BRIDGE OF JUJU

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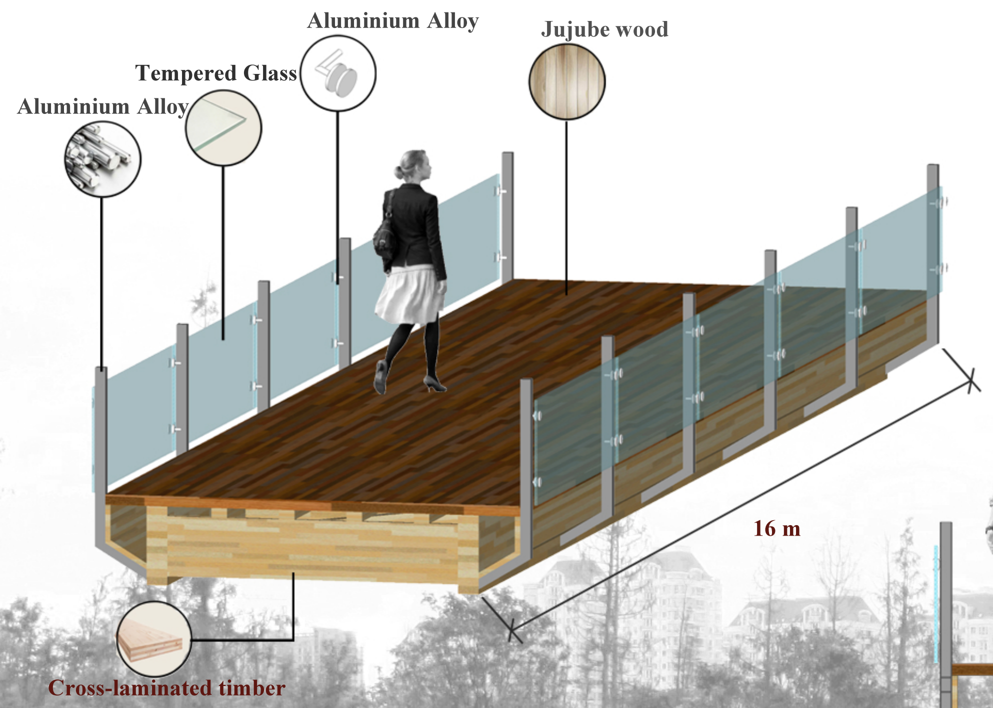
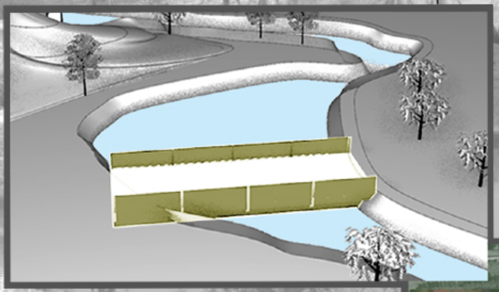




Structure choice

Material choice

Xianyang ancient ferry is the Weihe river ferry of Xianyang, crossing the Weihe River in Guanzhong. Since ancient times, people who come from south to north near Xianyang and Chang'an have to cross the Weihe River at Xianyang ferry. Because of the large seasonal water level drop of Weihe River, people often use Zhouqiao together. In winter and spring, they usually pass by bridge, while in summer and autumn, they ferry by boat. Historically, Xianyang ferry has experienced more than 2000 years of changes, from the "transverse bridge" of Qin Dynasty to the "Wei bridge" of Western Han Dynasty, and from the "temporary bridge" of Tang Dynasty to the "ancient ferry" of Ming and Qing Dynasties. Therefore, there is a saying of "Xianyang ancient crossing for thousands of years", also known as one of the eight sceneries in Guanzhong.

BRIDGE OF JUJU

Table 3.2. Glulam section properties and load carrying requirements [11].

