

# DESIGN OF 80.0 M SPAN THROUGH TYPE TRUSS

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## Design of truss superstructure span (centre to centre of expansion): 81.5m

### 1.0 Introduction

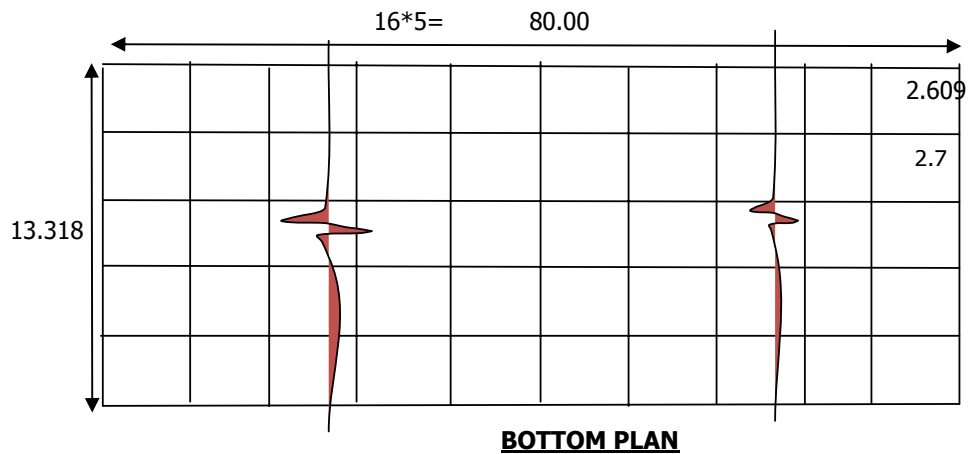
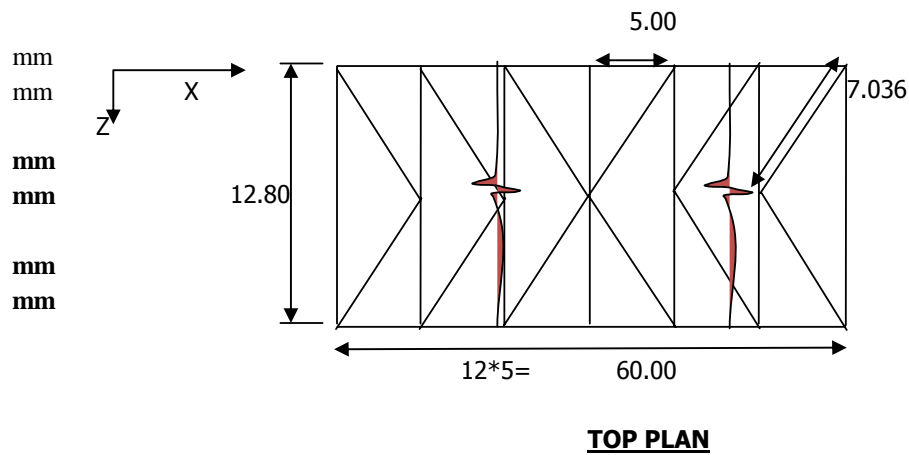
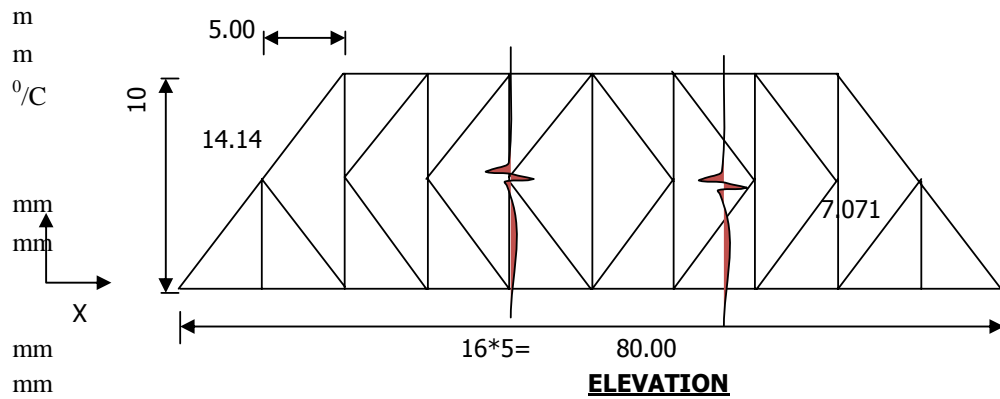
This design note consists of 80.0m (Brg/Brg) K-type through trussed bridge. The Various Code used in Design are listed Below

- |               |                |
|---------------|----------------|
| 1. IRC:6-2016 | 2. IRC:24-2010 |
| 3. IS:4000    |                |

### 1.1 Basic Design Data:

Statical scheme		
Main Girders	:	Simply supported K type trusses (2 sets) with concrete deck at the bottom acting compositely with the main longitudinals.
Cross Beams	:	at locations of the joint of verticals with the top & bottom chord
Top chord bracings	:	At every panel, as crossed braces.
Bottom chord bracing :		No bracing as the composite deck will serve the purpose
Overall Span of Main girders	:	81.5 m
Effective span	:	80 m
Carriageway width	:	11.5m
Crash barrier width	:	0.5 m
Clear width of structure m(span of cross girders)	:	12.5
Wearing coarse thickness	:	65 mm to be provided
Cross fall on roadway	:	2.5 % in one directions
Minimum depth of slab	:	2250mm
Live load	:	3lane classA, 1L class A+70R, Special Vechile
Density of concrete	:	2.4 t/m <sup>3</sup>
Density of wearing coarse	:	2.2 t/m <sup>3</sup>
Density of Structural Steel	:	7.85 t/m <sup>3</sup>
Grade of Concrete	:	M 35
Grade of Structural Steel	:	Fe 250
Yeild Stress of Steel	:	250 MPa
Modulus of Elasticity of Steel	:	2.1E+05 MPa
Modulus of Elasticity of Conc.	:	5000*sqrt(35) (as per IRC:21-2000 cl.303.1)
	:	29580 MPa
Moduar ratio for permanent loadings( $m_p$ ):		14.27
Moduar ratio for transient loadings( $m_t$ ):		7.13

## 1.2 Truss Configuration:



**Truss Configuration:**

No. of lane	=	3 Lane	
Effective Span	=	80.00	m
Height at midspan	=	10.00	m
Height at the end	=	10.00	m
No of panels	=	16	
Spacing of truss	=	12.80	m (c/c of Bottom Chord)
Type of structure	=	Through Truss	
Type of bearing	=	POT-PTFE	
Type of truss	=	K- Type	
Panel length	=	5	m
Stringer spacing	=	2.6	m
Foothpath width	=	-	m
Length of Diagonal Members	=	7.071	m
Length of Top Bracings	=	7.036	m
Modulus of Elasticity of Steel (E)	=	21100000	t/m <sup>2</sup>

**1.3 Loads**

**FOR DEAD LOAD:**

Increment Factor for self wt (Due to Gusset Plates and Connections)	=	0.4	
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**FOR SIDL:**

1500 LONG ISMC 150 @ 1000c/c	=	16.4	kg/m
4 Nos 65NB (Medium) Pipe	=	6.42	kg/m

**FOR LIVE LOAD:**

Here structure is analysed with 3Lane class A, 1L class A+70R, Special vehicle whichever governs

A) Most eccentric from the center line of Carriage way

B) at center of the carriage way

**FOR SEISMIC LOAD: As Per IRC: 6-2016**

As per IRC :6-2016 seismic force calculation, no calculation of seismic force is required for structures in Zone -II & Zone -III, if the two conditions stated below are satisfied simultaneously.

- i) The span is less than 15 meter.
- ii) The total length of the bridge is less than 60 meter.

Zone	=	V	
Span Length	=	80.00	> 15
Total Length	=	80.00	> 60

**FOR WIND LOAD: As Per IRC: 6-2016**



## 2.0 LOAD CALCULATIONS:

### (A) DL 1: Selfweight of truss

This include the load of the steel truss consisting of the top and bottom chords, webs and verticals, top and bottom cross girders and bracings. The dead load is taken as 1.40 times the weight of truss. This is done to allow for the weight of the Lacings, Sway Bracings, connections etc.

### (B) DL 2: Selfweight of Deck Slab

The deck is proposed to be cast after erection of the trusses and all bracings in place.

The weight of the deck concrete thus will be carried by the two truss only.

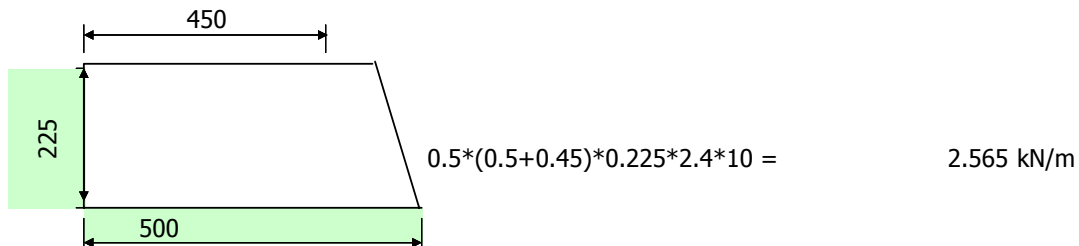
Running thickness of the deck: 200 mm

Additional depth of slab to maintain the cross slop 225mm  
load on each Stringer due to deck slab=  $2.2 \times 210.63 \times 2.4 \times 10 / 1000 =$  11.12 kN/m

### (C) SIDL: Super-imposed Dead Loads

Effective Width of Slab over each Stringer 2.2 m

#### a. Due to kerb



#### b. Due to Railing

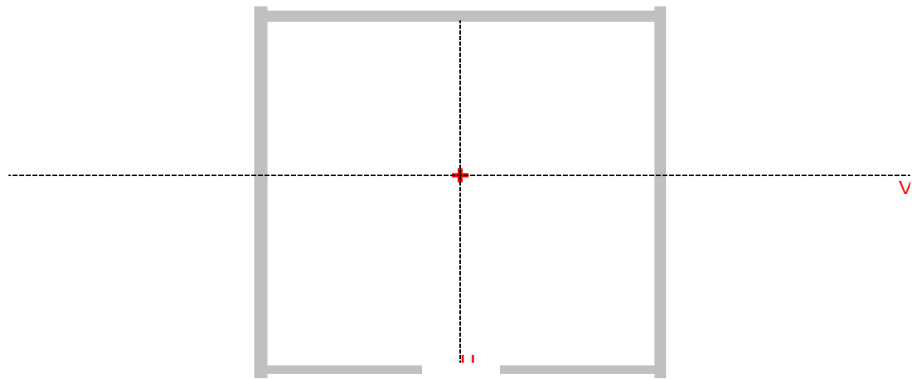
- |                                 |                                      |            |
|---------------------------------|--------------------------------------|------------|
| 1. 1500 LONG ISMC 150 @ 1000c/c | $1.5 \times 16.4 \times 10 / 1000 =$ | 0.246 kN/m |
| 2. 4 Nos 65NB (Medium) Pipe     | $4 \times 6.42 \times 10 / 1000 =$   | 0.257 kN/m |

### (D) LL: Live loads

Live Load is generated and applied in different placing condition within the STAAD analysis  
Here

- |  |                                  |
|--|----------------------------------|
| A) Most eccentric from the center line of Carriage way   | B) at center of the carriage way |
| Impact factor: (refer IRC:6-2014 cl.211.2 and figure 5.) | 0.154                            |

## **SECTIONAL PROPERTIES FOR TRUSS**



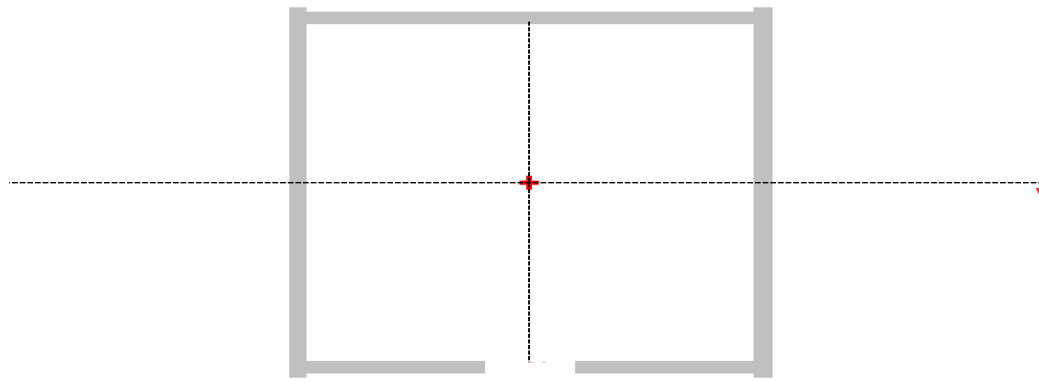
TOP CHORD R-1

Section element	Material	E (mton/mm^2)
Sheet 25 x 850	Steel	20.903
Sheet 25 x 850	Steel	20.903
Sheet 750 x 25	Steel	20.903
Sheet 300 x 20	Steel	20.903
Sheet 300 x 20	Steel	20.903

The overall dimensions of the section are 800 x 850 mm

Basic geometry of the section

	Parameter	Value	mm4
A	Cross sectional area	73250	mm4
$\alpha$	Angle between Y-Z and U-V axes	-90	deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	7467590957	mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	7960260417	mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	13502529.73	mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	319.29	mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	329.66	mm
$W_{u+}$	Max elastic modulus about U-axis	19900651.04	mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	19900651.04	mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	16174789.04	mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	19230552.18	mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	127611.03	mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	30018973.29	mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	7960260417	mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	7467590957	mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	329.66	mm
$i_v$	Radius of gyration about V-axis	319.29	mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	220.82	mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	262.53	mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	271.68	mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	271.68	mm
$y_M$	Distance to centroid along Y-axis	400	mm
$z_M$	Distance to centroid along Z-axis	461.68	mm
$y_P$	Distance to equal area axis along Y-axis	1083.4	mm
$z_P$	Distance to equal area axis along Z-axis	1703.32	mm



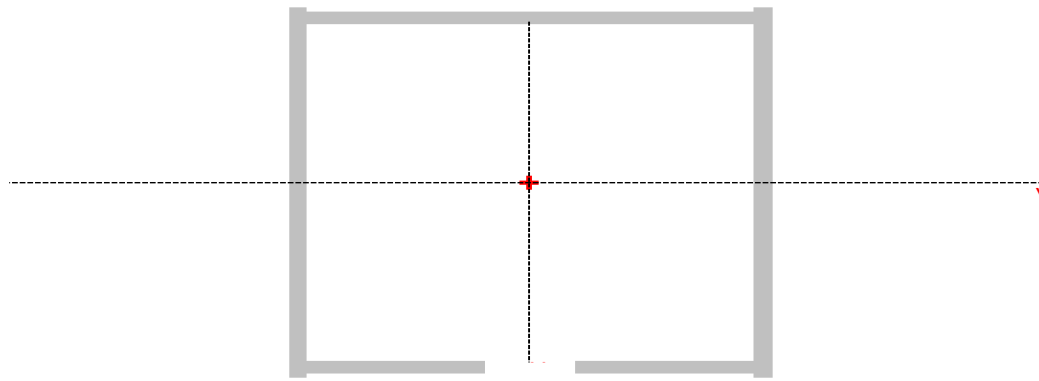
TOP CHORD R-2

Section element	Material	E (mton/mm <sup>2</sup> )
Sheet 30 x 850	Steel	20.903
Sheet 30 x 850	Steel	20.903
Sheet 750 x 30	Steel	20.903
Sheet 300 x 30	Steel	20.903
Sheet 300 x 30	Steel	20.903

The overall dimensions of the section are 810 x 850 mm

#### Basic geometry of the section

	Parameter	Value	mm <sup>4</sup>
A	Cross sectional area	91500	mm <sup>4</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90	deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	9518252664	mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	9861862500	mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	25798686.36	mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	322.53	mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	328.3	mm
$W_{u+}$	Max elastic modulus about U-axis	24350277.78	mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	24350277.78	mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	21405102.76	mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	23482847.83	mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	46470869.7	mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	37989696.05	mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	9861862500	mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	9518252664	mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	328.3	mm
$i_v$	Radius of gyration about V-axis	322.53	mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	233.94	mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	256.64	mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	266.12	mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	266.12	mm
$y_M$	Distance to centroid along Y-axis	405	mm
$z_M$	Distance to centroid along Z-axis	444.67	mm
$y_P$	Distance to equal area axis along Y-axis	1088.4	mm
$z_P$	Distance to equal area axis along Z-axis	-1778.93	mm



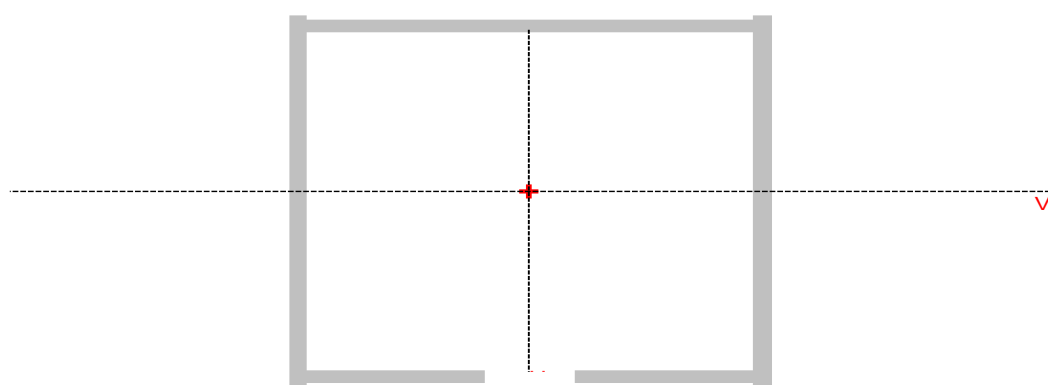
TOP CHORD R-3

Section element	Material	E (mton/mm <sup>2</sup> )
Sheet 36 x 850	Steel	20.903
Sheet 36 x 850	Steel	20.903
Sheet 750 x 32	Steel	20.903
Sheet 300 x 32	Steel	20.903
Sheet 300 x 32	Steel	20.903

The overall dimensions of the section are 822 x 850 mm

#### Basic geometry of the section

	Parameter	Value	mm <sup>4</sup>
A	Cross sectional area	104400	mm <sup>4</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90	deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	10530785586	mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	11699888400	mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	38663392.97	mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	317.6	mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	334.77	mm
$W_{u+}$	Max elastic modulus about U-axis	28466881.75	mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	28466881.75	mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	23753035.86	mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	25896106.33	mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	54926116.48	mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	41270301.92	mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	11699888400	mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	10530785586	mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	334.77	mm
$i_v$	Radius of gyration about V-axis	317.6	mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	227.52	mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	248.05	mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	272.67	mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	272.67	mm
$y_M$	Distance to centroid along Y-axis	411	mm
$z_M$	Distance to centroid along Z-axis	443.34	mm
$y_P$	Distance to equal area axis along Y-axis	1094.4	mm
$z_P$	Distance to equal area axis along Z-axis	-1780.26	mm



