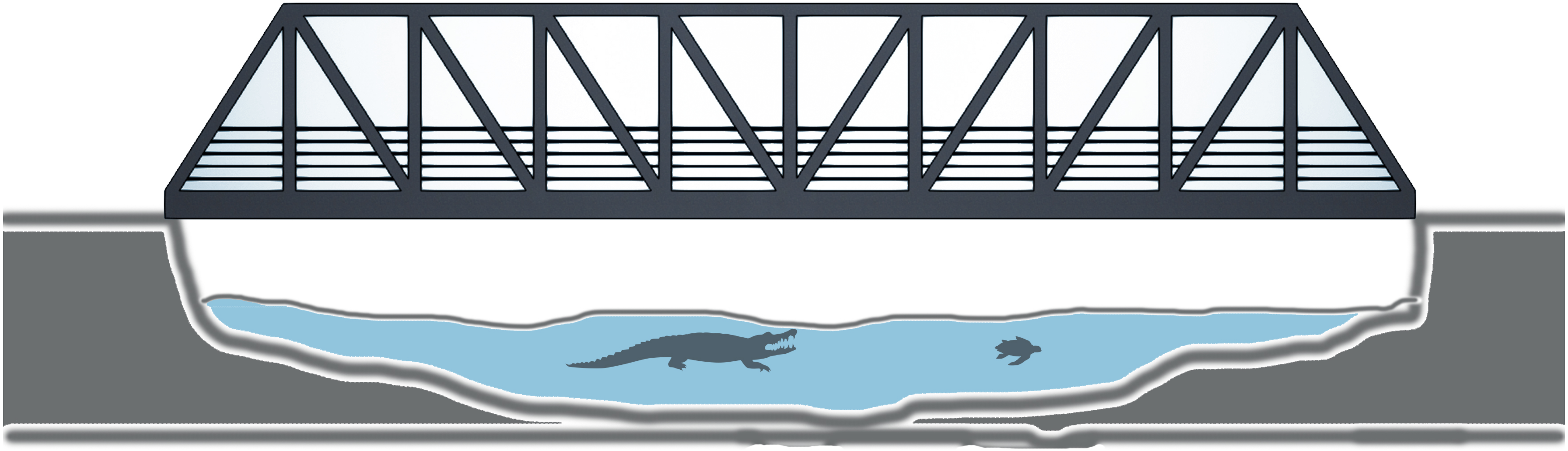
Rookie bridge



Our design site is located in Turin(45°06'30.3"N 7°46'13.7"E), where the terrain is flat. The design of our bridge is suitable for the local 20m wide river, and it is also convenient for the people on the river banks.

We use two different steel frames as the structure of the bridge: IPE450 and IPE200.The former is used as the main beam at the bottom of the bridge, total of two; the latter is used as the second beam. At the bottom of the bridge, there are four wooden joists, which are used to support the wooden decking. The armrests on both sides of the bridge are cable railing, which are made from 316 Low Carbon stainless steel to last in tough environments. For our steel bridge it has following adavantages:

High strength and light weight. Steel has high strength and high modulus of elasticity, so steel structure members are small and light. Uniform material, high reliability. The structure of steel is uniform, close to isotropic. Good plasticity and toughness. Convenient for mechanized manufacturing.Convenient installation and short construction period. The steel structure has the advantages of convenient installation and short construction period, which can give full play to the economic benefits of investment as soon as possible. The steel structure has good sealing performance, and it is easy to be made into atmospheric pressure and high-pressure vessel structure and large-diameter pipeline which are watertight and airtight.

Group 14

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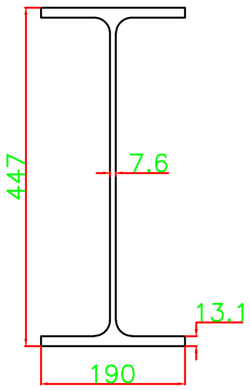
Ge min s241043 Qiao xuan s241292

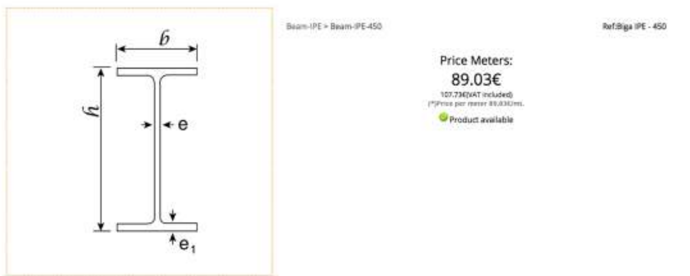
Beam indication

Identification	Nominal weight 1m	Nominal dimensions						Cross-section	Dimensions for detailing					Surface	
	kg/m	mm						A	h1	d	Ø	pmin	pmax	AL	AG
IPE 200	22,4	100	200	5,6	8,5	12,0		28,50	183,0	159,0	M10	54	58	0,768	34,36
IPE 450	77,6	190	450	9,4	14,6	21,0		98,82	420,8	378,8	M24	100	102	1,605	20,69