6-3/4-INCH WIDTH															
Depth (in.)	18	19-1/2	21	22-1/2	24	25-1/2	27	28-1/2	30	31-1/2	33	34-1/2	36	37-1/2	39
Beam Weight (lb/ft)	29.5	32.0	34.5	36.9	39.4	41.8	44.3	46.8	49.2	51.7	54.1	56.6	59.1	61.5	64.0
A (in.²)	121.5	131.6	141.8	151.9	162.0	172.1	182.3	192.4	202.5	212.6	222.8	232.9	243.0	253.1	263.3
S (in.³)	364.5	427.8	496.1	569.5	648.0	731.5	820.1	913.8	1013	1116	1225	1339	1458	1582	1711
I (in.⁴)	3281	4171	5209	6407	7776	9327	11070	13020	15190	17580	20210	23100	26240	29660	33370
EI (10⁶ lb-in.²)	5905	7508	9377	11530	14000	16790	19930	23440	27340	31650	36390	41580	47240	53390	60060
Moment Capacity (lb-ft)	72900	85560	99230	113900	129600	146300	164000	182800	202500	223300	245000	267800	291600	316400	342200
Shear Capacity (lb)	21470	23250	25040	26830	28620	30410	32200	33990	35780	37560	39350	41140	42930	44720	46510
8-3/4-INCH WIDTH															
Depth (in.)	24	25-1/2	27	28-1/2	30	31-1/2	33	34-1/2	36	37-1/2	39	40-1/2	42	43-1/2	45
Beam Weight (lb/ft)	51.0	54.2	57.4	60.6	63.8	67.0	70.2	73.4	76.6	79.8	82.9	86.1	89.3	92.5	95.7
A (in.²)	210.0	223.1	236.3	249.4	262.5	275.6	288.8	301.9	315.0	328.1	341.3	354.4	367.5	380.6	393.8
S (in.³)	840.0	948.3	1063	1185	1313	1447	1588	1736	1890	2051	2218	2392	2573	2760	2953
I (in.⁴)	10080	12090	14350	16880	19690	22790	26200	29940	34020	38450	43250	48440	54020	60020	66450
EI (10⁶ lb-in.²)	18140	21760	25830	30380	35440	41020	47170	53900	61240	69210	77860	87190	97240	108000	119600
Moment Capacity (lb-ft)	168000	189700	212600	236900	262500	289400	317600	347200	378000	410200	443600	478400	514500	551900	590600
Shear Capacity (lb)	37100	39420	41740	44060	46380	48690	51010	53330	55650	57970	60290	62610	64930	67240	69560

Notes:
(1) Beam weight is based on density of 35 pcf.
(2) Moment capacity must be adjusted for volume effect.
(3) Moment and shear capacities are based on a normal (10-year) duration of load and should be adjusted for the design duration of load per the applicable building code.

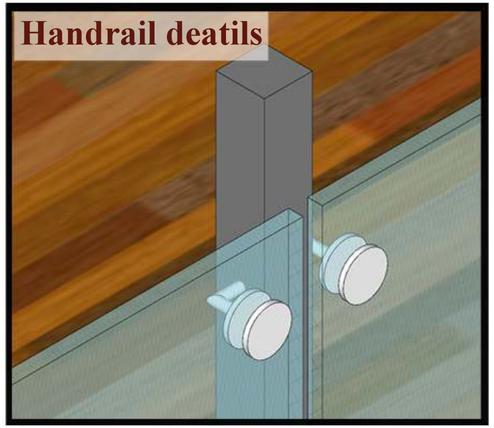
Rosboro Glulam Beams: Design Values

Product	Layup Combination	Flexural Stress F_b (psi)[1] Tension Zone	Compression Zone	Compression Perpendicular to Grain $F_{c\perp}$ (psi)	Shear[2] F_v (psi)	Modulus of Elasticity E (10^6 psi)
BigBeam	30F-E2M3	3,000	3,000	650	300	2.1
Stock Glulam	24F-V4	2,400	1,850	650	265	1.8
1.8E-IK	24F-V8	2,400	2,400	650	265	1.8
Treated Glulam	24F-V5M1/SP	2,400	2,400	740	300	1.8