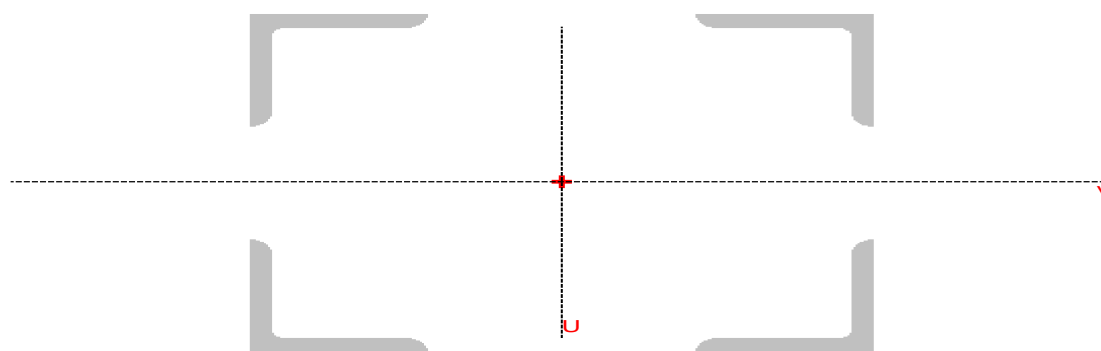
BOTTOM CHORD R-4

Section element	Material	E (mton/mm <sup>2</sup> )
Sheet 32 x 850	Steel	20.903
Sheet 32 x 850	Steel	20.903
Sheet 750 x 30	Steel	20.903
Sheet 300 x 32	Steel	20.903
Sheet 300 x 32	Steel	20.903

The overall dimensions of the section are 818 x 850 mm

#### Basic geometry of the section

	Parameter	Value	mm <sup>4</sup>
A	Cross sectional area	96100	mm <sup>4</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90	deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	9899300362	mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	10577355233	mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	29915844.43	mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	320.95	mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	331.76	mm
$W_{u+}$	Max elastic modulus about U-axis	25861504.24	mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	25861504.24	mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	22565009.89	mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	24068400	mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	51397919.68	mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	38841075.23	mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	10577355233	mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	9899300362	mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	331.76	mm
$i_v$	Radius of gyration about V-axis	320.95	mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	234.81	mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	250.45	mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	269.11	mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	269.11	mm
$y_M$	Distance to centroid along Y-axis	411	mm
$z_M$	Distance to centroid along Z-axis	438.7	mm
$y_P$	Distance to equal area axis along Y-axis	1094.4	mm
$z_P$	Distance to equal area axis along Z-axis	-1784.9	mm



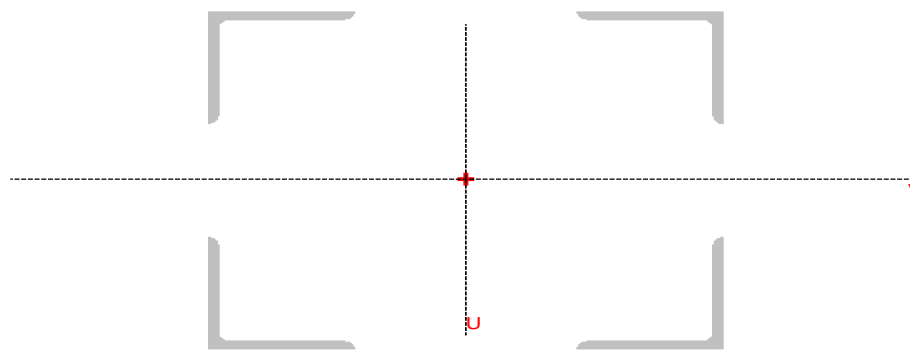
DIAGONAL R-7

Section element	Material	E (mton/mm <sup>2</sup> )
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903

The overall dimensions of the section are 700 x 600 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	37520 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	2358310802 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	3366783312 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	8078056.96 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	250.71 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	299.55 mm
$W_{u+}$	Max elastic modulus about U-axis	9619380.85 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	9619380.85 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	7861035.95 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	7861035.99 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	439831.91 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	17755653.47 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	3366783312 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	2358310802 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	299.55 mm
$i_v$	Radius of gyration about V-axis	250.71 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	209.52 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	209.52 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	256.38 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	256.38 mm
$y_M$	Distance to centroid along Y-axis	350 mm
$z_M$	Distance to centroid along Z-axis	300 mm
$y_P$	Distance to equal area axis along Y-axis	912.8 mm
$z_P$	Distance to equal area axis along Z-axis	1402.2 mm



DIAGONAL R-8,R-9

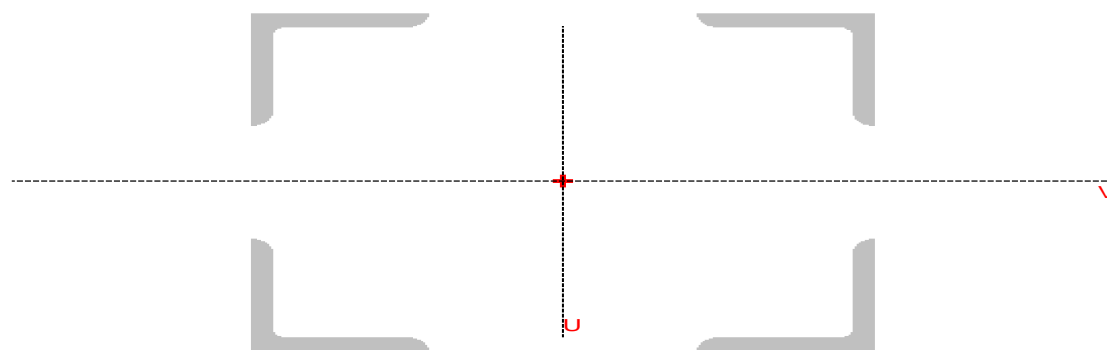
Section element	Material	E (mton/mm <sup>2</sup> )
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903

The overall dimensions of the section are 700 x 600 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	23120 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	1485661662 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	2112412892 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	1822903.78 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	253.49 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	302.27 mm
$W_{u+}$	Max elastic modulus about U-axis	6035465.38 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	6035465.38 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	4952205.5 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	4952205.53 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	119981.99 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	11214963.2 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	2112412892 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	1485661662 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	302.27 mm
$i_v$	Radius of gyration about V-axis	253.49 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	214.2 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	214.2 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	261.05 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	261.05 mm
$y_M$	Distance to centroid along Y-axis	350 mm
$z_M$	Distance to centroid along Z-axis	300 mm
$y_P$	Distance to equal area axis along Y-axis	912.8 mm
$z_P$	Distance to equal area axis along Z-axis	1400.7 mm





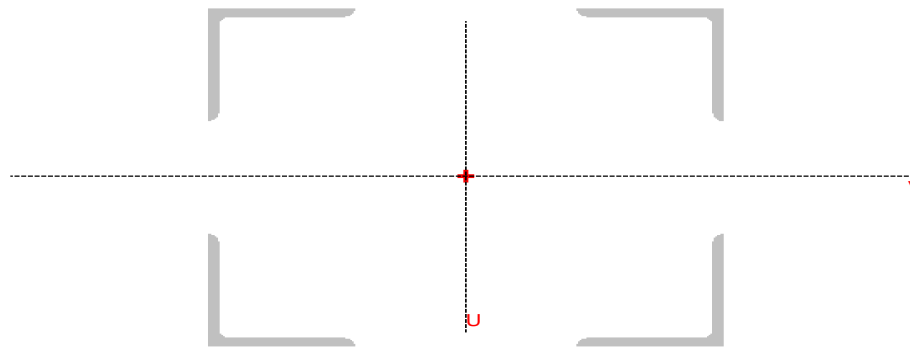
VERTICAL R-10

Section element	Material	E (mton/mm <sup>2</sup> )
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903
Equal Angles ISA200X200X25	Steel	20.903

The overall dimensions of the section are 700 x 600 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	37520 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	2358310802 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	3366783312 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	8078056.96 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	250.71 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	299.55 mm
$W_{u+}$	Max elastic modulus about U-axis	9619380.85 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	9619380.85 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	7861035.95 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	7861035.99 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	439831.91 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	17755653.47 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	3366783312 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	2358310802 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	299.55 mm
$i_v$	Radius of gyration about V-axis	250.71 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	209.52 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	209.52 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	256.38 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	256.38 mm
$y_M$	Distance to centroid along Y-axis	350 mm
$z_M$	Distance to centroid along Z-axis	300 mm
$y_P$	Distance to equal area axis along Y-axis	912.8 mm
$z_P$	Distance to equal area axis along Z-axis	1402.2 mm



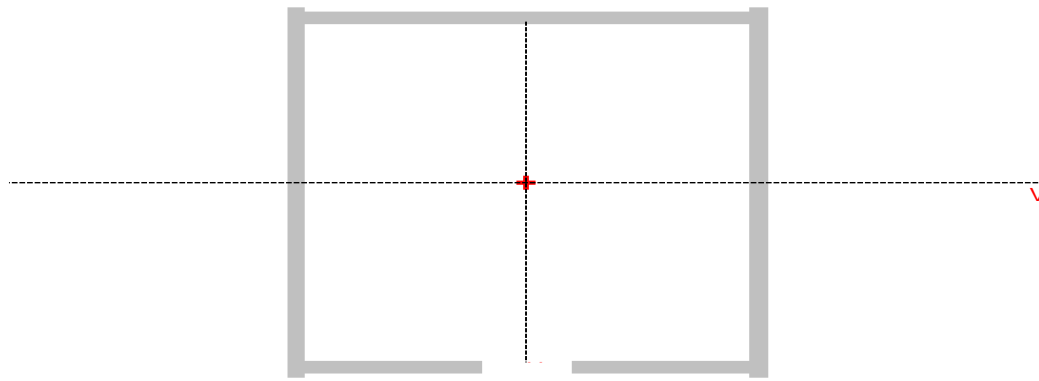
VERTICAL R-11,R-12,R-13

Section element	Material	E (mton/mm <sup>2</sup> )
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903
Equal Angles ISA200X200X15	Steel	20.903

The overall dimensions of the section are 700 x 600 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	23120 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	1485661662 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	2112412892 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	1822903.78 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	253.49 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	302.27 mm
$W_{u+}$	Max elastic modulus about U-axis	6035465.38 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	6035465.38 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	4952205.5 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	4952205.53 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	119981.99 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	11214963.2 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	2112412892 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	1485661662 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	302.27 mm
$i_v$	Radius of gyration about V-axis	253.49 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	214.2 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	214.2 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	261.05 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	261.05 mm
$y_M$	Distance to centroid along Y-axis	350 mm
$z_M$	Distance to centroid along Z-axis	300 mm
$y_P$	Distance to equal area axis along Y-axis	912.8 mm
$z_P$	Distance to equal area axis along Z-axis	1400.7 mm



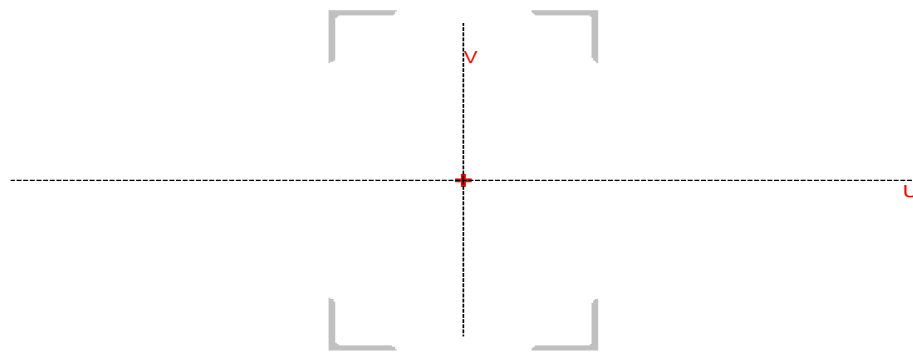
END RACKER R-14

Section element	Material	E (mton/mm <sup>2</sup> )
Sheet 30 x 850	Steel	20.903
Sheet 30 x 850	Steel	20.903
Sheet 750 x 25	Steel	20.903
Sheet 300 x 20	Steel	20.903
Sheet 300 x 20	Steel	20.903

The overall dimensions of the section are 810 x 850 mm

#### Basic geometry of the section

	Parameter	Value	mm4
A	Cross sectional area	81750	mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-90	deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	7989609303	mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	9337331250	mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	19559288.45	mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	312.62	mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	337.96	mm
$W_{u+}$	Max elastic modulus about U-axis	23055138.89	mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	23055138.89	mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	17449630.1	mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	20374742.1	mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	44009699.8	mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	30867643.03	mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	9337331250	mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	7989609303	mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	337.96	mm
$i_v$	Radius of gyration about V-axis	312.62	mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	213.45	mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	249.23	mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	282.02	mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	282.02	mm
$y_M$	Distance to centroid along Y-axis	405	mm
$z_M$	Distance to centroid along Z-axis	457.87	mm
$y_P$	Distance to equal area axis along Y-axis	1088.4	mm
$z_P$	Distance to equal area axis along Z-axis	-1765.73	mm



INT AND TOP LATERAL R-15,R-16

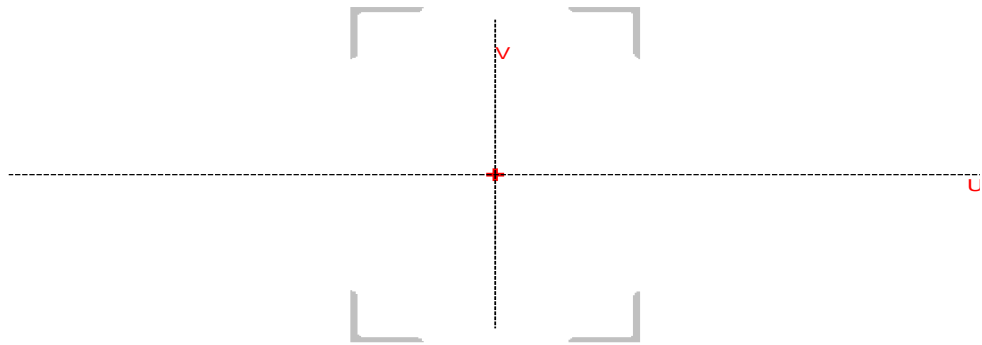
Section element	Material	E (mton/mm^2)
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903

The overall dimensions of the section are 400 x 650 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	7612 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	680278414.7 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	233156299.9 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	266482.15 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	298.95 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	175.01 mm
$W_{u+}$	Max elastic modulus about U-axis	2093164.35 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	2093164.35 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	1165781.5 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	1165781.5 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	2209023.18 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	1316055.54 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	680278414.7 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	233156299.9 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	298.95 mm
$i_v$	Radius of gyration about V-axis	175.01 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	153.15 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	153.15 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	274.98 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	274.98 mm
$y_M$	Distance to centroid along Y-axis	200 mm
$z_M$	Distance to centroid along Z-axis	325 mm
$y_P$	Distance to equal area axis along Y-axis	399.2 mm
$z_P$	Distance to equal area axis along Z-axis	1567.8 mm

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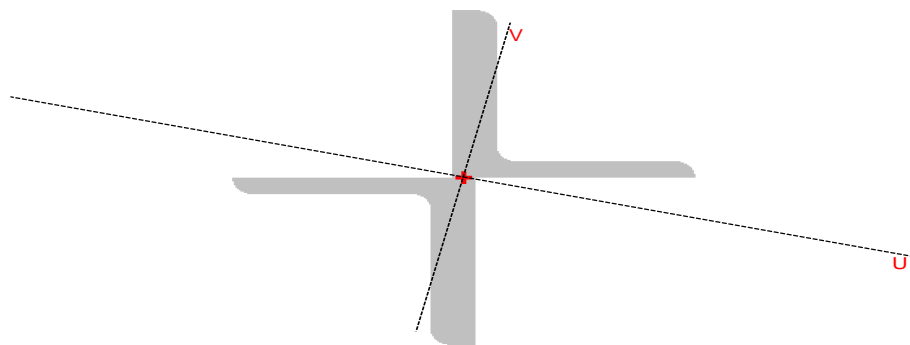
TOP BRACIN R-17

Section element	Material	E (mton/mm^2)
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903

The overall dimensions of the section are 400 x 650 mm

Basic geometry of the section

Parameter		Value
A	Cross sectional area	7612 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	680278414.7 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	233156299.9 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	266482.15 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	298.95 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	175.01 mm
$W_{u+}$	Max elastic modulus about U-axis	2093164.35 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	2093164.35 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	1165781.5 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	1165781.5 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	2209023.18 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	1316055.54 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	680278414.7 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	233156299.9 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	298.95 mm
$i_v$	Radius of gyration about V-axis	175.01 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	153.15 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	153.15 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	274.98 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	274.98 mm
$y_M$	Distance to centroid along Y-axis	200 mm
$z_M$	Distance to centroid along Z-axis	325 mm
$y_P$	Distance to equal area axis along Y-axis	399.2 mm
$z_P$	Distance to equal area axis along Z-axis	1567.8 mm



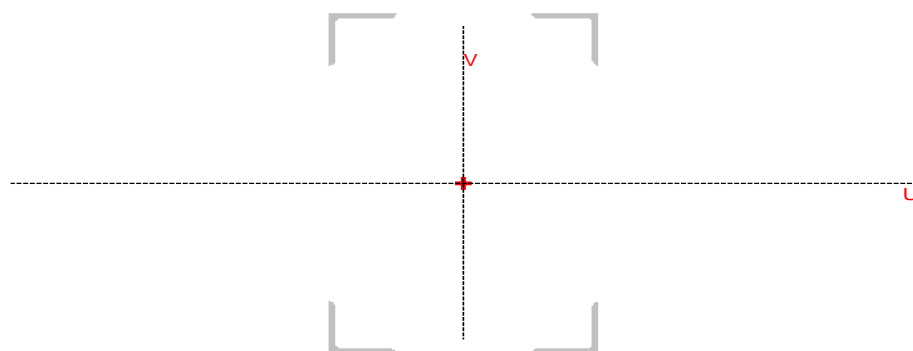
BOTTOM BRACING R-18

Section element	Material	E (mton/mm^2)
Equal Angles ISA150X150X15	Steel	20.903
Sheet 16 x 300	Steel	20.903
Equal Angles ISA150X150X15	Steel	20.903

The overall dimensions of the section are 316 x 300 mm

Basic geometry of the section

Parameter		Value
A	Cross sectional area	13356 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	-13.05 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	67740937.58 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	38049341.49 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	1055790.49 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	71.22 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	53.37 mm
$W_{u+}$	Max elastic modulus about U-axis	469311.53 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	469311.53 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	236251.32 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	236251.32 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	787096.15 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	456452.99 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	69426525.5 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	36363753.58 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	72.1 mm
$i_v$	Radius of gyration about V-axis	52.18 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	17.69 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	17.69 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	35.14 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	35.14 mm
$y_M$	Distance to centroid along Y-axis	8 mm
$z_M$	Distance to centroid along Z-axis	0 mm
$y_P$	Distance to equal area axis along Y-axis	6.35 mm
$z_P$	Distance to equal area axis along Z-axis	-4.85 mm



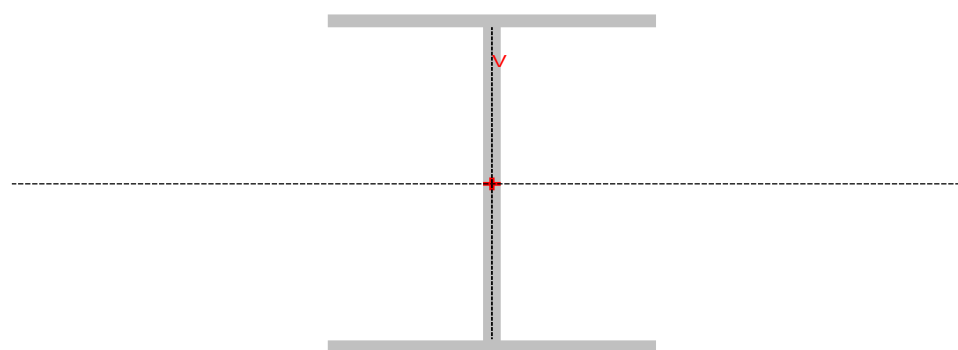
HORZ MEMBER R-19

Section element	Material	E (mton/mm^2)
Equal Angles ISA100X100X12	Steel	20.903
Equal Angles ISA100X100X12	Steel	20.903
Equal Angles ISA100X100X12	Steel	20.903
Equal Angles ISA100X100X12	Steel	20.903