Identification	Section properties, Static data												
	strong axis x-x						weak axis y-y						
	Ix	Wel.x	Wpl.x	ix	Avy	Sx	Iy	Wel.y	Wpl.y	iy	Ss	It	Iw
	cm4	cm3	cm3	cm	cm2	cm3	cm4	cm3	cm3	cm	mm	cm4	
IPE 200	1943	194,0	221,0	8,26	14,00	110	142,0	28,5	44,6	2,24	36,7	6,98	13,00
IPE 450	33740	1500,0	1702,0	18,48	50,90		1676,0	176,4	276,0	4,12	63,2	66,90	791,00

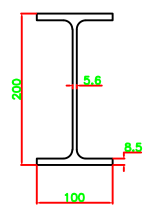
IPE 450



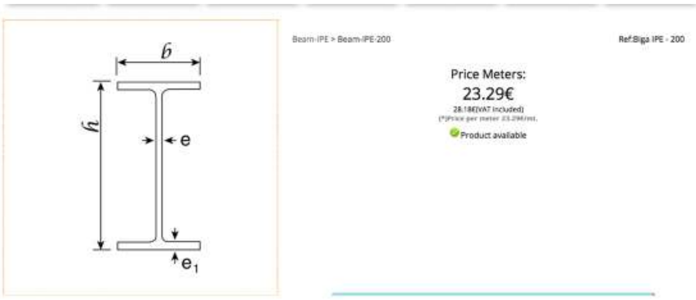


89.03 euro/meter

IPE 200

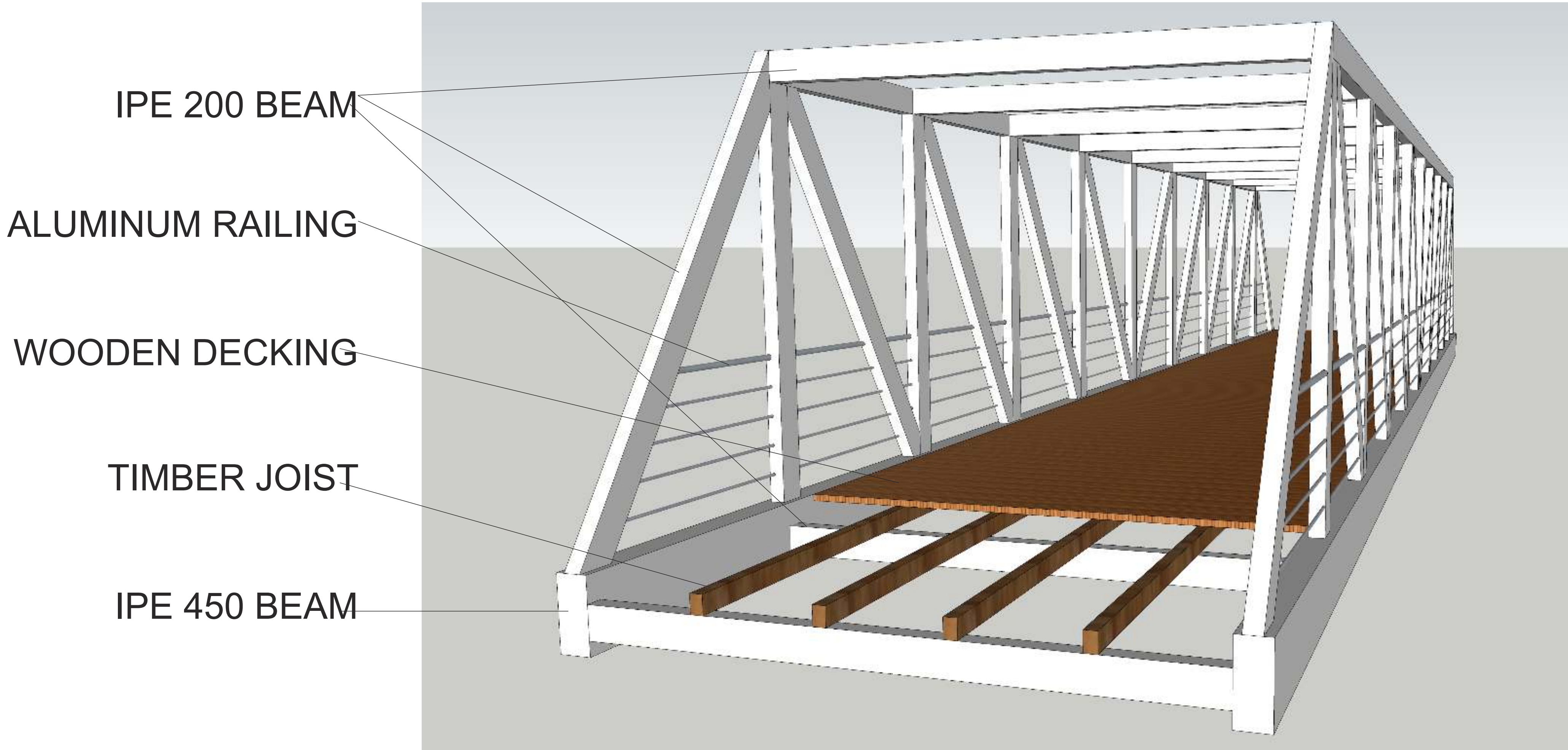


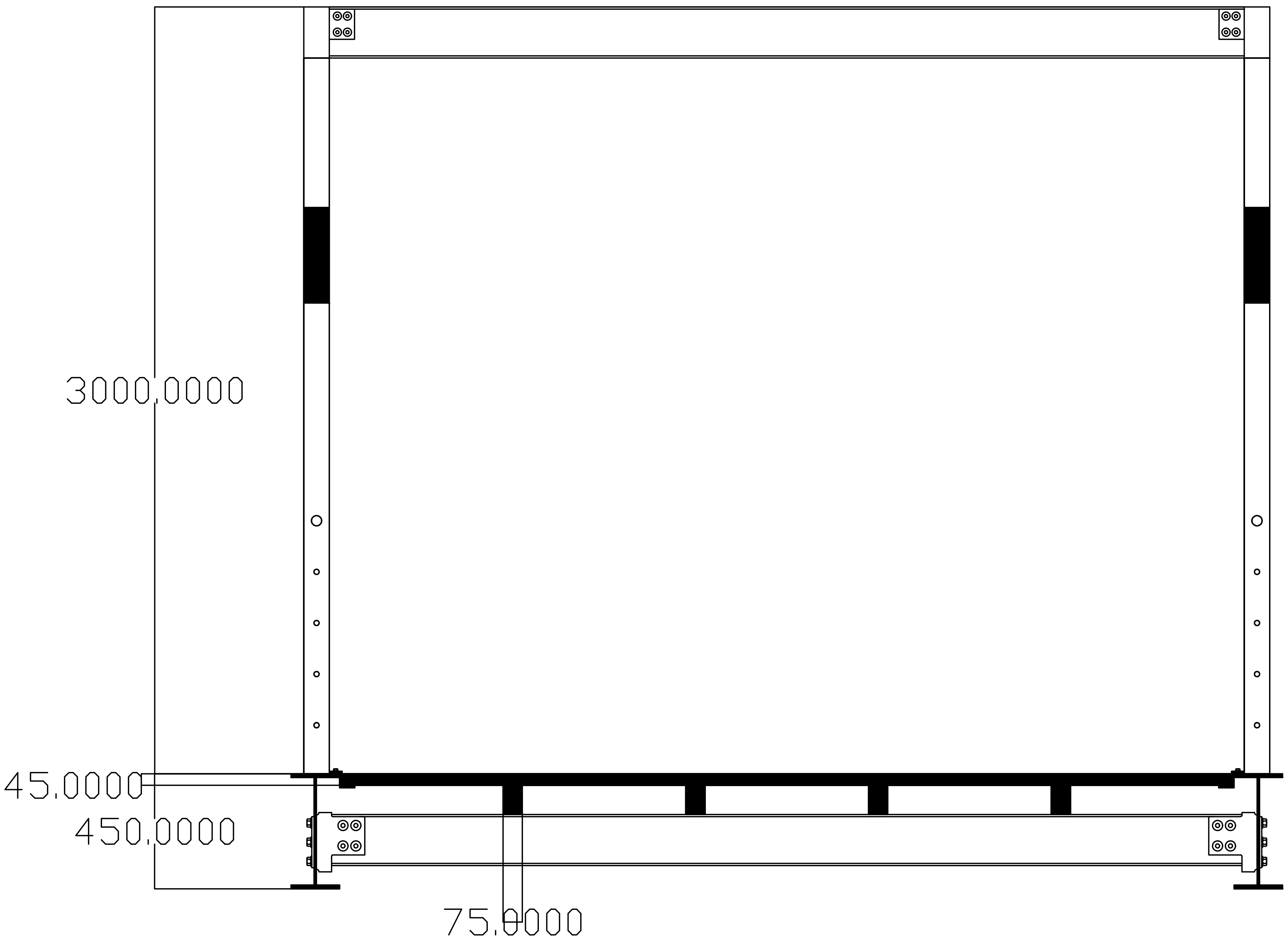
SECTION 1:100