Notes for Glulam Beams Design Values:
(1) F_b shall be adjusted by the volume effect factor using the following formula:
$C_v = (5.125/b)^{1/10} \times (12/d)^{1/10} \times (21/L)^{1/10} \leq 1.0$
Where: b = beam width (in.), d = beam depth (in.), L = beam length (ft.).
(2) For non-prismatic members, notched members, members subject to impact or cyclic loading, or shear design of bending members at connections (NDS-05 3.4.3.3), the design shear (F_v) shall be multiplied by a factor of 0.72.

Rosboro GLULAM Design Properties
F_b = 2,400 psi
F_v = 265 psi
E = 1.8 x 10^6 psi

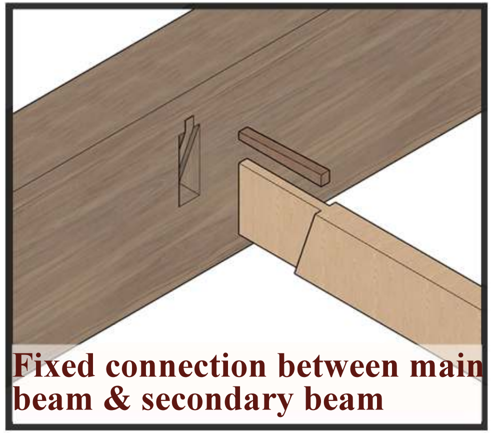
Width (in.)	Depth (in.)	Weight (lbf/ft.)	Maximum Resistive Shear (lbf) 100%	115%	125%	Maximum Resistive Moment (ft.-lbf) 100%	115%	125%	EI (10^6 in.² - lb.)
3-1/8	6	4.6	3,313	3,809	4,141	3,750	4,313	4,688	101
	7-1/2	5.7	4,141	4,762	5,176	5,859	6,738	7,324	198
	9	6.8	4,969	5,714	6,211	8,438	9,703	10,547	342
	10-1/2	8.0	5,797	6,666	7,246	11,484	13,207	14,355	543
	12	9.1	6,625	7,619	8,281	15,000	17,250	18,750	810
	13-1/2	10.3	7,453	8,571	9,316	18,984	21,832	23,730	1,153
	15	11.4	8,281	9,523	10,352	23,438	26,953	29,297	1,582
	16-1/2	12.5	9,109	10,476	11,387	28,359	32,613	35,449	2,106
	18	13.7	9,938	11,428	12,422	33,750	38,813	42,188	2,734
	19-1/2	14.8	10,766	12,380	13,457	39,609	45,551	49,512	3,476
	21	16.0	11,594	13,333	14,492	45,938	52,828	57,422	4,341
	22-1/2	17.1	12,422	14,285	15,527	52,734	60,645	65,918	5,339
	24	18.2	13,250	15,238	16,563	60,000	69,000	75,000	6,480
Width (in.)	**Depth (in.)**	**Weight (lbf/ft.)**	**Maximum Resistive Shear (lbf) 100%**	**115%**	**125%**	**Maximum Resistive Moment (ft.-lbf) 100%**	**115%**	**125%**	**EI (10^6 in.² - lb.)**
3-1/2	9	7.7	5,565	6,400	6,956	9,450	10,868	11,813	383
	10-1/2	8.9	6,493	7,466	8,116	12,863	14,792	16,078	608
	12	10.2	7,420	8,533	9,275	16,800	19,320	21,000	907
	13-1/2	11.5	8,348	9,600	10,434	21,263	24,452	26,578	1,292
	15	12.8	9,275	10,666	11,594	26,250	30,188	32,813	1,772
	16-1/2	14.0	10,203	11,733	12,753	31,763	36,527	39,703	2,358
Width (in.)	**Depth (in.)**	**Weight (lbf/ft.)**	**Maximum Resistive Shear (lbf) 100%**	**115%**	**125%**	**Maximum Resistive Moment (ft.-lbf) 100%**	**115%**	**125%**	**EI (10^6 in.² - lb.)**
5-1/8	6	7.5	5,433	6,247	6,791	6,150	7,073	7,688	166
	7-1/2	9.3	6,791	7,809	8,488	9,609	11,051	12,012	324
	9	11.2	8,149	9,371	10,186	13,838	15,913	17,297	560
	10-1/2	13.1	9,507	10,933	11,884	18,834	21,660	23,543	890
	12	14.9	10,865	12,495	13,581	24,600	28,290	30,750	1,328
	13-1/2	16.8	12,223	14,057	15,279	31,134	35,805	38,918	1,891
	15	18.7	13,581	15,618	16,977	38,438	44,203	48,047	2,595
	16-1/2	20.6	14,939	17,180	18,674	46,509	53,486	58,137	3,453
	18	22.4	16,298	18,742	20,372	55,350	63,653	69,188	4,483
	19-1/2	24.3	17,656	20,304	22,070	64,959	74,703	81,199	5,700