The overall dimensions of the section are 400 x 650 mm

Basic geometry of the section

Parameter		Value
A	Cross sectional area	9036 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	804852882.6 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	275114992.2 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	452514.81 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	298.45 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	174.49 mm
$W_{u+}$	Max elastic modulus about U-axis	2476470.41 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	2476470.41 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	1375574.96 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	1375574.96 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	2624795.36 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	1554159.03 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	804852882.6 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	275114992.2 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	298.45 mm
$i_v$	Radius of gyration about V-axis	174.49 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	152.23 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	152.23 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	274.07 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	274.07 mm
$y_M$	Distance to centroid along Y-axis	200 mm
$z_M$	Distance to centroid along Z-axis	325 mm
$y_P$	Distance to equal area axis along Y-axis	399.2 mm
$z_P$	Distance to equal area axis along Z-axis	1567.8 mm



END AND INT GIRDER R-20 R-19

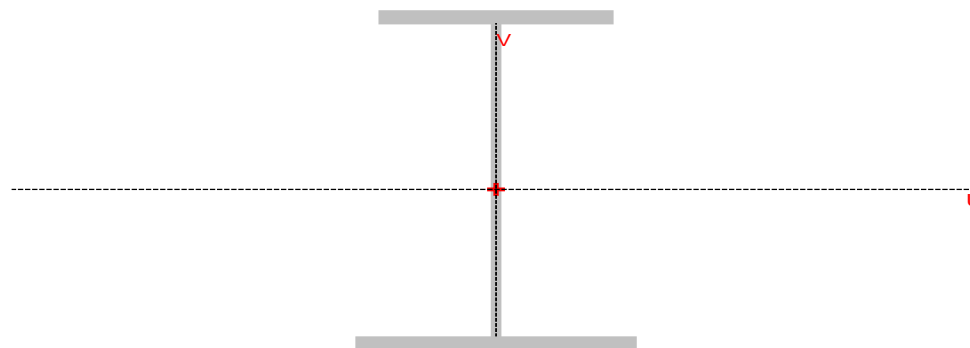
Section element	Material	E (mton/mm <sup>2</sup> )
Sheet 600 x 32	Steel	20.903
Sheet 32 x 786	Steel	20.903
Sheet 600 x 32	Steel	20.903

The overall dimensions of the section are 600 x 850 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	63552 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	7721767616 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	1154146304 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	20383706.52 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	348.57 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	134.76 mm
$W_{u+}$	Max elastic modulus about U-axis	18168864.98 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	18168864.98 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	3847154.35 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	3847154.35 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	20692514.64 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	5970190.4 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	7721767616 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	1154146304 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	348.57 mm
$i_v$	Radius of gyration about V-axis	134.76 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	60.54 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	60.54 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	285.89 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	285.89 mm
$y_M$	Distance to centroid along Y-axis	300 mm
$z_M$	Distance to centroid along Z-axis	425 mm
$y_P$	Distance to equal area axis along Y-axis	300.1 mm
$z_P$	Distance to equal area axis along Z-axis	426.8 mm





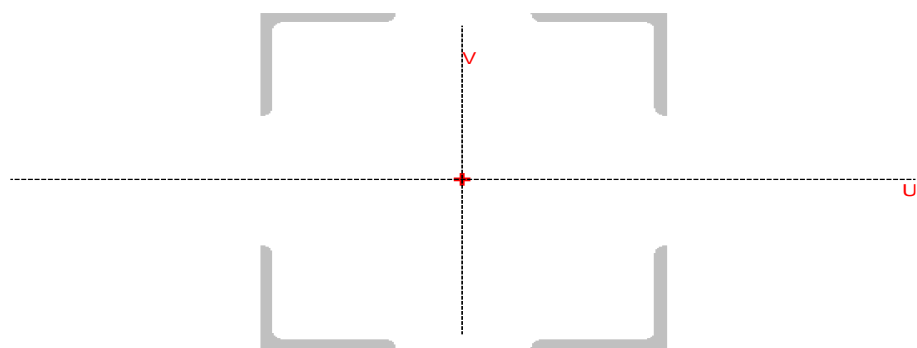
STRINGER R-21

Section element	Material	E (mton/mm^2)
Sheet 300 x 20	Steel	20.903
Sheet 12 x 460	Steel	20.903
Sheet 250 x 20	Steel	20.903

The overall dimensions of the section are 300 x 500 mm

#### Basic geometry of the section

	Parameter	Value
A	Cross sectional area	16568 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	730724843.1 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	71108482.67 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	1628968.67 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	210.01 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	65.51 mm
$W_{u+}$	Max elastic modulus about U-axis	2769852.64 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	3093848.31 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	474056.55 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	474056.55 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	3241917 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	779060 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	730724843.1 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	71108482.67 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	210.01 mm
$i_v$	Radius of gyration about V-axis	65.51 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	28.61 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	28.61 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	167.18 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	186.74 mm
$y_M$	Distance to centroid along Y-axis	150 mm
$z_M$	Distance to centroid along Z-axis	236.19 mm
$y_P$	Distance to equal area axis along Y-axis	150 mm
$z_P$	Distance to equal area axis along Z-axis	206.56 mm



KNEE BRACING R-22

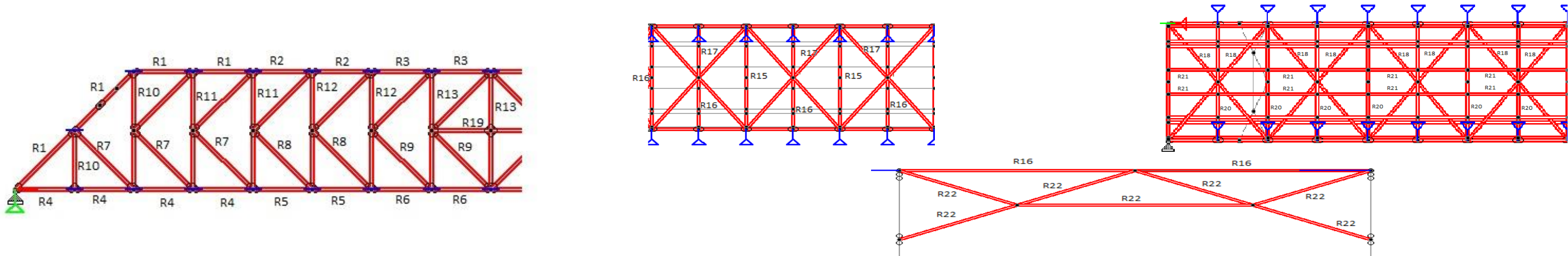
Section element	Material	E (mton/mm^2)
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903
Equal Angles ISA100X100X10	Steel	20.903

The overall dimensions of the section are 600 x 650 mm

Basic geometry of the section

Parameter		Value
A	Cross sectional area	27524 mm <sup>2</sup>
$\alpha$	Angle between Y-Z and U-V axes	0 deg
$I_y$	Moment of inertia about axis parallel to Y passing through centroid	2111498882 mm <sup>4</sup>
$I_z$	Moment of inertia about axis parallel to Z passing through centroid	1756614076 mm <sup>4</sup>
$I_t$	Torsional moment of inertia (St. Venant)	3103433.98 mm <sup>4</sup>
$i_y$	Radius of gyration about axis parallel to Y passing through centroid	276.97 mm
$i_z$	Radius of gyration about axis parallel to Z passing through centroid	252.63 mm
$W_{u+}$	Max elastic modulus about U-axis	6496919.64 mm <sup>3</sup>
$W_{u-}$	Min elastic modulus about U-axis	6496919.64 mm <sup>3</sup>
$W_{v+}$	Max elastic modulus about V-axis	5855380.25 mm <sup>3</sup>
$W_{v-}$	Min elastic modulus about V-axis	5855380.25 mm <sup>3</sup>
$W_{pl,u}$	Plastic modulus about U-axis	7353274.03 mm <sup>3</sup>
$W_{pl,v}$	Plastic modulus about V-axis	6759350.81 mm <sup>3</sup>
$I_u$	Moment of inertia about U-axis	2111498882 mm <sup>4</sup>
$I_v$	Moment of inertia about V-axis	1756614076 mm <sup>4</sup>
$i_u$	Radius of gyration about U-axis	276.97 mm
$i_v$	Radius of gyration about V-axis	252.63 mm
$a_{u+}$	Centroid to edge of compression zone along +ve U-axis	212.74 mm
$a_{u-}$	Centroid to edge of compression zone along -ve U-axis	212.74 mm
$a_{v+}$	Centroid to edge of compression zone along +ve V-axis	236.05 mm
$a_{v-}$	Centroid to edge of compression zone along -ve V-axis	236.05 mm
$y_M$	Distance to centroid along Y-axis	300 mm
$z_M$	Distance to centroid along Z-axis	325 mm
$y_P$	Distance to equal area axis along Y-axis	1025.4 mm
$z_P$	Distance to equal area axis along Z-axis	1760.5 mm

# **Truss Force Summary (80m Brg-Brg)**

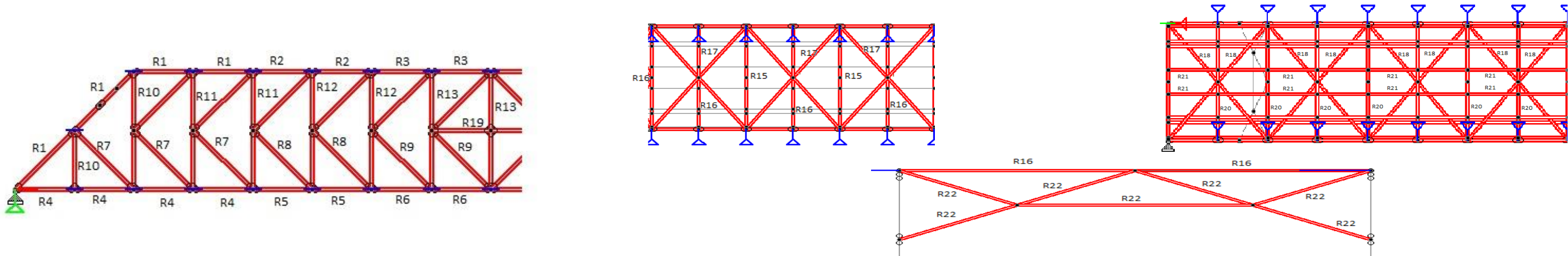


Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS																	
	a) Basic comb.		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00						
	b) Accidental comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	c) Seismic comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	SLS												Member	70R	Class A & SPEC.	Member	70R	Class A & SPEC.
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60		Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50		X beam	1.50	1.50	X beam	1.34	1.34

Fx

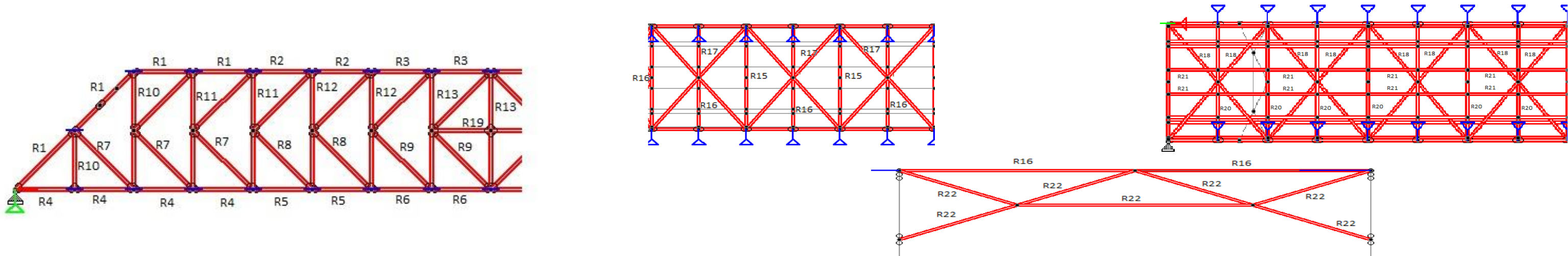
R1	TOP CHORD (U2-U4)	Max	3551.9	1924.8	628.2	531.7	3903.5	1663.0	2119.8	3.0	9.5	226.8	15958.0	10010.8	9560.1	11138.0	10010.7	6642.7
		Min	2323.4	1260.7	411.5	345.2	1260.7	0.0	0.0	-3.0	-9.5	-226.8	8185.4	5420.6	5675.0	5778.1	5420.6	4334.5
R2	TOP CHORD (U4-U6)	Max	4556.8	2498.5	815.4	680.3	4684.6	1942.2	2724.4	0.3	9.4	10.2	19960.7	12598.9	11894.7	13947.9	12597.2	8555.8
		Min	3981.5	2169.2	708.0	593.0	1260.7	-0.1	-0.1	-0.3	-9.4	-10.2	12507.8	8531.5	10318.2	8891.7	8533.2	7446.8
R3	TOP CHORD(U6-U8)	Max	5205.7	2862.0	934.1	779.5	5116.1	2062.6	3114.9	0.5	9.4	24.4	22413.8	14201.5	13624.4	15674.7	14199.9	9786.2
		Min	4964.6	2719.3	887.5	742.4	1260.7	0.0	0.0	-0.5	-9.4	-24.4	15093.3	10393.6	12882.6	10753.7	10395.2	9308.9
R4	BOTTOM CHORD (L0-L4)	Max	-1493.6	-798.1	-798.1	-221.2	-801.0	0.2	0.2	35.2	125.1	1064.1	-4611.1	-3210.9	-3068.0	-3150.7	-3214.8	-3231.0
		Min	-2411.0	-1310.0	-1310.0	-358.0	-2502.9	-1070.9	-1451.5	-35.2	-125.1	-1064.1	-9824.3	-6412.7	-9520.3	-6780.8	-6408.8	-5469.1
R5	BOTTOM CHORD(L4-L6)	Max	-2803.6	-1530.1	-499.4	-417.2	-807.0	0.2	0.2	22.7	125.1	748.8	-7128.3	-5150.1	-6039.3	-5102.3	-5161.5	-5176.4
		Min	-3376.7	-1849.9	-603.7	-504.1	-3390.2	-1397.4	-2059.3	-22.7	-125.1	-748.8	-11362.7	-7639.8	-10041.4	-8089.3	-7628.4	-6408.3
R6	BOTTOM CHORD (L6-L8)	Max	-3596.9	-1974.5	-644.4	-538.1	-1973.6	0.1	0.1	17.4	125.1	586.9	-9224.2	-6653.8	-8370.2	-6611.3	-6668.4	-6682.7
		Min	-3843.2	-2114.2	-690.0	-576.0	-3699.1	-1476.3	-3945.2	-17.4	-125.1	-586.9	-12725.4	-8596.7	-11032.9	-9063.6	-8582.2	-7294.6
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Max	1313.6	728.9	237.9	194.8	1495.4	649.8	884.2	1.8	2.7	121.1	6021.7	3767.2	3621.1	4199.5	3767.8	2477.5
		Min	-1313.6	-728.9	-237.9	-194.8	-1495.4	-649.8	-884.2	-1.8	-2.7	-121.1	-4563.1	-3037.9	-3621.1	-3227.1	-3038.4	-2477.5
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Max	817.9	453.4	237.9	123.4	1021.6	472.5	691.0	1.8	2.5	117.7	4066.7	2515.8	2478.2	2811.8	2516.3	1634.7
		Min	-817.9	-453.4	-148.0	-123.4	-1021.6	-472.5	-691.0	-1.8	-2.5	-117.7	-2962.2	-1952.3	-2320.9	-2090.4	-1952.9	-1544.9
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Max	342.5	192.8	62.9	52.5	586.9	319.9	508.3	1.7	14.3	115.3	1933.0	1168.5	1091.1	1341.7	1166.6	658.8
		Min	-342.5	-192.8	-62.9	-52.5	-586.9	-319.9	-508.3	-1.7	-14.3	-115.3	-1472.5	-938.2	-1091.1	-1034.8	-936.4	-658.8
R10	Vertical(L1-M1,L2-U2)	Max	-207.0	-152.7	806.0	-48.5	-132.8	16.7	829.2	1.8	14.3	146.5	2306.6	423.4	1093.2	432.9	421.6	405.7
		Min	-2309.2	-1284.2	-419.1	-351.6	-2578.5	-1089.3	-1403.8	-1.8	-14.3	-146.5	-7955.3	-5315.1	-6293.3	-5632.9	-5313.3	-4372.2
R11	Vertical( L3-U3,L4-U4)	Max	655.5	316.0	103.1	87.1	788.2	381.2	534.4	1.2	2.3	85.8	2973.3	1843.4	1740.6	2071.7	1843.6	1163.5
		Min	-892.7	-515.5	-168.2	-137.8	-1057.5	-459.5	-625.3	-1.2	-2.3	-85.8	-3178.3	-2112.4	-2512.5	-2246.2	-2112.6	-1715.9
R12	Vertical( L5-U5,L6-U6)	Max	322.2	139.2	45.4	38.0	470.5	267.8	413.1	1.2	2.3	84.0	1569.5	952.5	882.1	1089.5	952.8	546.6
		Min	-528.1	-320.7	-104.7	-87.2	-722.5	-334.2	-488.6	-1.2	-2.3	-84.0	-2027.5	-1330.8	-1575.3	-1428.6	-1331.1	-1042.5
R13	Vertical(L7-U7,L8-U8)	Max	655.5	316.0	103.1	-11.6	190.2	181.9	492.3	1.2	16.2	81.1	2343.3	1240.0	1614.1	1299.1	1237.4	1071.6
		Min	-191.5	-136.4	-44.5	-37.2	-441.1	-278.0	-359.5	-1.2	-16.2	-81.1	-1068.3	-662.3	-708.6	-746.7	-659.8	-418.3
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	18.3	43.8	35.0	71.2	43.8	26.3	21.9
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-43.8	-18.3	-43.8	-35.0	-71.2	-43.8	-26.3	-21.9
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Max	0.0	0.0	0.0	0.0	0.0	5.3	2.3	0.3	43.8	18.3	53.4	39.6	71.2	50.2	31.0	22.1
		Min	0.0	0.0	0.0	0.0	0.0	-5.3	-2.3	-0.3	-43.8	-18.3	-44.3	-35.0	-71.2	-44.1	-26.5	-22.1
R17	Top Bracing	Max	98.9	54.3	17.7	5.0	14.8	65.3	66.1	0.6	14.7	9.1	374.1	244.0	272.9	266.3	241.4	183.5
		Min	66.7	37.1	12.1	3.4	10.1	-17.5	0.0	-0.6	-14.7	-9.1	167.8	116.2	137.5	115.6	118.8	111.6
R18	Bottom Bracing	Max	290.7	159.0	51.9	14.5	43.3	149.9	168.7	6.4	208.8	158.2	1226.9	812.3	1163.4	903.6	774.4	623.6
		Min	-513.2	-280.0	-91.4	-25.7	-76.8	-216.9	-276.2	-6.4	-208.8	-158.2	-1616.3	-1143.6	-1711.5	-1213.8	-1105.6	-1017.9
R19	Horz. centre member(M7-M8)	Max	984.8	26.5	8.6	2.4	7.2	45.2	168.7	0.1	208.8	1.8	1883.6	1228.4	1595.1	1283.2	1186.6	1126.7
		Min	0.0	26.5	8.6	2.4	7.2	-1.2	-276.2	-0.1	-208.8	-1.8	-142.5	-123.4	-157.5	-163.1	-81.6	-67.0
R20	X girders	Max	984.8	202.8	66.2	18.6	55.6	174.4	185.6	4.8	1904.8	113.2	3976.3	2946.6	3818.8	3382.6	2568.6	2227.1
		Min	-21.6	-11.8	-3.9	-1.1	-3.2	-12.2	-3.9	-4.8	-1904.8	-113.2	-1971.0	-1565.0	-2128.0	-1951.7	-1186.9	-993.2
R21	STRINGERS	Max	984.8	32.3	10.6	3.0	8.9	24.2	29.7	5.9	1904.8	179.7	3360.7	2575.5	3570.1	2969.3	2198.1	1986.1
		Min	-1054.1	-577.5	-188.5	-52.8	-157.6	-374.8	-540.7	-4.8	-1904.8	-179.7	-4787.6	-3532.6	-4778.1	-3963.7	-3154.6	-2827.6
R22	KNEE BRACING	Max	984.8	0.1	0.0	0.0	0.3	0.1	0.1	1.8	1904.8	18.5	3237.6	2509.0	3262.3	2891.8	2129.1	1938.2
		Min	-14.3	-0.1	0.0	0.0	-0.1	-0.1	-0.1	-1.8	-1904.8	-18.5	-1927.0	-1538.3	-1952.0	-1921.0	-1158.4	-967.7
R14	END RACKER	Max	3551.2	1924.4	628.1	177.4	3903.5	1663.0	2120.6	355.6	9.5	226.8	16007.0	9655.4	9080.3	11135.1	9866.8	6463.6
		Min	0.0	1260.0	411.2	115.5	1260.7	0.0	0.0	-355.6	-9.5	-226.8	4208.4	2866.5	2227.0	2871.5	2655.1	1604.2