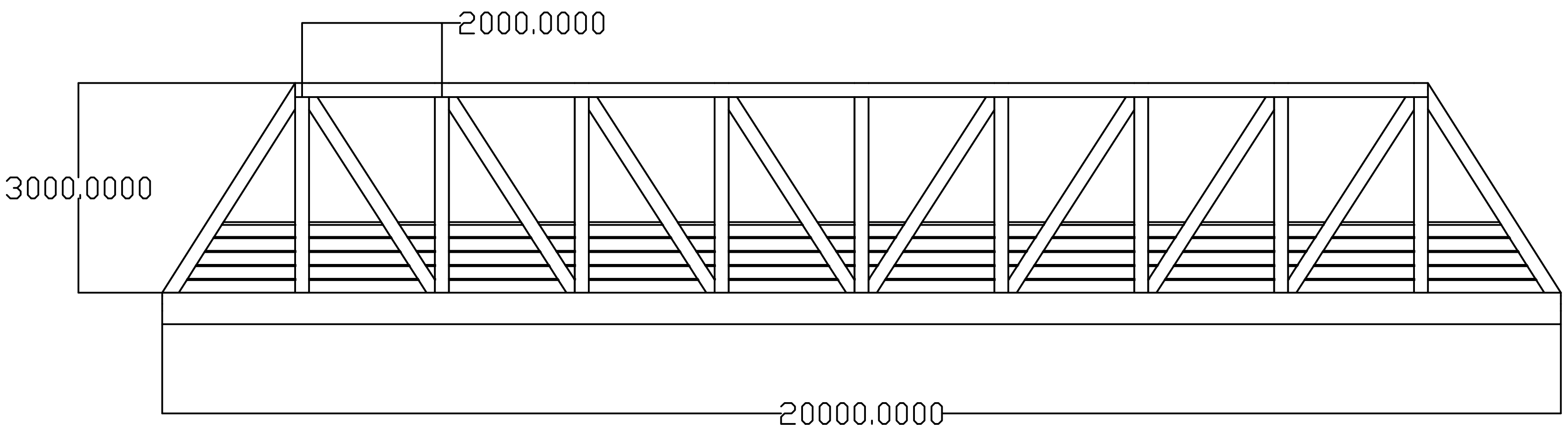
23.29 euro/meter

Bridge scheme

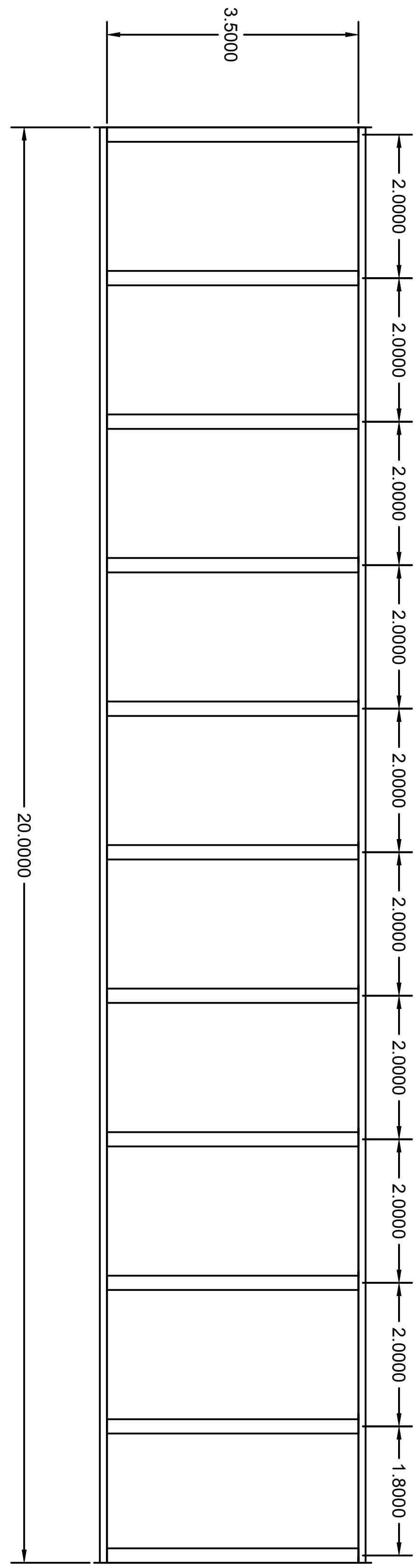




section 1:20



elevation 1:100



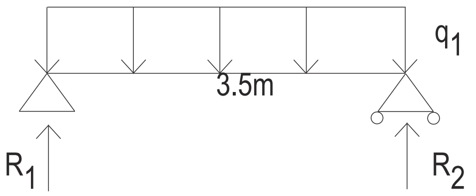
plan 1:100

Nolian results and caculation

Main beam: IPE450 Secondary beam: IPE200

load: people 5 kN/m^2
snow 1.23 kN/m^2
wood deck 770.5 kg/m^2*0.04 m*10 N/kg = 0.308 kN/m^2

Load (people, snow, deck): (5+1.23+0.308) kN/m^2*3.5 m*20 m = 457.6 kN
Load of top(supported by main beam): (20*3.28 m+18*2.6 m+2*16 m+9*3.5)*0.224 kN/m
= 39.4 kN
self-weight of secondary beam: 22.4 kg/m*3.5 m*10 N/kg*11