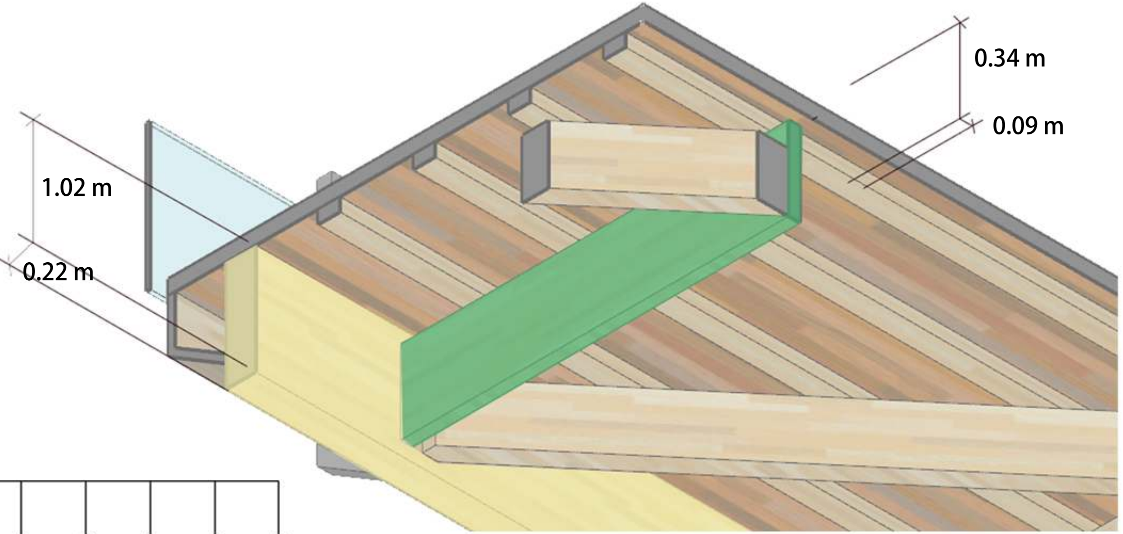


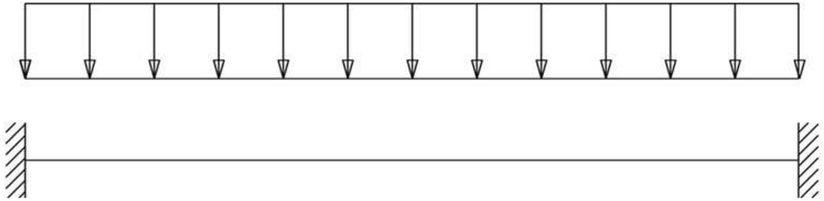
INTRODUCTION

Jujube trees generally grow very slowly, and the thick trunk of the bowl mouth needs to grow for decades. Jujube wood worms are not easy to decompose, and ancient carved books mostly used jujube wood carving. Jujube wood is hard and dense, fine wood grain, beautiful pattern, light red or dark red color, outstanding stability, corrosion resistance, wear resistance, insect resistance, especially suitable for high-end furniture, flooring. It is a classic popular high-end East Asian species.