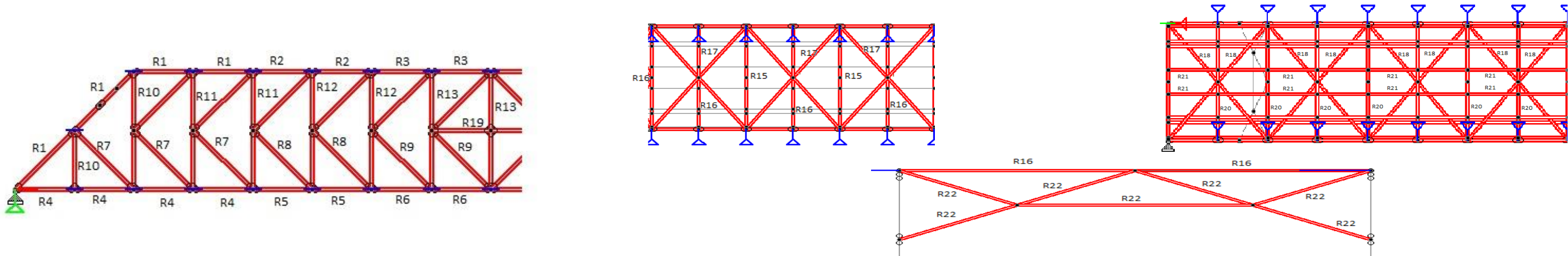
Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00						
	a) Basic comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	b) Accidental comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	c) Seismic comb.																	
	SLS												Member	70R	Class A & SPEC.	Member	70R	Class A & SPEC.
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60		Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50		X beam	1.50	1.50	X beam	1.34	1.34

Fy																		
R1	TOP CHORD (U2-U4)	Max	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	21.3	15.7	21.2	15.8	15.7	15.7
		Min	-15.7	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-21.3	-15.7	-21.2	-15.8	-15.7	-15.7
R2	TOP CHORD (U4-U6)	Max	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	17.6	23.8	17.6	17.6	17.6
		Min	-17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-23.8	-17.6	-23.8	-17.6	-17.6	-17.6
R3	TOP CHORD(U6-U8)	Max	20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	20.1	27.1	20.1	20.1	20.1
		Min	-20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-27.1	-20.1	-27.1	-20.1	-20.1	-20.1
R4	BOTTOM CHORD (L0-L4)	Max	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	9.6	13.0	9.6	9.6	9.6
		Min	-9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-13.0	-9.6	-13.0	-9.6	-9.6	-9.6
R5	BOTTOM CHORD(L4-L6)	Max	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.4	12.9	17.4	12.9	12.9	12.9
		Min	-12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-17.4	-12.9	-17.4	-12.9	-12.9	-12.9
R6	BOTTOM CHORD (L6-L8)	Max	14.1	0.0	0.0	0.0	0.0	0.0	12.1	0.0	0.0	205.2	39.9	14.1	326.9	14.1	14.1	14.1
		Min	-14.1	0.0	0.0	0.0	0.0	0.0	-12.1	0.0	0.0	-125.4	-19.0	-14.1	-207.1	-14.1	-14.1	-14.1
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Max	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	9.1	6.6	9.0	6.7	6.7	6.7
		Min	-6.6	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-9.1	-6.6	-9.0	-6.7	-6.7	-6.7
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Max	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	5.9	4.3	5.8	4.4	4.4	4.3
		Min	-4.3	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-5.9	-4.3	-5.8	-4.4	-4.4	-4.3
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Max	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	2.1	2.8	2.1	2.1	2.1
		Min	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.9	-2.1	-2.8	-2.1	-2.1	-2.1
R10	Vertical(L1-M1,L2-U2)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
R11	Vertical( L3-U3,L4-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
R12	Vertical( L5-U5,L6-U6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
R13	Vertical(L7-U7,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Max	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	4.2	3.1	26.6	3.1	3.1	3.1
		Min	-3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-14.9	-4.2	-3.1	-26.6	-3.1	-3.1	-3.1
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Max	20.5	0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.0	14.9	28.2	20.7	50.2	20.9	20.8	20.7
		Min	-20.5	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	0.0	-14.9	-28.1	-20.6	-50.1	-20.8	-20.7	-20.6
R17	Top Bracing	Max	2.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.8	3.0	2.2	4.0	2.2	2.2	2.1
		Min	-2.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	-0.8	-2.9	-2.1	-4.0	-2.2	-2.2	-2.1
R18	Bottom Bracing	Max	2.5	-0.1	0.0	0.0	0.4	102.3	78.3	0.0	0.0	0.0	179.6	90.6	3.2	120.0	90.6	2.4
		Min	-2.6	-0.2	-0.1	0.0	0.0	-94.4	-13.0	0.0	0.0	0.0	-4.0	-2.9	-3.9	-2.9	-2.9	-2.9
R19	Horz. centre member(M7-M8)	Max	13.4	0.0	0.0	0.0	0.0	0.0	76.9	0.0	0.0	0.0	150.8	13.4	18.1	13.4	13.4	13.4
		Min	-13.4	0.0	0.0	0.0	0.0	0.0	-12.8	0.0	0.0	0.0	-18.1	-13.4	-18.1	-13.4	-13.4	-13.4
R20	X girders	Max	241.1	192.2	62.7	17.6	52.0	313.2	320.6	0.2	1.9	5.3	1273.8	785.3	728.5	876.0	785.1	514.7
		Min	-241.1	-192.2	-62.7	-17.6	-52.0	-350.1	-304.3	-0.2	-1.9	-5.3	-810.4	-560.0	-728.5	-575.5	-559.8	-514.7
R21	STRINGERS	Max	57.1	9.4	3.1	0.8	2.0	128.0	192.3	0.1	1.9	2.3	430.0	182.4	101.7	219.7	182.1	71.4
		Min	-49.0	-0.3	-3.1	0.0	-2.0	-125.7	-125.4	-0.1	-1.9	-2.3	-77.6	-55.7	-77.4	-56.8	-55.4	-53.4
R22	KNEE BRACING	Max	13.4	0.1	0.0	0.0	0.1	0.0	0.1	0.4	1.9	35.6	21.0	15.2	73.6	16.0	15.0	14.7
		Min	984.8	-0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.4	-1.9	-35.6	1326.7	983.1	1274.0	982.3	983.3	983.5
R14	END RACKER	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



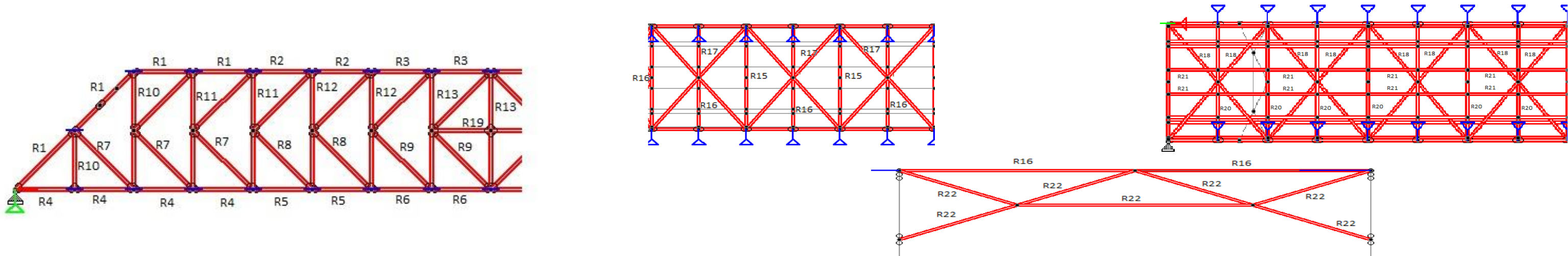
Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00	Member	70R	Class A & SPEC.	Member	70R	Class A & SPEC.
	a) Basic comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	b) Accidental comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	c) Seismic comb.																	
	SLS																	
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60	0.60	Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50	0.50	X beam	1.50	1.50	X beam	1.34	1.34
Fz																		
R1	TOP CHORD (U2-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.3	0.2	0.1
R2	TOP CHORD (U4-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	-0.4	0.0	0.0	-0.3	-0.2	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R3	TOP CHORD(U6-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R4	BOTTOM CHORD (L0-L4)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R5	BOTTOM CHORD(L4-L6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	5.5	0.2	0.1	0.1
R6	BOTTOM CHORD (L6-L8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	-3.7	-0.3	0.0	-5.6	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.3	0.2	0.1
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	-0.4	0.0	0.0	-0.3	-0.2	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.3	0.2	0.1
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	-0.4	0.0	0.0	-0.3	-0.2	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.3	0.2	0.1
R10	Vertical(L1-M1,L2-U2)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
R11	Vertical( L3-U3,L4-U4)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R12	Vertical( L5-U5,L6-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R13	Vertical(L7-U7,L8-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	2.2	1.0	0.0	3.2	0.6	0.4	0.3
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	0.0	-2.2	-1.0	0.0	-3.2	-0.6	-0.4	-0.3
		Max	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.2	4.0	2.6	6.7	3.0	2.8	2.7
R17	Top Bracing	Min	-2.5	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	-2.2	-4.0	-2.6	-6.7	-3.0	-2.8	-2.7
		Max	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.0	3.3	2.3	6.1	2.4	2.4	2.4
R18	Bottom Bracing	Min	-2.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-2.0	-3.3	-2.3	-6.1	-2.4	-2.4	-2.4
		Max	1.1	0.6	0.2	0.1	0.2	0.4	0.6	0.1	0.1	0.3	3.8	2.3	3.2	2.5	2.4	2.0
R19	Horz. centre member(M7-M8)	Min	-1.1	-0.6	-0.2	-0.1	-0.2	-0.4	-0.5	-0.1	-0.1	-0.3	-3.1	-2.1	-3.2	-2.3	-2.2	-2.0
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.1	0.0	1.3	0.1	0.1	0.3	0.2	0.1
R20	X girders	Min	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-0.2	-0.1	0.0	-0.4	-0.1	-0.1	-0.3	-0.2	-0.1
		Max	474.4	259.4	84.7	23.7	70.9	167.5	64.3	5.2	40.9	120.0	1508.4	1019.3	1391.6	1080.9	1014.3	865.2
R21	STRINGERS	Min	-474.3	-259.3	-84.6	-23.7	-70.9	-168.4	-64.2	-5.2	-40.9	-120.0	-1329.9	-935.8	-1391.4	-969.5	-930.7	-865.0
		Max	7.3	4.0	1.4	0.4	1.1	2.8	3.7	0.3	40.9	2.0	65.7	48.1	61.9	57.3	40.0	33.5
R22	KNEE BRACING	Min	-7.4	-4.0	-1.4	-0.4	-1.1	-2.8	-3.7	-0.3	-40.9	-2.0	-61.5	-46.8	-62.1	-55.6	-38.8	-33.7
		Max	7.6	0.1	0.0	0.0	0.2	0.1	0.1	0.1	40.9	6.5	51.7	40.5	61.0	48.8	32.4	28.2
R14	END RACKER	Min	-7.6	-0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-40.9	-6.5	-51.5	-40.4	-61.0	-48.7	-32.3	-28.2
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0





Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00	Class A & SPEC.			Class A & SPEC.		
	a) Basic comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	b) Accidental comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	c) Seismic comb.																	
	SLS												Member	70R		Member	70R	
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60	0.60	Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50	0.50	X beam	1.50	1.50	X beam	1.34	1.34

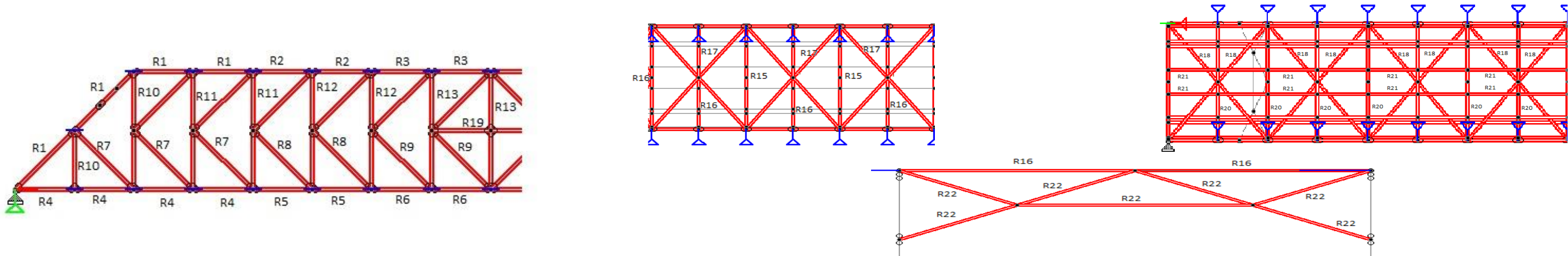
Mx																		
R1	TOP CHORD (U2-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2	TOP CHORD (U4-U6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R3	TOP CHORD(U6-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R4	BOTTOM CHORD (L0-L4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R5	BOTTOM CHORD(L4-L6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R6	BOTTOM CHORD (L6-L8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R10	Vertical(L1-M1,L2-U2)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R11	Vertical( L3-U3,L4-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R12	Vertical( L5-U5,L6-U6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13	Vertical(L7-U7,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	0.0
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Max	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1
		Min	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1
R17	Top Bracing	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R18	Bottom Bracing	Max	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.1	0.0
		Min	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R19	Horz. centre member(M7-M8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R20	X girders	Max	0.1	0.0	0.0	0.2	1.7	4.4	0.7	0.0	0.0	0.0	8.1	4.1	0.5	5.4	4.1	0.4
		Min	-0.1	0.0	0.0	-0.2	-1.7	-4.2	-1.1	0.0	0.0	0.0	-2.3	-1.8	-0.5	-2.3	-1.8	-0.4
R21	STRINGERS	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R22	KNEE BRACING	Max	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.3	0.7	0.3	0.3	0.3
		Min	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4	-0.3	-0.7	-0.3	-0.3	-0.3
R14	END RACKER	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00	Class A & SPEC.			Class A & SPEC.		
	a) Basic comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	b) Accidental comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	c) Seismic comb.																	
	SLS												Member	70R		Member	70R	
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60	0.60	Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50	0.50	X beam	1.50	1.50	X beam	1.34	1.34

My																		
R1	TOP CHORD (U2-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.7	0.0	0.0	0.4	0.3	0.2
R2	TOP CHORD (U4-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	-0.7	0.0	0.0	-0.4	-0.3	-0.2
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R3	TOP CHORD(U6-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R4	BOTTOM CHORD (L0-L4)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R5	BOTTOM CHORD(L4-L6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R6	BOTTOM CHORD (L6-L8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	11.4	0.3	0.0	17.1	0.2	0.1	0.1
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	-0.6	0.0	0.0	-0.4	-0.2	-0.2
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.6	0.0	0.0	0.4	0.2	0.2
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	-0.7	0.0	0.0	-0.4	-0.3	-0.2
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.7	0.0	0.0	0.4	0.3	0.2
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.7	0.0	0.0	0.5	0.3	0.2
R10	Vertical(L1-M1,L2-U2)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
R11	Vertical( L3-U3,L4-U4)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R12	Vertical( L5-U5,L6-U6)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R13	Vertical(L7-U7,L8-U8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3	0.0	0.0	-0.2	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Min	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.9	-0.1	-10.3	-1.5	-0.1	-15.5	-1.0	-0.6	-0.5
		Max	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.1	10.3	1.5	0.1	15.5	1.0	0.6	0.5
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Min	-11.9	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-0.1	-10.3	-17.0	-12.0	-31.7	-12.6	-12.3	-12.2
		Max	12.1	0.1	0.0	0.0	0.0	0.1	0.1	0.4	0.1	10.7	17.5	12.4	32.7	12.9	12.6	12.5
R17	Top Bracing	Min	-12.1	-0.1	0.0	0.0	0.0	-0.1	0.0	-0.4	-0.1	-10.7	-17.3	-12.3	-32.7	-12.8	-12.6	-12.5
		Max	6.2	3.4	1.1	0.3	0.9	2.3	3.2	0.1	0.4	1.7	21.5	13.4	18.3	14.3	13.4	11.3
R18	Bottom Bracing	Min	-6.3	0.0	0.0	-0.3	-0.9	-2.4	0.0	-0.1	-0.4	-1.7	-9.5	-7.7	-11.8	-8.2	-7.7	-6.8
		Max	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.2	0.4	0.0	6.3	0.3	0.4	0.6	0.4	0.3
R19	Horz. centre member(M7-M8)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4	0.0	-0.7	-0.3	-0.4	-0.6	-0.4	-0.3
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.3	0.3	0.4	0.6	0.4	0.3
R20	X girders	Min	-0.1	0.0	0.0	-0.2	-63.9	-150.6	-1.1	-4.7	-35.1	-107.6	-44.5	-83.5	-196.9	-113.7	-79.4	-20.3
		Max	427.2	233.6	76.2	21.4	63.9	151.3	68.6	4.7	35.1	107.6	1357.6	917.0	1250.8	972.3	912.9	778.3
R21	STRINGERS	Min	0.0	0.0	-4.2	0.0	-3.5	-8.5	0.0	-0.3	-35.1	-5.9	-42.9	-35.3	-51.2	-43.6	-28.4	-21.9
		Max	22.5	12.3	4.0	1.1	3.4	8.1	11.4	0.3	35.1	5.9	110.7	75.0	99.4	84.6	68.1	57.6
R22	KNEE BRACING	Min	-0.3	0.0	0.0	0.0	-0.5	-0.2	0.0	-0.3	-35.1	-22.9	-35.9	-28.6	-69.8	-35.9	-21.7	-18.0
		Max	30.7	0.3	0.1	0.0	0.5	0.2	0.3	0.3	35.1	22.9	78.4	59.6	111.5	67.0	52.7	48.8
R14	END RACKER	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.7	0.0	0.0	67.0	0.0	0.0	44.7	26.8	22.3