=8.624 kN
4 joist: 770.5 kg/m^3*0.075 m*0.155 m*10 N/kg*20 m*4 = 7 kN
For secondary beam total load: 457.6 kN + 8.624 kN + 7 kN = 473 kN
each secondary beam:473 kN/10=47.3 kN



Linear load q_1=47.3KN/3.5m=13.5KN/m
R1=R2=47.3KN/2=23.65KN
$M(X)=-1/2q_1X^2+R1X$ $M_{max}= M_{x=3.5/2}$=20.7KN*m

Vertical displacement: using differential equations (simplified formula can be adopted)
$V_{max}= (5/384)*q_1L^4/ EI_x = (5/384)13.5*10^3N/m*3.5^4/2.1*10^{11}N/m^2*1943*10^{-8}m^4$ = 0.0065 m < 3.5/400 m = 0.00875 m
Fits the requirement

For main beam:
self-weight of main beam : 0.776 kN/m*20m*2 = 31 kN
self-weight of main beam : 31 kN/2 = 15.5 kN
TOTAL LOADS : 457.6 kN + 39.4 kN + 8.624 kN + 7kN + 31 kN = 543.6 kN
load for each main beam 543.6 kN/2 = 271.8 kN
support reaction force of each main beam : $R_3 = R_4$ =271.8 kN/2=135.9 kN
$M_{max} = 3.728*10^4N*m$ (from Nolian)

vertical displacement : from Nolian V_{max} = 0.02 m < 20 m/400 = 0.05m
So fits the requirement.

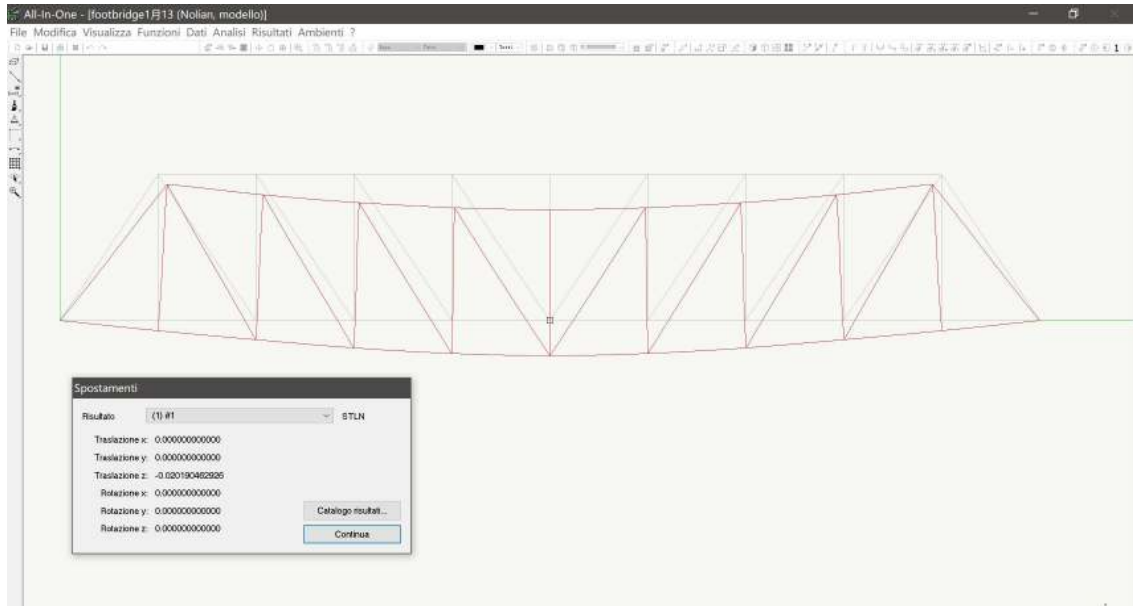
Slenderness: $\lambda = L_0/ \quad I_x/A$ = 2m / $(1943*10^{-8}m^4)/28.5*10^{-4}m^2$ = 24.2<200
So fits requirement.