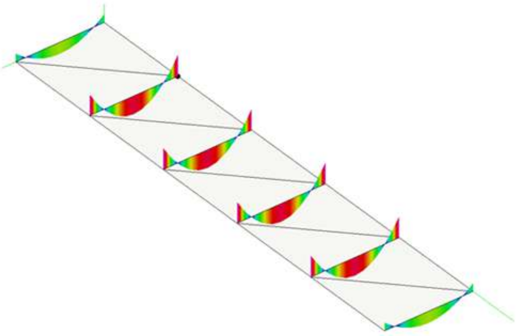
Due to the high price, combined with economic and aesthetic requirements, we use it for bridge decking, and the structure uses cheaper clt wood



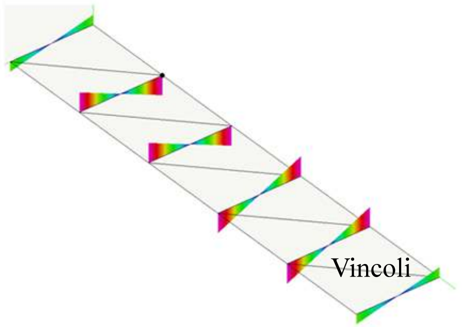




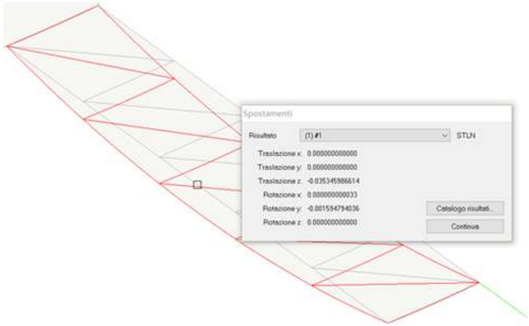
BRIDGE OF JUJU



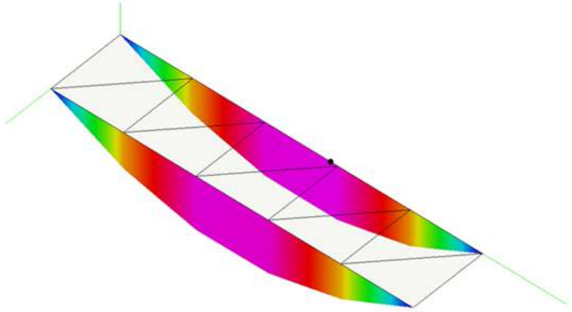
Moment of Secondary Beam



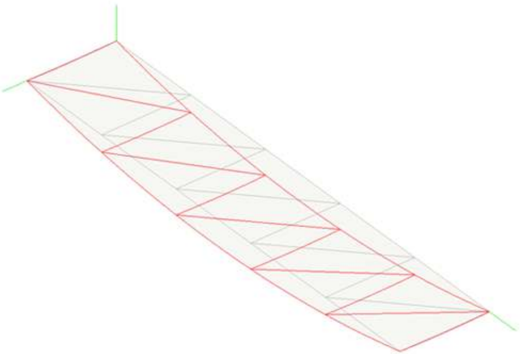
Shear Reaction of Secondary Beam



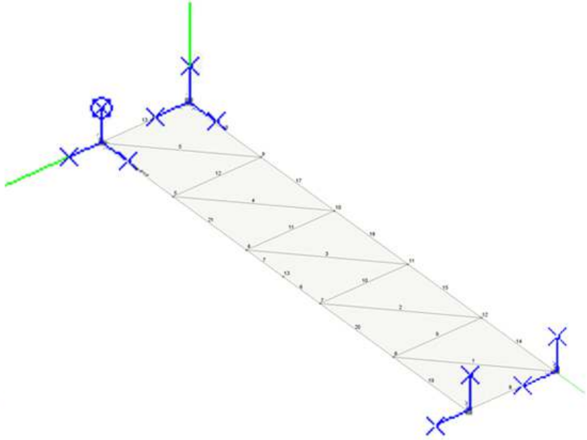
Vertical Displacements



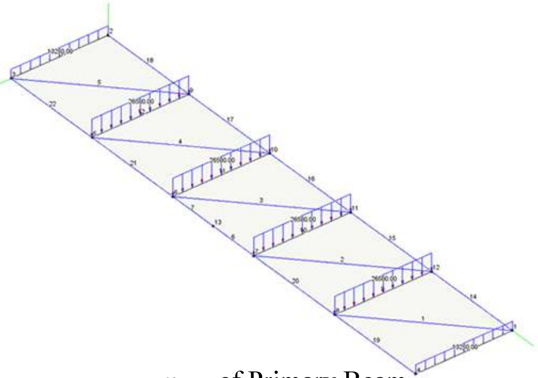
Moment of Primary Beam



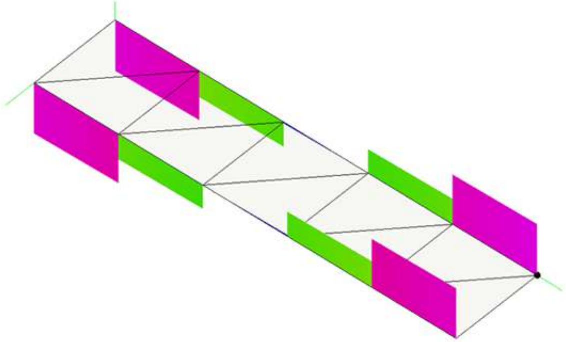
Load on Primary Beam



Shear Reaction of Primary Beam