Ref.	Members	Env.	SW	DECK	w/c	Rail&kerb	70Rw+Class A	3 L Class A	SP.LOAD	Wind	Temp	Seismic	ULS			SLS		
			Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	Max Fx kN	3 L Class A	MAX Fx KN	Fx	Max	Max	Basic	Accn.	Seis.	Rare	Freq.	Quassi
	ULS																	
	a) Basic comb.		1.35	1.35	1.75	1.35	1.50	1.50	1.50	1.50	1.00	0.00						
	b) Accidental comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.00	0.80	0.00						
	c) Seismic comb.		1.35	1.35	1.75	1.35	0.00	0.00	0.00	0.00	1.00	1.50						
	SLS												Member	70R	Class A & SPEC.	Member	70R	Class A & SPEC.
	a) Rare comb.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		Truss	1.15	1.15	Truss	1.15	1.15
	b) freq. comb.		1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.60	0.60		Stringer	1.58	1.58	Stringer	1.58	1.58
	c) Quassi comb.		1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50		X beam	1.50	1.50	X beam	1.34	1.34

Mz																		
R1	TOP CHORD (U2-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
R2	TOP CHORD (U4-U6)	Min	-24.6	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-33.5	-24.6	-33.3	-24.8	-24.7	-24.7
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R3	TOP CHORD(U6-U8)	Min	-19.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-26.4	-19.6	-26.4	-19.6	-19.6	-19.6
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	-22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-30.1	-22.3	-30.1	-22.3	-22.3	-22.3
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R4	BOTTOM CHORD (L0-L4)	Min	-10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-14.4	-10.7	-14.4	-10.7	-10.7	-10.7
R5	BOTTOM CHORD(L4-L6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Min	-14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-19.3	-14.3	-19.3	-14.3	-14.3	-14.3
R6	BOTTOM CHORD (L6-L8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	115.6	0.0	0.0	173.5	0.0	0.0	0.0
		Min	-14.3	0.0	0.0	0.0	0.0	0.0	0.0	-13.4	0.0	0.0	-199.3	-19.3	-14.3	-318.2	-14.3	-14.3
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.1
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Min	-10.4	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-14.3	-10.4	-14.1	-10.6	-10.5	-10.5
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Min	-6.8	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-9.3	-6.8	-9.1	-6.9	-6.8	-6.8
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
		Min	-3.7	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-5.1	-3.7	-5.0	-3.8	-3.7	-3.7
		Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
R10	Vertical(L1-M1,L2-U2)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
R11	Vertical( L3-U3,L4-U4)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
R12	Vertical( L5-U5,L6-U6)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.1	-0.1
R13	Vertical(L7-U7,L8-U8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Max	-4.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	107.8	-5.1	-3.8	156.4	-3.7	-3.8	-3.9
		Min	-13.2	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.2	-107.8	-18.2	-13.5	-179.8	-13.5	-13.4	-13.4
R16	TOP Transverse( short)(U2-L2,U3-L3,U5-L5,U7-L7)	Max	0.0	0.4	0.1	0.0	0.1	0.3	0.5	2.2	0.2	107.8	5.1	1.0	162.6	3.3	2.2	1.7
		Min	-126.7	-0.5	-0.2	0.0	-0.1	-0.4	-0.1	-2.2	-0.2	-107.8	-175.8	-127.7	-334.0	-130.0	-129.0	-128.6
R17	Top Bracing	Max	3.5	0.6	0.1	0.1	0.2	0.4	0.2	0.1	0.0	5.0	6.5	4.5	13.1	4.7	4.6	4.2
		Min	-2.8	-0.4	0.0	0.0	-0.1	-0.3	-0.1	-0.1	0.0	-5.0	-4.8	-3.4	-11.9	-3.5	-3.5	-3.4
R18	Bottom Bracing	Max	4.5	0.0	0.0	0.1	0.8	149.2	99.6	0.0	0.0	0.3	263.6	133.3	6.7	176.2	133.3	4.7
		Min	-3.2	-1.3	-0.4	-0.2	-2.7	-138.4	-57.3	0.0	0.0	-0.3	-11.8	-7.5	-7.6	-8.3	-7.5	-5.2
R19	Horz. centre member(M7-M8)	Max	0.0	0.0	0.0	0.0	0.0	0.0	97.0	0.0	0.0	0.0	167.4	0.0	0.0	0.0	0.0	0.0
		Min	-2.5	0.0	0.0	0.0	0.0	0.0	0.0	-56.3	0.0	0.0	0.0	-3.5	-2.6	-3.5	-2.6	-2.6
R20	X girders	Max	0.0	0.5	0.2	0.2	3.0	59.2	71.1	0.6	5.6	17.3	130.4	56.3	32.7	75.1	55.6	3.9
		Min	-894.3	-611.9	-199.7	-29.4	-17.1	-1038.2	-1679.1	-0.6	-5.6	-17.3	-2458.5	-1754.5	-2454.1	-1761.2	-1753.8	-1738.4
R21	STRINGERS	Max	22.9	0.0	0.0	0.0	0.0	57.3	115.6	0.4	5.6	11.4	236.6	76.8	53.6	94.8	76.0	25.9
		Min	-81.4	-47.1	-15.6	0.0	-256.3	-252.7	-199.3	-0.4	-5.6	-11.4	-550.7	-366.6	-223.5	-440.7	-365.7	-147.1
R22	KNEE BRACING	Max	139.6	0.2	0.0	0.0	0.3	0.1	0.2	1.3	5.6	126.1	196.7	144.5	383.5	146.9	144.1	143.2
		Min	-13.3	-0.2	-0.1	0.0	-0.5	-0.2	-0.2	-1.3	-5.6	-126.1	-26.2	-18.2	-213.1	-20.7	-17.9	-17.0
R14	END RACKER	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.1	0.0	0.0	114.1	0.0	0.0	76.1	45.6	38.0
		Min	-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-76.1	0.0	0.0	-151.5	-27.7	-37.4	-103.8	-73.3

Ref.	Members	Force / Moments	env.	ULS			SLS		
				Basic	Accn.	Seis.	Rare	Freq.	Quassi
R1	TOP CHORD (U2-U4)	Fx	Max	15958.02	10010.79	9560.10	11137.96	10010.71	6642.70
			Min	8185.35	5420.57	5675.04	5778.10	5420.64	4334.54
		Fy	Max	21.30	15.68	21.17	15.77	15.73	15.72
			Min	-21.30	-15.68	-21.17	-15.77	-15.73	-15.72
		Fz	Max	0.43	0.00	0.00	0.29	0.17	0.14
			Min	-0.43	0.00	0.00	-0.29	-0.17	-0.14
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.67	0.00	0.00	0.45	0.27	0.22
			Min	-0.67	0.00	0.00	-0.45	-0.27	-0.22
		Mz	Max	0.20	0.00	0.00	0.14	0.08	0.07
			Min	-33.46	-24.64	-33.26	-24.77	-24.72	-24.71
R2	TOP CHORD (U4-U6)	Fx	Max	19960.68	12598.94	11894.72	13947.91	12597.21	8555.81
			Min	12507.78	8531.46	10318.18	8891.75	8533.18	7446.81
		Fy	Max	23.78	17.62	23.78	17.62	17.62	17.62
			Min	-23.78	-17.62	-23.78	-17.62	-17.62	-17.62
		Fz	Max	0.30	0.00	0.00	0.20	0.12	0.10
			Min	-0.30	0.00	0.00	-0.20	-0.12	-0.10
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.33	0.00	0.00	0.22	0.13	0.11
			Min	-0.33	0.00	0.00	-0.22	-0.13	-0.11
		Mz	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	-26.42	-19.57	-26.42	-19.57	-19.57	-19.57
R3	TOP CHORD(U6-U8)	Fx	Max	22413.82	14201.47	13624.40	15674.73	14199.87	9786.21
			Min	15093.26	10393.65	12882.60	10753.74	10395.25	9308.87
		Fy	Max	27.12	20.09	27.12	20.09	20.09	20.09
			Min	-27.12	-20.09	-27.12	-20.09	-20.09	-20.09
		Fz	Max	0.30	0.00	0.00	0.20	0.12	0.10
			Min	-0.30	0.00	0.00	-0.20	-0.12	-0.10
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.33	0.00	0.00	0.22	0.13	0.11
			Min	-0.33	0.00	0.00	-0.22	-0.13	-0.11
		Mz	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	-30.13	-22.32	-30.13	-22.32	-22.32	-22.32
R4	BOTTOM CHORD (L0-L4)	Fx	Max	-4611.11	-3210.92	-3068.03	-3150.66	-3214.81	-3230.98
			Min	-9824.29	-6412.69	-9520.35	-6780.79	-6408.80	-5469.12
		Fy	Max	12.96	9.60	12.96	9.60	9.60	9.60
			Min	-12.96	-9.60	-12.96	-9.60	-9.60	-9.60
		Fz	Max	0.29	0.00	0.00	0.19	0.12	0.10
			Min	-0.29	0.00	0.00	-0.19	-0.12	-0.10
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.32	0.00	0.00	0.22	0.13	0.11
			Min	-0.32	0.00	0.00	-0.22	-0.13	-0.11
		Mz	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	-14.40	-10.67	-14.40	-10.67	-10.67	-10.67
R5	BOTTOM CHORD(L4-L6)	Fx	Max	-7128.27	-5150.11	-6039.34	-5102.35	-5161.50	-5176.42
			Min	-11362.74	-7639.81	-10041.35	-8089.30	-7628.42	-6408.35
		Fy	Max	17.39	12.88	17.39	12.88	12.88	12.88
			Min	-17.39	-12.88	-17.39	-12.88	-12.88	-12.88
		Fz	Max	0.32	0.00	0.00	0.21	0.13	0.11
			Min	-0.32	0.00	0.00	-0.21	-0.13	-0.11
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.35	0.00	0.00	0.23	0.14	0.12
			Min	-0.35	0.00	0.00	-0.23	-0.14	-0.12
		Mz	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	-19.33	-14.32	-19.33	-14.32	-14.32	-14.32
R6	BOTTOM CHORD (L6-L8)	Fx	Max	-9224.24	-6653.82	-8370.22	-6611.35	-6668.37	-6682.68
			Min	-12725.42	-8596.74	-11032.90	-9063.63	-8582.19	-7294.61
		Fy	Max	39.86	14.09	326.86	14.09	14.09	14.09
			Min	-19.03	-14.09	-207.10	-14.09	-14.09	-14.09
		Fz	Max	0.31	0.00	5.53	0.21	0.12	0.10
			Min	-0.31	0.00	-5.59	-0.21	-0.12	-0.10
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	-0.01	0.00	0.00	0.00
		My	Max	0.34	0.00	17.12	0.23	0.14	0.11
			Min	-0.34	0.00	-0.01	-0.23	-0.14	-0.11
		Mz	Max	0.00	0.00	173.46	0.00	0.00	0.00
			Min	-19.33	-14.32	-318.21	-14.32	-14.32	-14.32

Ref.	Members	Force / Moments	env.	ULS			SLS		
				Basic	Accn.	Seis.	Rare	Freq.	Quassi
R7	Diagonal(L2-M1,L3-M2,L4-M3,M1-U2,M2-U3,M3-U4)	Fx	Max	6021.75	3767.21	3621.11	4199.48	3767.76	2477.53
			Min	-4563.12	-3037.90	-3621.11	-3227.06	-3038.45	-2477.53
		Fy	Max	9.11	6.65	8.98	6.74	6.70	6.69
			Min	-9.11	-6.65	-8.98	-6.74	-6.70	-6.69
		Fz	Max	0.40	0.00	0.00	0.27	0.16	0.13
			Min	-0.40	0.00	0.00	-0.27	-0.16	-0.13
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.62	0.00	0.00	0.42	0.25	0.21
			Min	-0.62	0.00	0.00	-0.42	-0.25	-0.21
		Mz	Max	0.21	0.00	0.00	0.14	0.08	0.07
			Min	-14.31	-10.45	-14.10	-10.59	-10.53	-10.52
R8	Diagonal (L5-M4,L6-M5,M4-U5,M5-U6)	Fx	Max	4066.69	2515.76	2478.21	2811.77	2516.34	1634.75
			Min	-2962.18	-1952.27	-2320.93	-2090.41	-1952.86	-1544.87
		Fy	Max	5.93	4.31	5.81	4.39	4.35	4.35
			Min	-5.93	-4.31	-5.81	-4.39	-4.35	-4.35
		Fz	Max	0.42	0.00	0.00	0.28	0.17	0.14
			Min	-0.42	0.00	0.00	-0.28	-0.17	-0.14
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.66	0.00	0.00	0.44	0.27	0.22
			Min	-0.66	0.00	0.00	-0.44	-0.27	-0.22
		Mz	Max	0.19	0.00	0.00	0.13	0.08	0.06
			Min	-9.32	-6.77	-9.13	-6.89	-6.84	-6.83
R9	Diagonal (L7-M6,L8-M7,M6-U7,M7-U8)	Fx	Max	1933.00	1168.47	1091.10	1341.74	1166.61	658.83
			Min	-1472.52	-938.23	-1091.10	-1034.75	-936.37	-658.83
		Fy	Max	2.88	2.08	2.81	2.13	2.11	2.11
			Min	-2.88	-2.08	-2.81	-2.13	-2.11	-2.11
		Fz	Max	0.44	0.00	0.00	0.29	0.17	0.15
			Min	-0.44	0.00	0.00	-0.29	-0.17	-0.15
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	-0.11	0.00	0.00	-0.07	-0.04	-0.04
			Min	0.68	0.00	0.00	0.46	0.27	0.23
		Mz	Max	0.11	0.00	0.00	0.07	0.04	0.04
			Min	-5.08	-3.69	-4.97	-3.76	-3.73	-3.72
R10	Vertical(L1-M1,L2-U2)	Fx	Max	2306.56	423.44	1093.21	432.86	421.64	405.68
			Min	-7955.26	-5315.12	-6293.30	-5632.93	-5313.33	-4372.22
		Fy	Max	0.10	0.00	0.00	0.07	0.04	0.03
			Min	-0.10	0.00	0.00	-0.07	-0.04	-0.03
		Fz	Max	0.18	0.00	0.00	0.12	0.07	0.06
			Min	-0.18	0.00	0.00	-0.12	-0.07	-0.06
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.21	0.00	0.00	0.14	0.08	0.07
			Min	-0.21	0.00	0.00	-0.14	-0.08	-0.07
		Mz	Max	0.11	0.00	0.00	0.07	0.04	0.04
			Min	-0.11	0.00	0.00	-0.07	-0.04	-0.04
R11	Vertical( L3-U3,L4-U4)	Fx	Max	2973.33	1843.38	1740.59	2071.67	1843.64	1163.47
			Min	-3178.27	-2112.38	-2512.46	-2246.18	-2112.64	-1715.94
		Fy	Max	0.10	0.00	0.00	0.07	0.04	0.03
			Min	-0.10	0.00	0.00	-0.07	-0.04	-0.03
		Fz	Max	0.28	0.00	0.00	0.19	0.11	0.09
			Min	-0.28	0.00	0.00	-0.19	-0.11	-0.09
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.32	0.00	0.00	0.21	0.13	0.11
			Min	-0.32	0.00	0.00	-0.21	-0.13	-0.11
		Mz	Max	0.18	0.00	0.00	0.12	0.07	0.06
			Min	-0.18	0.00	0.00	-0.12	-0.07	-0.06
R12	Vertical( L5-U5,L6-U6)	Fx	Max	1569.47	952.53	882.13	1089.46	952.78	546.63
			Min	-2027.46	-1330.84	-1575.28	-1428.58	-1331.09	-1042.52
		Fy	Max	0.18	0.00	0.00	0.12	0.07	0.06
			Min	-0.18	0.00	0.00	-0.12	-0.07	-0.06
		Fz	Max	0.28	0.00	0.00	0.19	0.11	0.09
			Min	-0.28	0.00	0.00	-0.19	-0.11	-0.09
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.31	0.00	0.00	0.21	0.13	0.10
			Min	-0.31	0.00	0.00	-0.21	-0.13	-0.10
		Mz	Max	0.20	0.00	0.00	0.13	0.08	0.07
			Min	-0.20	0.00	0.00	-0.13	-0.08	-0.07

Ref.	Members	Force / Moments	env.	ULS			SLS		
				Basic	Accn.	Seis.	Rare	Freq.	Quassi
R13	Vertical(L7-U7,L8-U8)	Fx	Max	2343.32	1239.97	1614.07	1299.05	1237.42	1071.63
			Min	-1068.28	-662.35	-708.59	-746.68	-659.80	-418.26
		Fy	Max	0.11	0.00	0.00	0.07	0.04	0.04
			Min	-0.11	0.00	0.00	-0.07	-0.04	-0.04
		Fz	Max	0.31	0.00	0.00	0.21	0.12	0.10
			Min	-0.31	0.00	0.00	-0.21	-0.12	-0.10
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.34	0.00	0.00	0.23	0.14	0.11
			Min	-0.34	0.00	0.00	-0.23	-0.14	-0.11
		Mz	Max	0.12	0.00	0.00	0.08	0.05	0.04
			Min	-0.12	0.00	0.00	-0.08	-0.05	-0.04
R15	TOP Transverse(U4-L4,L6-U6,L8-U8)	Fx	Max	43.78	35.03	71.16	43.78	26.27	21.89
			Min	-43.78	-35.03	-71.16	-43.78	-26.27	-21.89
		Fy	Max	4.24	3.14	26.60	3.14	3.14	3.13
			Min	-4.23	-3.14	-26.60	-3.14	-3.14	-3.13
		Fz	Max	0.96	0.01	3.23	0.64	0.38	0.32
			Min	-0.95	-0.01	-3.23	-0.64	-0.38	-0.32
		Mx	Max	0.00	0.00	0.11	0.00	0.00	0.00
			Min	0.00	0.00	-0.11	0.00	0.00	0.00
		My	Max	1.52	0.10	15.49	1.03	0.64	0.50
			Min	-1.48	-0.08	-15.49	-1.01	-0.62	-0.50
		Mz	Max	107.80	-5.09	-3.81	156.44	-3.73	-3.84
			Min	-107.80	-18.18	-13.45	-179.79	-13.51	-13.42
R16	TOP Transverse(short)(U2-L2,U3-L3,U5-L5,U7-L7)	Fx	Max	53.39	39.59	71.18	50.19	31.03	22.07
			Min	-44.30	-35.04	-71.18	-44.13	-26.48	-22.07
		Fy	Max	28.24	20.66	50.20	20.85	20.76	20.70
			Min	-28.05	-20.57	-50.13	-20.75	-20.68	-20.65
		Fz	Max	4.04	2.56	6.67	2.96	2.79	2.74
			Min	-4.04	-2.56	-6.67	-2.95	-2.79	-2.74
		Mx	Max	0.13	0.09	0.23	0.09	0.09	0.09
			Min	-0.12	-0.09	-0.23	-0.09	-0.09	-0.09
		My	Max	17.03	12.05	31.65	12.59	12.33	12.25
			Min	-17.00	-12.04	-31.65	-12.57	-12.32	-12.25
		Mz	Max	5.14	0.96	162.62	3.30	2.24	1.70
			Min	-175.79	-127.70	-333.97	-129.98	-128.98	-128.61
R17	Top Bracing	Fx	Max	374.11	243.97	272.85	266.27	241.37	183.50
			Min	167.75	116.23	137.49	115.62	118.83	111.63
		Fy	Max	3.00	2.17	4.00	2.21	2.18	2.13
			Min	-2.94	-2.14	-4.01	-2.17	-2.16	-2.13
		Fz	Max	3.33	2.30	6.06	2.45	2.38	2.35
			Min	-3.31	-2.30	-6.06	-2.44	-2.37	-2.35
		Mx	Max	0.01	0.01	0.01	0.01	0.01	0.01
			Min	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		My	Max	17.45	12.40	32.75	12.88	12.63	12.52
			Min	-17.28	-12.34	-32.71	-12.82	-12.58	-12.50
		Mz	Max	6.51	4.49	13.05	4.74	4.57	4.21
			Min	-4.84	-3.38	-11.89	-3.55	-3.46	-3.36
R18	Bottom Bracing	Fx	Max	1226.88	812.32	1163.44	903.57	774.39	623.62
			Min	-1616.31	-1143.58	-1711.55	-1213.81	-1105.65	-1017.92
		Fy	Max	179.57	90.56	3.21	119.96	90.56	2.36
			Min	-3.95	-2.90	-3.93	-2.91	-2.89	-2.86
		Fz	Max	3.81	2.33	3.19	2.54	2.36	2.00
			Min	-3.14	-2.13	-3.19	-2.27	-2.16	-2.00
		Mx	Max	0.24	0.12	0.01	0.16	0.12	0.01
			Min	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		My	Max	21.49	13.41	18.34	14.28	13.40	11.33
			Min	-9.52	-7.70	-11.82	-8.16	-7.69	-6.83
		Mz	Max	263.60	133.31	6.68	176.21	133.31	4.66
			Min	-11.84	-7.52	-7.56	-8.30	-7.51	-5.19
R19	Horz centre member(M7-M8)	Fx	Max	1883.57	1228.35	1595.11	1283.19	1186.63	1126.74
			Min	-142.47	-123.37	-157.50	-163.15	-81.65	-66.96
		Fy	Max	150.75	13.44	18.15	13.44	13.44	13.44
			Min	-18.15	-13.44	-18.15	-13.44	-13.44	-13.44
		Fz	Max	1.34	0.07	0.08	0.29	0.17	0.14
			Min	-0.39	-0.07	-0.08	-0.29	-0.17	-0.14
		Mx	Max	0.08	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	6.25	0.32	0.40	0.62	0.37	0.31
			Min	-0.73	-0.32	-0.40	-0.62	-0.37	-0.31
		Mz	Max	167.36	0.03	0.03	0.03	0.02	0.02
			Min	-3.46	-2.57	-3.46	-2.57	-2.56	-2.56

