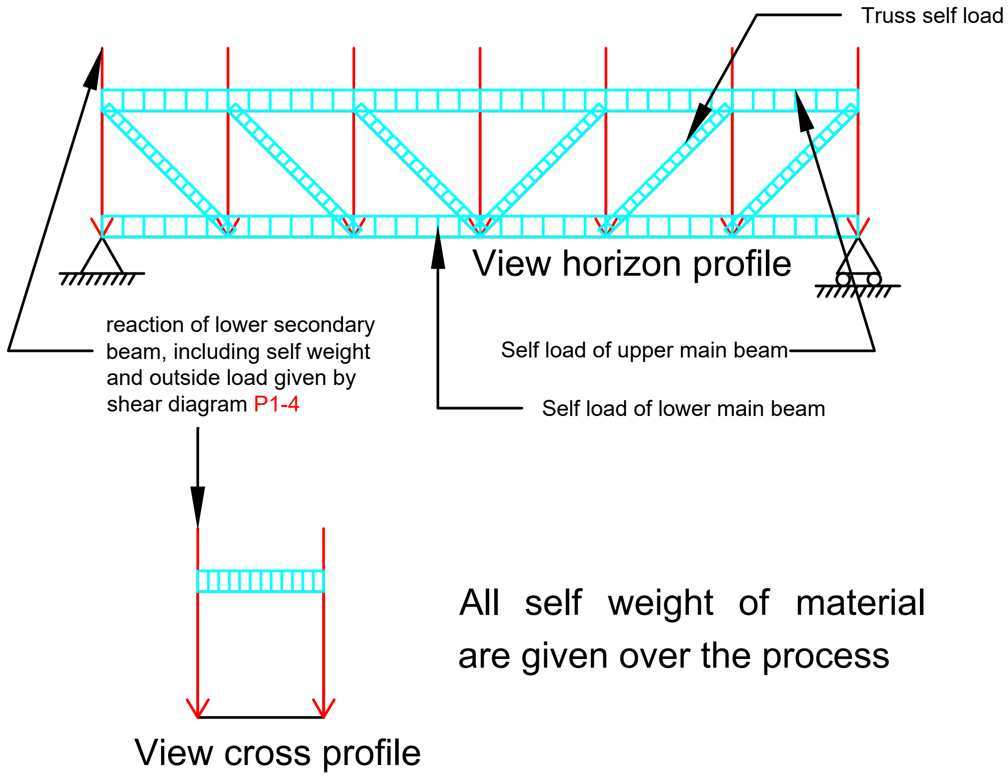
2.Lower secondary beam:



a: Center beam: Reaction by the timbers which include live load, snow and self weight of timber, according to analysis model before.R=323000/(6*4)=13458N
Then give sw of IPE200 is 224N/m. Analysis we get the deflection is about 0.057m<0.075m IPE200 is preliminary satisfied. (Load, Reaction and deformation as P1-2-1)

b: Lateral beam: Lateral lower secondary bear less load or reaction of upper layer (half of reaction of center beam), so the deflection must satisfy. (Load, Reaction and deformation as P1-2-2)

3.Whole system
The load and force are given in whole system as law in Nolian. (As P1-3 and P1-4)

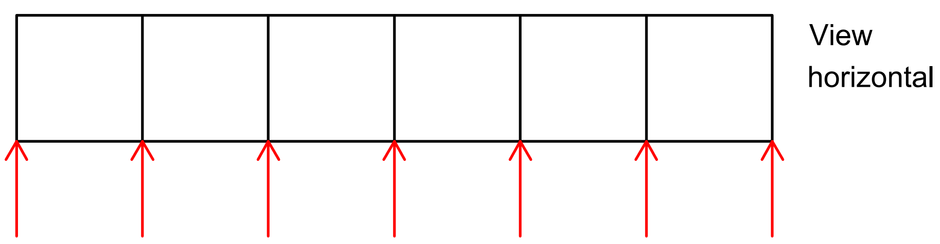


All self weight of material are given over the process

After analysis, the deflection of main beam is satisfied. 0.041m<0.045m. (Deformation as P1-5)

PROCESS 2

We use Nolian to find the max axial force in the whole system is 139200N (P2-1-1)
critical load: Nc=π^2*E*Iy/L^2 (know: max axial force exist upper main beam IPE300, and distance L=3m, E=2.1*10^11, Iy of IPE300 is 604cm^4.
Nc=π^2*2.1*10^11*604*10^-8/3*3=1389546.3N
Nc is 10 times Nmax so is checked satisfied
ρmin=root(Iy/A)=root(604/53.8)=3.4mm (IPE300 A=53.8cm^2)
λ=L/ρmin=88.24<200 so slenderness is satisfied.



We use Nolian to find the max axial force in the horizontal beam is 4283N (P2-1-2)
The horizontal force=15%F(tot)/number of secondary beam
Total force=outside load+self weight=
323000+21*158+224*21+36*422+36*1220+167*(14*3+12*3*root2)=399753.2N
21m for both upper and lower secondary beam respectively. 14 beams
36m for both upper and lower main beam respectively. 4 beams
(14*3+12*3*root2)m for truss
F=399753.2*15%/14=4283.07N
Nc=π^2*E*Iy/L^2=π^2*2.1*10^11*68.3*10^-8/3*3=157129N (IPE160 Iy=68.3cm^4)
Lower secondary beam is IPE200 Iy is bigger than IPE160
so Nc>Nmax is enough
ρmin=root(Iy/A)=root(68.3/20.1)=1.84mm (IPE160 A=20.1cm^2)
λ=L/ρmin=61.33<200 so slenderness is satisfied.

PROCESS 3

From the moment diagram (P3-1-1) we found that the max moment of main beam are 2379Nm(check into sforzi P3-1-2) and 33879Nm(check in color P3-1-1) for IPE300 and IPE 600 respectively. Wx for IPE300 and IPE600 are 557cm^3 and 3070cm^3
Upper secondary beam IPE160 max moment is 17.78Nm Wx=109cm^3 (P3-2-1)
Lower secondary beam IPE200 max moment is 24480Nm Wx=194cm^3 (P3-2-2)

Upper main beam max shear force is 2368N for IPE300, and 9473N for IPE600 in lower main beam.
We have seek that the lower secondary beam IPE200 in before diagram is 27250N (P3-3)
Upper secondary beam only bear its self weight so it must satisfied.

Stress for every beam:
Upper secondary beam IPE160
σmax=Mmax/Wx=17.78*1000/109000=0.16N/mm^2
Upper main beam IPE300
σmax=Mmax/Wx=2379*1000/557000=4.3N/mm^2
τ≈Tmax/bw*hw=2368/7.1*(300-2*10.7)=1.2N/mm^2
Bottom secondary beam IPE200
σmax=Mmax/Wx=24480*1000/194000=126N/mm^2
τ≈Tmax/bw*hw=27250/5.6*(200-2*8.5)=26.6N/mm^2
Bottom main beam IPE600
σmax=Mmax/Wx=33870*1000/3070000=11N/mm^2
τ≈Tmax/bw*hw=9473/12*(200-2*19)=4.9N/mm^2
σlim=0.8*235=188N/mm^2 so it bigger than every stress of beam. Every type of beam is satisfied.