$v_{(max)}$ of Primary Beam



Shear Reaction of Primary Beam

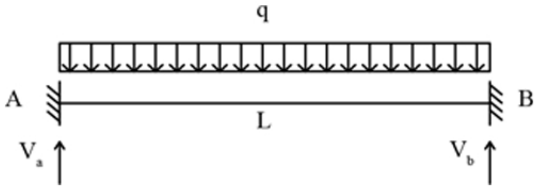
BRIDGE OF JUJU

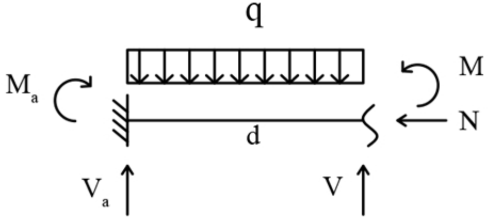
Calculation

Secondary Beam

Total load applied on secondary beams=Hollow aluminum bracket+Tempered glass panel+Jujube wood decking+Human load+Snow load

$M_{tot} = M_a + M_p + M_d + M_h + M_{sv} = 1.4kN + 23.25kN + 27.6kN + 320kN + 22.8kN = 395kN$





$q = W_{tot} /(W \times n) = 395kN / (3m \times 5) = 26.3kN/m$

$V_a = V_b = q \times L / 2 = 39.5kN$

$M_a - qd^2/2 + M = 0$

$M_{max} = qL^2/8 - V_a L/2 = 29.7kN.m$

Selction of secondary beam: GLT beam below of 3 ½ and 13 ½ inches (0.09*0.34m)