Ref.	Members	Force / Moments	env.	ULS			SLS		
				Basic	Accn.	Seis.	Rare	Freq.	Quassi
R20	X girders	Fx	Max	3976.26	2946.65	3818.75	3382.58	2568.57	2227.15
			Min	-1970.97	-1565.03	-2127.98	-1951.73	-1186.95	-993.19
		Fy	Max	1273.80	785.34	728.47	875.95	785.07	514.74
			Min	-810.41	-560.03	-728.46	-575.55	-559.76	-514.74
		Fz	Max	1508.38	1019.34	1391.65	1080.86	1014.28	865.21
			Min	-1329.87	-935.81	-1391.35	-969.55	-930.74	-864.99
		Mx	Max	8.05	4.15	0.52	5.40	4.15	0.37
			Min	-2.32	-1.80	-0.52	-2.28	-1.80	-0.37
		My	Max	1357.62	917.04	1250.81	972.30	912.86	778.35
			Min	-44.53	-83.55	-196.94	-113.66	-79.36	-20.29
		Mz	Max	130.36	56.33	32.73	75.10	55.60	3.93
			Min	-2458.53	-1754.49	-2454.10	-1761.15	-1753.76	-1738.42
R21	STRINGERS	Fx	Max	3360.66	2575.47	3570.06	2969.34	2198.07	1986.08
			Min	-4787.63	-3532.63	-4778.06	-3963.73	-3154.55	-2827.64
		Fy	Max	429.99	182.41	101.65	219.69	182.08	71.44
			Min	-77.58	-55.73	-77.39	-56.77	-55.39	-53.45
		Fz	Max	65.66	48.07	61.88	57.31	40.05	33.52
			Min	-61.50	-46.81	-62.11	-55.57	-38.79	-33.69
		Mx	Max	0.01	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	110.71	74.95	99.40	84.58	68.10	57.61
			Min	-42.87	-35.29	-51.24	-43.61	-28.44	-21.88
		Mz	Max	236.62	76.84	53.59	94.83	75.97	25.92
			Min	-550.72	-366.57	-223.45	-440.75	-365.70	-147.11
R22	KNEE BRACING	Fx	Max	3237.58	2509.02	3262.26	2891.81	2129.11	1938.23
			Min	-1926.99	-1538.30	-1952.00	-1921.03	-1158.38	-967.68
		Fy	Max	20.97	15.15	73.59	15.97	15.01	14.68
			Min	1326.72	983.11	1274.00	982.32	983.26	983.53
		Fz	Max	51.67	40.52	61.02	48.84	32.40	28.17
			Min	-51.52	-40.45	-61.02	-48.74	-32.33	-28.17
		Mx	Max	0.38	0.28	0.71	0.28	0.28	0.28
			Min	-0.38	-0.28	-0.71	-0.28	-0.28	-0.28
		My	Max	78.39	59.62	111.45	67.05	52.75	48.76
			Min	-35.86	-28.58	-69.84	-35.93	-21.71	-17.96
		Mz	Max	196.68	144.49	383.48	146.94	144.14	143.24
			Min	-26.21	-18.24	-213.12	-20.67	-17.89	-17.04
R14	END RACKER	Fx	Max	16007.01	9655.39	9080.27	11135.11	9866.84	6463.58
			Min	4208.44	2866.51	2226.95	2871.49	2655.05	1604.20
		Fy	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		Fz	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		Mx	Max	0.00	0.00	0.00	0.00	0.00	0.00
			Min	0.00	0.00	0.00	0.00	0.00	0.00
		My	Max	0.00	67.01	0.00	0.00	44.67	26.80
			Min	0.00	-0.15	0.00	0.00	-0.10	-0.06
		Mz	Max	114.08	0.00	0.00	76.05	45.63	38.03
			Min	-151.49	-27.72	-37.42	-103.77	-73.35	-65.74

# **Truss Design (80m Brg-Brg)**



**Top Chord (TC)****R-1****Compression check**

Force acting on member (Refer results)	C	kN	<b>15958.00</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	73250.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	7.5E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	8.0E+09
Radius of gyration y-y	r <sub>y</sub>	mm	319.29
Radius of gyration z-z	r <sub>z</sub>	mm	329.66
	k	-	0.65
	l	mm	5000.00
Eff. Elngth	k*l	mm	3250.00
slenderness ratio ( $\lambda$ )	k*l/r <sub>y</sub>		10.18

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c )  
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**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	227.00
	kN	<b>16627.75</b>
Check		<b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>0.43</b>
Partial safety factors	( $\gamma_{mo}$ )		1.10
	( $\gamma_{m1}$ )		1.25
	( $\gamma_{mb}$ )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			2.00
No. of bolts in Each row			8.00
No. of rows			8.00
Pitch Provided		mm	85.00
Gauge Provided		mm	75.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critrical section		bolts	16.00
Thickness of member	t <sub>1</sub>	mm	25.00
	t <sub>2</sub>	mm	20.00
Area of bolts hole provided	A <sub>b</sub>		9360.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	73250.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	63890.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/( $\gamma_{mo}$ )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/( $\gamma_{m1}$ )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732* $\gamma_{mo}$ ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/ $\gamma_{m1}$ )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732* $\gamma_{m1}$ )+(A <sub>tg</sub> *f <sub>y</sub> )/ $\gamma_{mo}$	
	T <sub>dg</sub>	kN <b>16647.73</b>
	T <sub>dn</sub>	kN <b>18860.33</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	$\text{mm}^2$	29250.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	$\text{mm}^2$	20475.00	
Min. Gross area in tension from bolt hole to the toe of angle ,enc	$A_{tg}$	$\text{mm}^2$	23625.00	
Min. Net area in tension from bolt hole to the toe of angle ,end b	$A_{tn}$	$\text{mm}^2$	15435.00	
	$T_{db1}$	kN	8394.59	
	$T_{db2}$	kN	8859.05	
Min. of above	$T_{db}$	kN	<b>8394.59</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>8394.59</b>	
			<b>safe</b>	

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000.00	
Radius of Gyration	mm	319.29	
slenderness Ratio		15.66	
Width of Lacing	mm	120.00	
Angle of Lacing	Degree	45.00	
Effective Horizontal span for lacing	mm	500.00	
Effective Length of Lacing Plate	mm	707.11	
Required min. Thickness of Lacing	mm	14.14	
Provided Thickness of Lacing		22.00	
Effective Length for Local Buckling	mm	1000.00	
Radius of Gyration		298.92	
Slenderness Ratio		3.35	
		<	50.00
		<	10.96
Check		<b>OK</b>	

**Design Force in Lacing**

Max Axial Force	kN	15958.00	
Design Axial Force for lacing ( 2.5 % )	kN	398.95	
No. of Shear Planes	(N)	1.00	
Transverse Shear			
For Single Lacing System	kN	199.48	
For Double Lacing System	kN	99.74	
Force acting on Each Lacing plate			
For Single Lacing System	kN	282.10	
For Double Lacing System	kN	141.05	
Min. Radius of gyration of lacing	mm	6.35	
Effective Length of Lacing	mm	707.11	
Slenderness ratio of lacing		111.34	< 140
fcd (for buckling Class c )	Mpa	115.40	
Compressive strength	kN	304.66	
Check		<b>OK</b>	
Tensile Strength			
Due to Rupture	kN	779.33	
Due to Gross Yeilding	kN	600.00	
	min	600.00	
		<b>OK</b>	



**Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	8.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	538.86
Compressive Force in lacing bar	kN	282.10
Length of weld required	mm	523.51
Available Length of Weld	mm	459.41

**Lacing using angle section(double lacing back toback)**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000.00
Radius of Gyration	mm	319.29
slenderness Ratio		15.66
width of angle leg		65.00
Size of angle	mm	65*65*10
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		10.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		319.29
Slenderness Ratio		3.13
		< 50
		< 10.9618215
Check		OK

**Design Force in Lacing**

Max Axial Force	kN	15958.00
Design Axial Force for lacing ( 2.5 %)	kN	398.95
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	199.48
Force acting on Each Lacing plate		
For Single Lacing System	kN	282.10
Min. Radius of gyration of lacing	mm	18.63
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		37.96
$f_{cd}$ (for buckling Class c )	Mpa	204.50
Area	mm <sup>2</sup>	2400.00
Compressive strength	kN	490.80
Check		OK
Tensile Strength		
Due to Rupture	kN	383.76
Due to Gross Yeilding	kN	295.45
	min	295.45

OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	282.10
Length of weld required		mm	698.02
Available Length of Weld		mm	248.85

**Top Chord (TC)**  
**R-2**

**Compression check**

Force acting on member (Refer results)	C	kN	<b>19960.68</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	91500.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	9.5E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	9.9E+09
Radius of gyration y-y	r <sub>y</sub>	mm	3.20E+02
Radius of gyration z-z	r <sub>z</sub>	mm	329.15
	k	-	0.65
	l	mm	5000.00
Eff. Elngth	k*l	mm	3250.00
slenderness ratio (λ)	k*l/r <sub>y</sub>		10.15

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	227.00
Check	kN	<b>20770.50</b> <b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>0.30</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			2.00
No. of bolts in Each row			8.00
No. of rows			9.00
Pitch Provided		mm	85.00
Gauge Provided		mm	75.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	16.00
Thickness of member	t <sub>1</sub>	mm	30.00
	t <sub>2</sub>	mm	30.00
Area of bolts hole provided	A <sub>b</sub>		12480.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	91500.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	79020.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>te</sub> *f <sub>y</sub> )/Y <sub>mo</sub>	
	T <sub>dg</sub>	kN <b>20795.45</b>
	T <sub>dn</sub>	kN <b>23326.70</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	$\text{mm}^2$	44100.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	$\text{mm}^2$	30840.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	$\text{mm}^2$	31500.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	$\text{mm}^2$	20580.00	
	$T_{db1}$	kN	11862.01	
	$T_{db2}$	kN	12415.42	
Min. of above	$T_{db}$	kN	<b>11862.01</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>11862.01</b> <b>safe</b>	
Design of Lacing (for Top and Bottom face)				
Arrangement of Lacing				
Total Length of member		mm	5000.00	
Radius of Gyration		mm	320.28	
slenderness Ratio			15.61	
Width of Lacing		mm	125.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thickness of Lacing		mm	14.14	
Provided Thickness of Lacing			26.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			320.28	
Slenderness Ratio			3.12	
			<	50.00
			<	10.93
Check			<b>OK</b>	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	19960.68	
Design Axial Force for lacing ( 2.5 %)		kN	499.02	
No. of Shear Planes		(N)	1.00	
Transverse Shear				
For Single Lacing System		kN	249.51	
For Double Lacing System		kN	124.75	
Force acting on Each Lacing plate				
For Single Lacing System		kN	352.86	
For Double Lacing System		kN	176.43	
Min. Radius of gyration of lacing		mm	7.51	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			94.21	< 140
fc (for buckling Class c )		Mpa	115.40	
Compressive strength		kN	375.05	
Check			<b>OK</b>	
Tensile Strength				
Due to Rupture		kN	959.40	
Due to Gross Yeilding		kN	738.64	
		min	738.64	
			<b>OK</b>	

**Calculation for weld Length**

Minimum thickness of weld	mm	3
Size of weld provided	mm	8
Ultimate stress of weld material	Mpa	250
Design strength of weld	$f_{wd}$ N/mm	538.8602512
Compressive Force in lacing bar	kN	352.8583046
Length of weld required	mm	654.8234052
Available Length of Weld	mm	478.5533906

**Lacing using angle section(double lacing back to back)**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000
Radius of Gyration	mm	320.28
slenderness Ratio		15.61134008
width of angle leg		70
Size of angle	mm	70*70*10
Angle of Lacing	Degree	45
Effective Horizontal span for lacing	mm	500
Effective Length of Lacing Angle	mm	707.1067812
Provided Thickness of Lacing		10
Effective Length for Local Buckling	mm	1000
Radius of Gyration		320.28
Slenderness Ratio		3.122268015
		< 50
		< 10.9279381
Check		OK

**Design Force in Lacing**

Max Axial Force	kN	19960.68
Design Axial Force for lacing ( 2.5 %)	kN	499.017
No. of Shear Planes	(N)	2
Transverse Shear		
For Single Lacing System	kN	249.5085
Force acting on Each Lacing plate		
For Single Lacing System	kN	249.5085
Min. Radius of gyration of lacing	mm	20.21
Effective Length of Lacing	mm	707.1067812
Slenderness ratio of lacing		34.98796542
$f_{cd}$ (for buckling Class c )	Mpa	204.5
Area	mm <sup>2</sup>	2604
Compressive strength	kN	532.518
Check		OK
Tensile Strength		
Due to Rupture	kN	413.28
Due to Gross Yielding	kN	318.1818182
	min	318.1818182
		OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3
Size of weld provided		mm	6
Ultimate stress of weld material		Mpa	250
Design strength of weld	$f_{wd}$	N/mm	404.1451884
Compressive Force in lacing bar		kN	249.5085
Length of weld required		mm	617.373427
Available Length of Weld		mm	267.9898987

**Top Chord (TC)****R-3****Compression check**

Force acting on member (Refer results)	C	kN	<b>22413.00</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	104400.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	1.1E+10
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	1.2E+10
Radius of gyration y-y	r <sub>y</sub>	mm	3.18E+02
Radius of gyration z-z	r <sub>z</sub>	mm	334.77
	k	-	0.65
	l	mm	5000.00
Eff. Elngth	k*I	mm	3250.00
slenderness ratio ( $\lambda$ )	k*I/r <sub>y</sub>		10.23

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	<b>227.00</b>
	kN	<b>23698.80</b>
Check		<b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>0.30</b>
Partial safety factors	( $\gamma_{m0}$ )		1.10
	( $\gamma_{m1}$ )		1.25
	( $\gamma_{mb}$ )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			2.00
No. of bolts in Each row			9.00
No. of rows			9.00
Pitch Provided		mm	75.00
Gauge Provided		mm	75.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critrical section		bolts	18.00
Thickness of member	t <sub>1</sub>	mm	20.00
	t <sub>2</sub>	mm	25.00
Area of bolts hole provided	A <sub>b</sub>		10530.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	104400.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	93870.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>m0</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

Tensile strength due to Bolk shear min of following:

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>m0</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>ta</sub> *f <sub>y</sub> )/Y <sub>m0</sub>	
	T <sub>dg</sub>	kN <b>23727.27</b>
	T <sub>dn</sub>	kN <b>27710.42</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	29475.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	19530.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	27000.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	17640.00	
	$T_{db1}$	kN	9075.03	
	$T_{db2}$	kN	9465.03	
Min. of above	$T_{db}$	kN	9075.03	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	9075.03 safe	
Design of Lacing (for Top and Bottom face)				
Arrngement of Lacing				
Total Length of member		mm	5000.00	
Radius of Gyration		mm	317.60	
slenderness Ratio			15.74	
Width of Lacing		mm	130.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thickness of Lacing		mm	14.14	
Provided Thickness of Lacing			28.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			298.92	
Slenderness Ratio			3.35	
			<	50.00
			<	11.02
Check			OK	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	22413.00	
Design Axial Force for lacing ( 2.5 %)		kN	560.33	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	280.16	
For Double Lacing System		kN	140.08	
Force acting on Each Lacing plate				
For Single Lacing System		kN	396.21	
For Double Lacing System		kN	198.10	
Min. Radius of gyration of lacing		mm	8.08	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			87.48	< 140
fcd (for buckling Class c )		Mpa	115.21	
Compressive strength		kN	419.36	
Check			OK	
Tensile Strength				
Due to Rupture		kN	1074.53	
Due to Gross Yeilding		kN	827.27	
		min	827.27	
			OK	



**Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	8.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	538.86
Compressive Force in lacing bar	kN	396.21
Length of weld required	mm	735.27
Available Length of Weld	mm	497.70

**Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000.00
Radius of Gyration	mm	317.60
slenderness Ratio		15.74
width of angle leg		80.00
Size of angle	mm	80*80*12
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		12.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		317.60
Slenderness Ratio		3.15
		< 50
		< 11.02
Check		OK

min 8mm is  
mandatory**Design Force in Lacing**

Max Axial Force	kN	22413.00
Design Axial Force for lacing ( 2.5 %)	kN	560.33
No. of Shear Planes	(N)	1.00
Transverse Shear		
For Single Lacing System	kN	280.16
Force acting on Each Lacing plate		
For Single Lacing System	kN	396.21
Min. Radius of gyration of lacing	mm	22.96
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		30.80
$f_{cd}$ (for buckling Class c )	Mpa	211.00
Area	mm <sup>2</sup>	3562
Compressive strength	kN	751.58

Check OK

Tensile Strength

Due to Rupture	kN	566.78
Due to Gross Yielding	kN	436.36
	min	436.36

OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	396.21
Length of weld required		mm	980.36
Available Length of Weld		mm	306.27

**Bottom Chord (BC)**  
**R-4,5,6**

**Compression check**

Force acting on member (Refer results)	C	kN	0.31
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	96100.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	9.9E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	1.1E+10
Radius of gyration y-y	r <sub>y</sub>	mm	3.21E+02
Radius of gyration z-z	r <sub>z</sub>	mm	3.32E+02
	k	-	0.65
	l	mm	5000.00
Eff. Elngth	k*l	mm	3250.00
slenderness ratio (λ)	k*l/r <sub>y</sub>		10.13

Corresponding to buckling class c as it is a built up member corresponds to table 9  
( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	227.00
	kN	21814.70
Check		safe

**Check for tension**

Max force in member	T	kN	12725.00
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			2.00
No. of bolts in Each row			8.00
No. of rows			7.00
Pitch Provided		mm	100.00
Gauge Provided		mm	100.00
End Distance		mm	65.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	16.00
Thickness of member	t <sub>1</sub>	mm	32.00
	t <sub>2</sub>	mm	32.00
Area of bolts hole provided	A <sub>b</sub>		13312.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	96100.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	82788.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

Tensile strength due to Bolk shear min of following:

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> /Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tq</sub> *f <sub>y</sub> )/Y <sub>mo</sub>	
T <sub>dg</sub>	kN	21840.91
T <sub>dn</sub>	kN	24439.02

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	42560.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	31744.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	44800.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	33152.00	
	$T_{db1}$	kN	15371.19	
	$T_{db2}$	kN	15592.23	
Min. of above	$T_{db}$	kN	15371.19	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	15371.19 safe	

## # Design of Lacing (for Top and Bottom face)

## Arrangement of Lacing

Total Length of member	mm	5000.00	
Radius of Gyration	mm	320.95	
slenderness Ratio		15.58	
Width of Lacing	mm	100.00	
Angle of Lacing	Degree	45.00	
Effective Horizontal span for lacing	mm	500.00	
Effective Length of Lacing Plate	mm	707.11	
Required min. Thickness of Lacing	mm	14.14	
Provided Thickness of Lacing		24.00	
Effective Length for Local Buckling	mm	1000.00	
Radius of Gyration		320.95	
Slenderness Ratio		3.12	
		<	50.00
		<	10.91
Check		OK	

**Design Force in Lacing**

Max Axial Force	kN	12725.00	
Design Axial Force for lacing ( 2.5 %)	kN	318.13	
No. of Shear Planes	(N)	2.00	
Transverse Shear			
For Single Lacing System	kN	159.06	
For Double Lacing System	kN	79.53	
Force acting on Each Lacing plate			
For Single Lacing System	kN	224.95	
For Double Lacing System	kN	112.47	
Min. Radius of gyration of lacing	mm	6.93	
Effective Length of Lacing	mm	707.11	
Slenderness ratio of lacing		102.06	< 140
fcd (for buckling Class c )	Mpa	94.00	
Compressive strength	kN	225.60	
Check		OK	
Tensile Strength			
Due to Rupture	kN	708.48	
Due to Gross Yeilding	kN	545.45	
	min	545.45	
		OK	

# **Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	8.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	538.86
Compressive Force in lacing bar	kN	224.95
Length of weld required	mm	417.45
Available Length of Weld	mm	382.84

2 **Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000
Radius of Gyration	mm	320.95
slenderness Ratio		15.57875058
width of angle leg		80.00
Size of angle	mm	80*80*12
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500
Effective Length of Lacing Angle	mm	707.1067812
Provided Thickness of Lacing		12 min 8mm is mandatory
Effective Length for Local Buckling	mm	1000
Radius of Gyration		320.95
Slenderness Ratio		3.115750117
		< 50
		< 10.905125
Check		OK

**Design Force in Lacing**

Max Axial Force	kN	12725
Design Axial Force for lacing ( 2.5 %)	kN	318.125
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	159.0625
Force acting on Each Lacing plate		
For Single Lacing System	kN	224.9483448
Min. Radius of gyration of lacing	mm	14.75
Effective Length of Lacing	mm	707.1067812
Slenderness ratio of lacing		47.93944279
$f_{cd}$ (for buckling Class c )	Mpa	183
Area	mm <sup>2</sup>	1781
Compressive strength	kN	325.923

Check OK

Tensile Strength

Due to Rupture	kN	283.392
Due to Gross Yielding	kN	218.1818182
	min	218.1818182
		Check

**2 Calculation for weld Length**

Minimum thickness of weld		mm	3
Size of weld provided		mm	6
Ultimate stress of weld material		Mpa	250
Design strength of weld	$f_{wd}$	N/mm	404.1451884
Compressive Force in lacing bar		kN	224.9483448
Length of weld required		mm	556.6028032
Available Length of Weld		mm	306.27417

**Main Diagonals-1**  
**R-7**

**Compression check**

Force acting on member (Refer results)	C	kN	<b>6021.75</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	37520
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	2.4E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	3.4E+09
Radius of gyration y-y	r <sub>y</sub>	mm	2.51E+02
Radius of gyration z-z	r <sub>z</sub>	mm	3.00E+02
	k	-	0.65
	l	mm	7071.00
Eff. Elngth	k*I	mm	4596.15
slenderness ratio (λ)	k*I/r <sub>y</sub>		18.33

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	222.00
	kN	<b>8329.44</b>
Check		<b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>4563.12</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			2.00
No. of rows			12.00
Pitch Provided		mm	85.00
Gauge Provided		mm	70.00
End Distance		mm	65.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	8.00
Thickness of member	t	mm	25.00
Area of bolts hole provided	A <sub>b</sub>		5200.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	37520.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	32320.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> /Y <sub>mo</sub> )	
	T <sub>dg</sub>	kN <b>8527.27</b>
	T <sub>dn</sub>	kN <b>9540.86</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	100000.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	70100.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	15000.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	11100.00	
	$T_{db1}$	kN	16398.70	
	$T_{db2}$	kN	15356.85	
Min. of above	$T_{db}$	kN	<b>15356.85</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>8527.27</b> <b>safe</b>	
Design of Lacing (for Top and Bottom face)				
Arrngement of Lacing				
Total Length of member		mm	7071.00	
Radius of Gyration		mm	250.71	
slenderness Ratio			28.20	
Width of Lacing		mm	100.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thichness of Lacing		mm	14.14	
Provided Thichness of Lacing			16.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			250.71	
Slenderness Ratio			3.99	
			<	50.00
			<	19.74
Check			<b>OK</b>	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	6021.75	
Design Axial Force for lacing ( 2.5 %)		kN	150.54	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	75.27	
For Double Lacing System		kN	37.64	
Force acting on Each Lacing plate				
For Single Lacing System		kN	106.45	
For Double Lacing System		kN	53.23	
Min. Radius of gyration of lacing		mm	4.62	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			153.09	< 140
fcd (for buckling Class c )		Mpa	69.37	
Compressive strength		kN	110.99	
Check			<b>OK</b>	
Tensile Strength				
Due to Rupture		kN	472.32	
Due to Gross Yeilding		kN	363.64	
		min	363.64	
			<b>OK</b>	



**Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	106.45
Length of weld required	mm	263.40
Available Length of Weld	mm	382.84

**Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	7071.00
Radius of Gyration	mm	250.71
slenderness Ratio		28.20
width of angle leg		65.00
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		8.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		250.71
Slenderness Ratio		3.99
		< 50
		< 19.74
Check		OK

min 8mm is mandatory

**Design Force in Lacing**

Max Axial Force	kN	6021.75
Design Axial Force for lacing ( 2.5 %)	kN	150.54
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	75.27
Force acting on Each Lacing plate		
For Single Lacing System	kN	106.45
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		37.10
$f_{cd}$ (for buckling Class c )	Mpa	207.00
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	202.03

Check OK

Tensile Strength

Due to Rupture	kN	153.50
Due to Gross Yeilding	kN	118.18
	min	118.18

OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	106.45
Length of weld required		mm	263.40
Available Length of Weld		mm	248.85

**Main Diagonals-2**  
**R-8,R-9**

**Compression check**

Force acting on member (Refer results)	C	kN	<b>4066.69</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	23120
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	1.5E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	2.1E+09
Radius of gyration y-y	r <sub>y</sub>	mm	2.53E+02
Radius of gyration z-z	r <sub>z</sub>	mm	302.27
	k	-	0.65
	l	mm	7071.00
Eff. Elngth	k*l	mm	4596.15
slenderness ratio (λ)	k*l/r <sub>y</sub>		18.13

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	224.60
	kN	<b>5192.75</b>
Check		<b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>2962.18</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			2.00
No. of rows			12.00
Pitch Provided		mm	85.00
Gauge Provided		mm	80.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	8.00
Thickness of member	t	mm	15.00
Area of bolts hole provided	A <sub>b</sub>		3120.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	23120.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	20000.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> /Y <sub>mo</sub> )	
	T <sub>dg</sub>	kN <b>5254.55</b>
	T <sub>dn</sub>	kN <b>5904.00</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	59400.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	41460.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	8400.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	6060.00	
	$T_{db1}$	kN	9583.37	
	$T_{db2}$	kN	8975.48	
Min. of above	$T_{db}$	kN	8975.48	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	5254.55	
			safe	
# Design of Lacing (for Top and Bottom face)				
Arrangement of Lacing				
Total Length of member		mm	7071.00	
Radius of Gyration		mm	253.49	
slenderness Ratio			27.89	
Width of Lacing		mm	100.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thichness of Lacing		mm	14.14	
Provided Thichness of Lacing			16.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			61.58	
Slenderness Ratio			16.24	
			<	50.00
			<	19.53
Check			OK	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	4066.69	
Design Axial Force for lacing ( 2.5 %)		kN	101.67	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	50.83	
For Double Lacing System		kN	25.42	
Force acting on Each Lacing plate				
For Single Lacing System		kN	71.89	
For Double Lacing System		kN	35.94	
Min. Radius of gyration of lacing		mm	4.62	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			153.09	< 140
fcd (for buckling Class c )		Mpa	69.37	
Compressive strength		kN	110.99	
Check			OK	
Tensile Strength				
Due to Rupture		kN	472.32	
Due to Gross Yeilding		kN	363.64	
		min	363.64	
			OK	

# Calculation for weld Length

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	71.89
Length of weld required	mm	177.88
Provide Length of Weld	mm	382.84

# Lacing using angle section

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	7071.00
Radius of Gyration	mm	253.49
slenderness Ratio		27.89
width of angle leg		65.00
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		8.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		253.49
Slenderness Ratio		3.94
		< 50
		< 19.53
Check		OK

min 8mm is mandatory

Design Force in Lacing

Max Axial Force	kN	4066.69
Design Axial Force for lacing ( 2.5 %)	kN	101.67
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	50.83
Force acting on Each Lacing plate		
For Single Lacing System	kN	71.89
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		37.10
$f_{cd}$ (for buckling Class c )	Mpa	201.77
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	196.93

Check OK

Tensile Strength

Due to Rupture	kN	153.50
Due to Gross Yeilding	kN	118.18
	min	118.18
		OK

# Calculation for weld Length

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	71.89
Length of weld required		mm	177.88
Available Length of Weld		mm	248.85

Vertical member**7 Compression check**

Force acting on member (Refer results)	C	kN	<b>2306.56</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	37520
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	2.4E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	3.4E+09
Radius of gyration y-y	r <sub>y</sub>	mm	250.71
Radius of gyration z-z	r <sub>z</sub>	mm	3.00E+02
	k	-	0.65
	l	mm	10000.00
Eff. length	k*l	mm	6500.00
slenderness ratio ( $\lambda$ )	k*l/r <sub>y</sub>		25.93

Corresponding to buckling class c as it is a built up member corresponds to table 9  
( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	226.00
	kN	<b>8479.52</b>
Check		<b>safe</b>

**7 Check for tension**

Max force in member	T	kN	<b>7955.26</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			2.00
No. of rows			4.00
Pitch Provided		mm	85.00
Gauge Provided		mm	75.00
End Distance		mm	65.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	8.00
Thickness of member	t	mm	25.00
Area of bolts hole provided	A <sub>b</sub>		5200.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	37520.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	32320.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> /Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> /Y <sub>mo</sub> )	
T <sub>dg</sub>	kN	8527.27
T <sub>dn</sub>	kN	9540.86

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	32000.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	22900.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	15000.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	11100.00	
	$T_{db1}$	kN	7475.75	
	$T_{db2}$	kN	7312.14	
Min. of above	$T_{db}$	kN	7312.14	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	7312.14	not safe
# Design of Lacing (for Top and Bottom face)				
Arrngement of Lacing				
Total Length of member		mm	10000.00	
Radius of Gyration		mm	250.71	
slenderness Ratio			39.89	
Width of Lacing		mm	80.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thickness of Lacing		mm	14.14	
Provided Thickness of Lacing			16.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			298.92	
Slenderness Ratio			3.35	
			<	50.00
			<	27.92
Check			OK	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	2306.56	
Design Axial Force for lacing ( 2.5 %)		kN	57.66	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	28.83	
For Double Lacing System		kN	14.42	
Force acting on Each Lacing plate				
For Single Lacing System		kN	40.77	
For Double Lacing System		kN	20.39	
Min. Radius of gyration of lacing		mm	4.62	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			153.09	< 140
fcd (for buckling Class c )		Mpa	69.38	
Compressive strength		kN	88.80	
Check			OK	
Tensile Strength				
Due to Rupture		kN	377.86	
Due to Gross Yeilding		kN	290.91	
		min	290.91	
			OK	



# Calculation for weld Length

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	40.77
Length of weld required	mm	100.89
Provide Length of Weld	mm	306.27

# Lacing using angle section

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	10000.00
Radius of Gyration	mm	250.71
slenderness Ratio		39.89
width of angle leg		65.00
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		8.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		250.71
Slenderness Ratio		3.99
		< 50
		< 27.92
Check		OK

min 8mm is  
mandatoryDesign Force in Lacing

Max Axial Force	kN	2306.56
Design Axial Force for lacing ( 2.5 %)	kN	57.66
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	28.83
Force acting on Each Lacing plate		
For Single Lacing System	kN	40.77
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		37.10
$f_{cd}$ (for buckling Class c )	Mpa	201.77
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	196.93

Check OK

Tensile Strength

Due to Rupture	kN	153.50
Due to Gross Yeilding	kN	118.18
	min	118.18

OK

# Calculation for weld Length

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	40.77
Length of weld required		mm	100.89
Available Length of Weld		mm	248.85

**Main Vertical (V2)****8 Compression check**

Force acting on member (Refer results)	C	kN	<b>2973.33</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	23120.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	1.5E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	2.1E+09
Radius of gyration y-y	r <sub>y</sub>	mm	2.54E+02
Radius of gyration z-z	r <sub>z</sub>	mm	302.27
	k	-	0.65
	l	mm	10000.00
Eff. Elngth	k*l	mm	6500.00
slenderness ratio ( $\lambda$ )	k*l/r <sub>y</sub>		25.64

Corresponding to buckling class c as it is a built up member corresponds to table 9 ( c ) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	226.00
	kN	<b>5225.12</b>
Check		<b>safe</b>

**8 Check for tension**

Max force in member	T	kN	<b>3178.27</b>
Partial safety factors	( $\gamma_{mo}$ )		1.10
	( $\gamma_{m1}$ )		1.25
	( $\gamma_{mb}$ )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			1.00
No. of rows			3.00
Pitch Provided		mm	100.00
Gauge Provided		mm	85.00
End Distance		mm	70.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	4.00
Thickness of member	t	mm	15.00
Area of bolts hole provided	A <sub>b</sub>		1560.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	23120.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	21560.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/( $\gamma_{mo}$ )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/( $\gamma_{m1}$ )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> /Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> /Y <sub>mo</sub>	
T <sub>dg</sub>	kN	5254.55
T <sub>dn</sub>	kN	6364.51

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	16200.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	12300.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	4200.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	3420.00	
	$T_{db1}$	kN	3135.35	
	$T_{db2}$	kN	3050.94	
Min. of above	$T_{db}$	kN	<b>3050.94</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>3050.94</b> <b>not safe</b>	

# **Design of Lacing (for Top and Bottom face)**

Arrngement of Lacing				
Total Length of member	mm	10000.00		
Radius of Gyration	mm	253.50		
slenderness Ratio		39.45		
Width of Lacing	mm	80.00		
Angle of Lacing	Degree	45.00		
Effective Horizontal span for lacing	mm	500.00		
Effective Length of Lacing Plate	mm	707.11		
Required min. Thickness of Lacing	mm	14.14		
Provided Thickness of Lacing		18.00		
Effective Length for Local Buckling	mm	1000.00		
Radius of Gyration		298.92		
Slenderness Ratio		3.35		
		<	50.00	
		<	27.61	
Check		<b>OK</b>		

**Design Force in Lacing**

Max Axial Force	kN	2973.33		
Design Axial Force for lacing ( 2.5 %)	kN	74.33		
No. of Shear Planes	(N)	2.00		
Transverse Shear				
For Single Lacing System	kN	37.17		
For Double Lacing System	kN	18.58		
Force acting on Each Lacing plate				
For Single Lacing System	kN	52.56		
For Double Lacing System	kN	26.28		
Min. Radius of gyration of lacing	mm	5.20		
Effective Length of Lacing	mm	707.11		
Slenderness ratio of lacing		136.08	< 140	
fcd (for buckling Class c )	Mpa	69.38		
Compressive strength	kN	99.90		
Check		<b>OK</b>		
Tensile Strength				
Due to Rupture	kN	425.09		
Due to Gross Yeilding	kN	327.27		
	min	327.27		
		<b>OK</b>		

**1 Calculation for weld Length**

Minimum thickness of weld	mm	3
Size of weld provided	mm	6
Ultimate stress of weld material	Mpa	250
Design strength of weld	$f_{wd}$ N/mm	404.145188
Compressive Force in lacing bar	kN	52.5615451
Length of weld required	mm	130.056095
Provide Length of Weld	mm	306.27417

**2 Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	10000
Radius of Gyration	mm	253.5
slenderness Ratio		39.4477318
width of angle leg		65
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45
Effective Horizontal span for lacing	mm	500
Effective Length of Lacing Angle	mm	707.106781
Provided Thickness of Lacing		8
Effective Length for Local Buckling	mm	1000
Radius of Gyration		253.5
Slenderness Ratio		3.94477318
		< 50
		< 27.613412
Check		OK

min 8mm is mandatory

**Design Force in Lacing**

Max Axial Force	kN	2973.33
Design Axial Force for lacing ( 2.5 %)	kN	74.33325
No. of Shear Planes	(N)	2
Transverse Shear		
For Single Lacing System	kN	37.166625
Force acting on Each Lacing plate		
For Single Lacing System	kN	37.166625
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	707.106781
Slenderness ratio of lacing		37.0989917
$f_{cd}$ (for buckling Class c )	Mpa	201.77
Area	mm <sup>2</sup>	976
Compressive strength	kN	196.92752

Check OK

Tensile Strength

Due to Rupture	kN	153.504
Due to Gross Yielding	kN	118.181818
	min	118.181818

OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3
Size of weld provided		mm	6
Ultimate stress of weld material		Mpa	250
Design strength of weld	$f_{wd}$	N/mm	404.145188
Compressive Force in lacing bar		kN	37.166625
Length of weld required		mm	91.9635469
Available Length of Weld		mm	248.847763

**End Raker (ER)****3 Compression check**

Force acting on member (Refer results)	C	kN	<b>16007.00</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	81750.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	8.0E+09
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	9.3E+09
Radius of gyration y-y	r <sub>y</sub>	mm	3.13E+02
Radius of gyration z-z	r <sub>z</sub>	mm	3.38E+02
	k	-	0.65
	l	mm	14142.00
Eff. Elngth	k*I	mm	9192.30
slenderness ratio (λ)	k*I/r <sub>y</sub>		29.40

Corresponding to buckling class c as it is a built up member corresponds to table 9  
( c) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	225.60
	kN	<b>18442.80</b>
Check		<b>safe</b>

**3 Check for tension**

Max force in member	T	kN	<b>4208.44</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			2.00
No. of bolts in Each row			8.00
No. of rows			8.00
Pitch Provided		mm	75.00
Gauge Provided		mm	75.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at crittical section		bolts	16.00
Thickness of member	t <sub>1</sub>	mm	20.00
	t <sub>2</sub>	mm	25.00
Area of bolts hole provided	A <sub>b</sub>		9360.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	81750.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	72390.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> )/Y <sub>mo</sub>	
T <sub>dg</sub>	kN	18579.55
T <sub>dn</sub>	kN	21369.53