Critical load (middle of the upper horizontal hinge)
$Fcr = \pi^2 EI/L_0^2$
$Ncr = Ncr^{(XZ)} = 3.14^2*2.1*10^{11}N/m^2*142*10^{-8}m^4$ = 735000N = 735kN
from Nolian : $Nx = 4.107*10^5$ N = 410.7kN
Ncr > Nx
So fits the requirement.

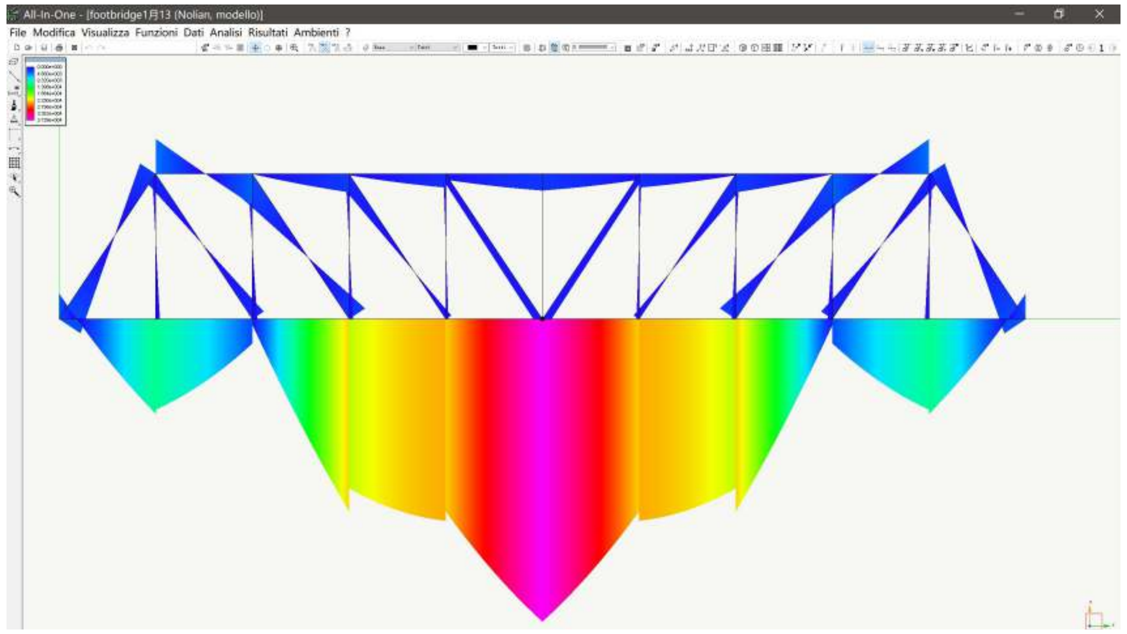
Normal Stress:

Secondary beam:
$\delta z^{max}=Mx/Ix*y_{max}=(20.7kNm/1943*10^{-8}m^4)*0.2m/2=106Mpa < 0.8f_{yk}$ = 0.8*235 = 188Mpa
So fits requirement.

Main beam:
$\delta z^{max}=Mx/Ix*y_{max}=(3.728*10^4Nm/33740*10^{-8}m^4)*0.45m/2$ = 24.86 Mpa < $0.8f_{yk}$ = 188Mpa
So fits requirement.



deflection



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