$M_{lim} = 36.03kN.m$

Width (in.)	Depth (in.)	Weight (lbf/ft.)	Maximum Resistive Shear (lbf) 100%	115%	125%	Maximum Resistive Moment (ft.-lbf) 100%	115%	125%	EI (10^6 in.² - lb.)
3½	9	7.7	5,565	6,400	6,956	9,450	10,868	11,813	383
	10½	8.9	6,493	7,466	8,116	12,863	14,792	16,078	608
	12	10.2	7,420	8,533	9,275	16,800	19,320	21,000	907
	13½	11.5	8,348	9,600	10,434	21,263	24,452	26,578	1,292

$V_{lim} = 46.4kN$

$E = 1.24 \times 10^4$ Mpa

$I_X = bh^3/12 = 2.9 \times 10^{-4}\ m^4$

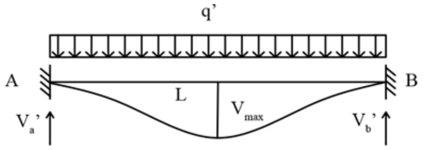
$W_{sb} = 11.5$ lbf/ft x 9,84ft = 113.16lbf = 0.50kN $\quad q' = q + W_{sb} / 3m = 26.5kN/m$

$V_a' = q'L/2 = 39.75kN < V_{lim} \quad M'_{max} = q'L^2/8 - V_a'L/2 = 29.8\ kN.m < M_{lim}$

Vertical displacement: $d^2v(x)/dx^2 = - M(x) / EI_X \quad dv(x)/dx=(1/6q'x^3 - 1/2V_a'x^2)/EI_X+c1$

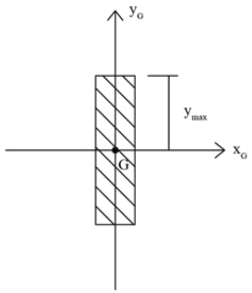
$v(x)=(1/24q'x^4 - 1/6V_a'x^3)/EIx + c1x + c2$ From boundary conditions: c1=c2=0(fixed ending)

EI= $(1.23 \times 10^{10}) \times 0.09 \times 0.34^3 / 12= 3660kN.m^2$



$V_{lim} = L/400 = 3m/400 = 0.0075m$

$V(x)max=V(L/2) =q'L^4/384EIx =0.0015m < V_{lim}$



Considering these secondary beams are fixed ending, we have:

$L_0= L/2,\ F_{cr}= 4\pi EI_X/L^2$

$N_{cr}= \min(N_{cr}(x,z),N_{cr}(y,z)) = \min(4\pi EI_{yy}/L^2, 4\pi\ EI_{xx}/L^2)$

$H = 0.34m,\ b = 0.09m$, so $I_{xx}<I_{yy}$,

Thus $N_{cr}= 4\pi EI_{yy}/L^2= 400kN \quad \sigma_{z\,max}=M_x \times y_{max}/I_{max} =17.1MPa$

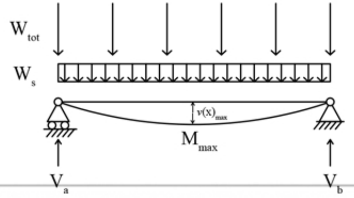
from the list, fyd=20.7MPa > $\sigma_{z\,max}$

Main Beam

Truss: $W_{truss} = 3kN \times (4.5/2) \times (5/6) = 3.75kN$

$W_{tot} = q' \times L_{sb} \times n + W_{truss} = 426.85kN$

E mainbeam = 1241060000n/m2



8-3/4-INCH WIDTH

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Shear Capacity (lb)	37100	39420	41740	44060	46380	48690	51010	53330	55650	57970	60290	62610	64930	67240	69560

We got the maximum of displacement in nolian that 0.035m

$V_a = V_b = q_2 \times L / 2 = 100kN$

$M_{max} = qL^2/8 - V_a L/2 = 250kN.m$

Maximum vertical displacement $v(x)_{max}$=16m/400 = 4cm >3.5cm

which is lower than the the displacement of material we used.

Thus it works