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	26100.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	17325.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	23625.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	15435.00	
	$T_{db1}$	kN	7981.25	
	$T_{db2}$	kN	8322.17	
Min. of above	$T_{db}$	kN	<b>7981.25</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>7981.25</b> <b>safe</b>	
# Design of Lacing (for Top and Bottom face)				
Arrngement of Lacing				
Total Length of member		mm	3535.50	
Radius of Gyration		mm	312.62	
slenderness Ratio			11.31	
Width of Lacing		mm	120.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	450.00	
Effective Length of Lacing Plate		mm	636.40	
Required min. Thichness of Lacing		mm	12.73	
Provided Thichness of Lacing			22.00	
Effective Length for Local Buckling		mm	900.00	
Radius of Gyration			298.92	
Slenderness Ratio			3.01	
			<	50.00
			<	7.92
Check			<b>OK</b>	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	16007.00	
Design Axial Force for lacing ( 2.5 %)		kN	400.18	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	200.09	
For Double Lacing System		kN	100.04	
Force acting on Each Lacing plate				
For Single Lacing System		kN	282.97	
For Double Lacing System		kN	141.48	
Min. Radius of gyration of lacing		mm	6.35	
Effective Length of Lacing		mm	636.40	
Slenderness ratio of lacing			100.21	< 140
fcd (for buckling Class c )		Mpa	118.39	
Compressive strength		kN	312.55	
Check			<b>OK</b>	
Tensile Strength				
Due to Rupture		kN	779.33	
Due to Gross Yeilding		kN	600.00	
		min	600.00	
			<b>OK</b>	



**Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	8.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	538.86
Compressive Force in lacing bar	kN	282.97
Length of weld required	mm	525.12
Available Length of Weld	mm	459.41

**4 Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	3535.5
Radius of Gyration	mm	312.62
slenderness Ratio		11.3092572
width of angle leg		65
Size of angle	mm	65*65*10
Angle of Lacing	Degree	45
Effective Horizontal span for lacing	mm	450
Effective Length of Lacing Angle	mm	636.396103
Provided Thickness of Lacing		10
Effective Length for Local Buckling	mm	900
Radius of Gyration		312.62
Slenderness Ratio		2.8788945
		< 50
		< 7.9164801
Check		OK

min 8mm is mandatory

**Design Force in Lacing**

Max Axial Force	kN	16007
Design Axial Force for lacing ( 2.5 %)	kN	400.175
No. of Shear Planes	(N)	2
Transverse Shear		
For Single Lacing System	kN	200.0875
Force acting on Each Lacing plate		
For Single Lacing System	kN	282.966456
Min. Radius of gyration of lacing	mm	18.63
Effective Length of Lacing	mm	636.396103
Slenderness ratio of lacing		34.1597479
$f_{cd}$ (for buckling Class c )	Mpa	204.5
Area	mm <sup>2</sup>	2400
Compressive strength	kN	490.8
Check		OK

Tensile Strength

Due to Rupture	kN	383.76
Due to Gross Yielding	kN	295.454545
	min	295.454545
		OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3
Size of weld provided		mm	6
Ultimate stress of weld material		Mpa	250
Design strength of weld	$f_{wd}$	N/mm	404.145188
Compressive Force in lacing bar		kN	282.966456
Length of weld required		mm	700.160398
Available Length of Weld		mm	248.847763

TI

**Top lateral members**

<b>12.1 Type of Section</b>	Plastic or Semi Compact		<b>100*100*8</b>
Plastic Section Modulus	Z <sub>py</sub>	mm <sup>3</sup>	2209023.18
	Z <sub>pz</sub>	mm <sup>3</sup>	1316055.54
(For semi Compact or Plastic Sections)	β <sub>b</sub>		1.00
	f <sub>y</sub>		250.00
Partial Safety Factor (CL - IRC : 503.4)	Y <sub>m0</sub>		1.10
	N	kN	43.39
	M <sub>y</sub>	kNm	17.03
	M <sub>z</sub>	kNm	175.78
Design Bending Strength	M <sub>dv</sub>	kNm	502.05
	M <sub>dvz</sub>	kNm	299.10
Cross Section Area	A	mm <sup>2</sup>	7612.00
	N <sub>d</sub>	kN	1730.00
	$(N/N_d) + (M_y/M_{dy}) + (M_z/M_{dz})$		0.65
	Check		<b>OK</b>
<b>12.2 Design of Lacing (for Top and Bottom face)</b>			
Arrangement of Lacing			
Total Length of member	mm		12800.00
Radius of Gyration	mm		175.01
slenderness Ratio			73.14
Width of Lacing	mm		80.00
Angle of Lacing	Degree		45.00
Effective Horizontal span for lacing	mm		550.00
Effective Length of Lacing Plate	mm		777.82
Required min. Thickness of Lacing	mm		15.56
Provided Thickness of Lacing			20.00
Effective Length for Local Buckling	mm		1100.00
Radius of Gyration			298.92
Slenderness Ratio			3.68
			< 50.00
			< 51.20
Check			<b>OK</b>

**Design Force in Lacing**

Max Axial Force	kN	1730.00	
Design Axial Force for lacing ( 2.5 %)	kN	43.25	
No. of Shear Planes	(N)	2.00	
Transverse Shear			
For Single Lacing System	kN	21.63	
For Double Lacing System	kN	10.81	
Force acting on Each Lacing plate			
For Single Lacing System	kN	30.58	
For Double Lacing System	kN	15.29	
Min. Radius of gyration of lacing	mm	5.77	
Effective Length of Lacing	mm	777.82	
Slenderness ratio of lacing		134.72	< 140
fcd (for buckling Class c )	Mpa	70.48	
Compressive strength	kN	112.76	
Check		OK	
Tensile Strength			
Due to Rupture	kN	472.32	
Due to Gross Yeilding	kN	363.64	
	min	363.64	OK

12.3 **Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	30.58
Length of weld required	mm	75.67
Provide Length of Weld	mm	306.27

## 12.4 Lacing using angle section

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	12800.00
Radius of Gyration	mm	175.01
slenderness Ratio		73.14

width of angle leg		65.00
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	550.00
Effective Length of Lacing Angle	mm	777.82

Provided Thickness of Lacing		8.00
Effective Length for Local Buckling	mm	1100.00
Radius of Gyration		175.01
Slenderness Ratio		6.29

min 8mm  
is  
mandator  
y

&lt; 50

&lt; 51.20

Check **OK**

**Design Force in Lacing**

Max Axial Force	kN	1730.00
Design Axial Force for lacing ( 2.5 %)	kN	43.25
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	21.63
Force acting on Each Lacing plate		
For Single Lacing System	kN	30.14
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	777.82
Slenderness ratio of lacing		40.81
$f_{cd}$ (for buckling Class c )	Mpa	196.80
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	192.08
Check		OK
Tensile Strength		
Due to Rupture	kN	153.50
Due to Gross Yielding	kN	118.18
	min	118.18
		OK

**12.5 Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	30.14
Length of weld required	mm	74.57
Available Length of Weld	mm	248.85

**Top Cross bracing**# **Compression check**

Force acting on member (Refer results)	C	kN	<b>374.11</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	7612.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	2.3E+08
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	6.8E+08
Radius of gyration y-y	r <sub>y</sub>	mm	1.75E+02
Radius of gyration z-z	r <sub>z</sub>	mm	298.95
	k	-	0.65
	l	mm	8122.00
Eff. Elngth	k*l	mm	5279.30
slenderness ratio (λ)	k*l/r <sub>y</sub>		30.17

Corresponding to buckling class c as it is a built up member corresponds to table 9  
( c) pg-42 IS 800-2007

	F <sub>cd</sub>	N/mm <sup>2</sup>	210.80
Design compressive strength		kN	<b>1604.61</b>
	Check		<b>safe</b>

# **Check for tension**

Max force in member	T	kN	<b>3.31</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			1.00
No. of rows			3.00
Pitch Provided		mm	70.00
Gauge Provided		mm	70.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	4.00
Thickness of member	t	mm	10.00
Area of bolts hole provided	A <sub>b</sub>		1040.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	7612.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	6572.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tq</sub> *f <sub>y</sub> /Y <sub>mo</sub> )

$T_{dg}$	kN	<b>1730.00</b>
$T_{dn}$	kN	<b>1940.05</b>



Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	7800.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	5200.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	2200.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	1680.00	
	$T_{db1}$	kN	1519.45	
	$T_{db2}$	kN	1386.28	
Min. of above	$T_{db}$	<b>kN</b>	<b>1386.28</b>	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	<b>1386.28</b> <b>safe</b>	

## # Design of Lacing (for Top and Bottom face)

## Arrngement of Lacing

Total Length of member	mm	8122.00	
Radius of Gyration	mm	175.01	
slenderness Ratio		46.41	
Width of Lacing	mm	80.00	
Angle of Lacing	Degree	45.00	
Effective Horizontal span for lacing	mm	550.00	
Effective Length of Lacing Plate	mm	777.82	
Required min. Thickness of Lacing	mm	15.56	
Provided Thickness of Lacing		20.00	
Effective Length for Local Buckling	mm	1100.00	
Radius of Gyration		298.92	
Slenderness Ratio		3.68	
		<	50.00
		<	32.49
Check		<b>OK</b>	

**Design Force in Lacing**

Max Axial Force	kN	374.11	
Design Axial Force for lacing ( 2.5 %)	kN	9.35	
No. of Shear Planes	(N)	2.00	
Transverse Shear			
For Single Lacing System	kN	4.68	
For Double Lacing System	kN	2.34	
Force acting on Each Lacing plate			
For Single Lacing System	kN	6.61	
For Double Lacing System	kN	3.31	
Min. Radius of gyration of lacing	mm	5.77	
Effective Length of Lacing	mm	777.82	
Slenderness ratio of lacing		134.72	< 140
fcd (for buckling Class c )	Mpa	70.50	
Compressive strength	kN	112.80	
Check		<b>OK</b>	
Tensile Strength			
Due to Rupture	kN	472.32	
Due to Gross Yeilding	kN	363.64	
	min	363.64	

# **Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	6.61
Length of weld required	mm	16.36
Provide Length of Weld	mm	306.27

# **Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	8122.00	
Radius of Gyration	mm	175.01	
slenderness Ratio		46.41	
		0.00	
width of angle leg		65.00	
Size of angle	mm	65*65*8	
Angle of Lacing	Degree	45.00	
Effective Horizontal span for lacing	mm	550.00	
Effective Length of Lacing Angle	mm	777.82	
Provided Thickness of Lacing		8.00	min 8mm is mandatory
Effective Length for Local Buckling	mm	1100.00	
Radius of Gyration		175.01	
Slenderness Ratio		6.29	
		<	50
		<	32.49
Check		OK	

**Design Force in Lacing**

Max Axial Force	kN	374.11
Design Axial Force for lacing ( 2.5 %)	kN	9.35
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	4.68
Force acting on Each Lacing plate		
For Single Lacing System	kN	4.68
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	777.82
Slenderness ratio of lacing		40.81
$f_{cd}$ (for buckling Class c )	Mpa	198.00
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	193.25
Check		OK
Tensile Strength		
Due to Rupture	kN	153.50
Due to Gross Yielding	kN	118.18
	min	118.18
		OK

# Calculation for weld Length

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	4.68
Length of weld required		mm	11.57
Available Length of Weld		mm	248.85

**Bottom Cross bracing (2Ls 150x150x10)**# **Compression check**

Force acting on member (Refer results)	C	kN	<b>1226.88</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	13356.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	3.6E+07
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	6.9E+07
Radius of gyration y-y	r <sub>y</sub>	mm	5.22E+01
Radius of gyration z-z	r <sub>z</sub>	mm	7.21E+01
	k	-	0.65
	l	mm	8122.00
Eff. Elngth	k*I	mm	5279.30
slenderness ratio ( $\lambda$ )	k*I/r <sub>y</sub>		101.17

Corresponding to buckling class c as it is a built up member corresponds to table 9  
( c) pg-42 IS 800-2007

	F <sub>cd</sub>	N/mm <sup>2</sup>	227.00
		kN	<b>3031.81</b>
<b><u>Design compressive strength</u></b>	Check		<b>safe</b>

# **Check for tension**

Max force in member	T	kN	<b>1616.31</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of Faces			1.00
No. of bolts in Each row			4.00
No. of rows			4.00
Pitch Provided		mm	100.00
Gauge Provided		mm	90.00
End Distance		mm	75.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critcal section		bolts	<b>4.00</b>
Thickness of member	t	mm	15.00
Area of bolts hole provided	A <sub>b</sub>		1560.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	13356.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	11796.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

	$T_{db1}$	$((A_{vg} * f_y) / (1.732 * Y_{mo})) + ((0.9 * A_{tn} * f_u) / Y_{m1})$		
	$T_{db2}$	$(0.9 * A_{vn} * f_u / 1.732 * Y_{m1}) + (A_{tg} * f_y) / Y_{mo}$		
	$T_{dg}$	kN	<b>3035.45</b>	
	$T_{dn}$	kN	<b>3482.18</b>	
Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	5625.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	4260.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	5175.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	3810.00	
	$T_{db1}$	kN	1862.82	
	$T_{db2}$	kN	1902.21	
Min. of above	$T_{db}$	<b>kN</b>	<b>1862.82</b>	min.
<u><b>Design tension strength</b></u>	$T_d$	kN	<b>1862.82</b> <b>safe</b>	

**HORZ. MEMBER****Compression check**

Force acting on member (Refer results)	C	kN	<b>1883.57</b>
Section properties ( refer annexure -A)			
Area	A	mm <sup>2</sup>	9036.00
Moment of Inertia y-y	I <sub>y</sub>	mm <sup>4</sup>	2.8E+08
Moment of Inertia z-z	I <sub>z</sub>	mm <sup>4</sup>	8.0E+08
Radius of gyration y-y	r <sub>y</sub>	mm	174.49
Radius of gyration z-z	r <sub>z</sub>	mm	2.98E+02
	k	-	0.65
	l	mm	5000.00
Eff. Elngth	k*l	mm	3250.00
slenderness ratio (λ)	k*l/r <sub>y</sub>		18.63

Corresponding to buckling class c as it is a built up member corresponds to table 9 (c) pg-42 IS 800-2007

**Design compressive strength**

F <sub>cd</sub>	N/mm <sup>2</sup>	224.41
	kN	<b>2027.77</b>
Check		<b>safe</b>

**Check for tension**

Max force in member	T	kN	<b>142.47</b>
Partial safety factors	(Y <sub>mo</sub> )		1.10
	(Y <sub>m1</sub> )		1.25
	(Y <sub>mb</sub> )		1.25
	f <sub>y</sub>	Mpa	250.00
	f <sub>u</sub>	Mpa	410.00
For bolts of grade 10.9	f <sub>ub</sub>	Mpa	1040.00
Bolt value		kN	124.80
Bolt Arrangement			
No. of angles			4.00
No. of bolts in Each row			1.00
No. of rows			3.00
Pitch Provided		mm	70.00
Gauge Provided		mm	70.00
End Distance		mm	55.00
Dia. Of Bolt Provided		mm	24.00
Dia. Of hole Provided		mm	26.00
No. of bolts at critical section		bolts	4.00
Thickness of member	t	mm	12.00
Area of bolts hole provided	A <sub>b</sub>		1248.00
Provide 24 mm bolts in number in n lines at a pitch of (p) and edge distance (e)			
Provide gross area of built up section	A <sub>g</sub>	mm <sup>2</sup>	9036.00
Net area	A <sub>n</sub>	mm <sup>2</sup>	7788.00

**Design tension strength**

	T <sub>d</sub>	Min of T <sub>dg</sub> and T <sub>dn</sub>
Tensile strength due to yeilding	T <sub>dg</sub>	(A <sub>g</sub> *f <sub>y</sub> )/(Y <sub>mo</sub> )
Tensile strength due to rupture	T <sub>dn</sub>	(0.9*A <sub>n</sub> *f <sub>u</sub> )/(Y <sub>m1</sub> )

**Tensile strength due to Bolk shear min of following:**

T <sub>db1</sub>	((A <sub>vg</sub> *f <sub>y</sub> )/(1.732*Y <sub>mo</sub> ))+((0.9*A <sub>tn</sub> *f <sub>u</sub> )/Y <sub>m1</sub> )	
T <sub>db2</sub>	(0.9*A <sub>vn</sub> *f <sub>u</sub> /1.732*Y <sub>m1</sub> )+(A <sub>tg</sub> *f <sub>y</sub> /Y <sub>mo</sub> )	
	T <sub>dg</sub>	kN <b>2053.64</b>
	T <sub>dn</sub>	kN <b>2299.02</b>

Min. Gross area in shear along bolt line parallel to ext force	$A_{vg}$	mm <sup>2</sup>	9360.00	
Min. Net area in shear along bolt line parallel to ext. force	$A_{vn}$	mm <sup>2</sup>	6240.00	
Min. Gross area in tension from bolt hole to the toe of angle ,end bolt line, perpendicular to line of force	$A_{tg}$	mm <sup>2</sup>	2640.00	
Min. Net area in tension from bolt hole to the toe of angle ,end bolt line,perpendicular to line of force	$A_{tn}$	mm <sup>2</sup>	2016.00	
	$T_{db1}$	kN	1823.34	
	$T_{db2}$	kN	1663.54	
Min. of above	$T_{db}$	kN	1663.54	min.
<b><u>Design tension strength</u></b>	$T_d$	kN	1663.54 safe	
Design of Lacing (for Top and Bottom face)				
Arrngement of Lacing				
Total Length of member		mm	5000.00	
Radius of Gyration		mm	174.49	
slenderness Ratio			28.65	
Width of Lacing		mm	80.00	
Angle of Lacing		Degree	45.00	
Effective Horizontal span for lacing		mm	500.00	
Effective Length of Lacing Plate		mm	707.11	
Required min. Thichness of Lacing		mm	14.14	
Provided Thichness of Lacing			16.00	
Effective Length for Local Buckling		mm	1000.00	
Radius of Gyration			298.92	
Slenderness Ratio			3.35	
			<	50.00
			<	20.06
Check			OK	
<b><u>Design Force in Lacing</u></b>				
Max Axial Force		kN	1883.57	
Design Axial Force for lacing ( 2.5 %)		kN	47.09	
No. of Shear Planes		(N)	2.00	
Transverse Shear				
For Single Lacing System		kN	23.54	
For Double Lacing System		kN	11.77	
Force acting on Each Lacing plate				
For Single Lacing System		kN	33.30	
For Double Lacing System		kN	16.65	
Min. Radius of gyration of lacing		mm	4.62	
Effective Length of Lacing		mm	707.11	
Slenderness ratio of lacing			153.09	< 140
$f_{cd}$ (for buckling Class c )		Mpa	93.00	
Compressive strength		kN	119.04	
Check			OK	
Tensile Strength				
Due to Rupture		kN	377.86	
Due to Gross Yeilding		kN	290.91	
		min	290.91	
			OK	

# **Calculation for weld Length**

Minimum thickness of weld	mm	3.00
Size of weld provided	mm	6.00
Ultimate stress of weld material	Mpa	250.00
Design strength of weld	$f_{wd}$ N/mm	404.15
Compressive Force in lacing bar	kN	33.30
Length of weld required	mm	82.39
Provide Length of Weld	mm	306.27

**Lacing using angle section**

Design of Lacing (for Top and Bottom face)

Arrangement of Lacing

Total Length of member	mm	5000.00
Radius of Gyration	mm	174.49
slenderness Ratio		28.65
width of angle leg		65.00
Size of angle	mm	65*65*8
Angle of Lacing	Degree	45.00
Effective Horizontal span for lacing	mm	500.00
Effective Length of Lacing Angle	mm	707.11
Provided Thickness of Lacing		8.00
Effective Length for Local Buckling	mm	1000.00
Radius of Gyration		174.49
Slenderness Ratio		5.73
		< 50
		< 20.06
Check		OK

min 8mm is  
mandatory**Design Force in Lacing**

Max Axial Force	kN	1883.57
Design Axial Force for lacing ( 2.5 %)	kN	47.09
No. of Shear Planes	(N)	2.00
Transverse Shear		
For Single Lacing System	kN	23.54
Force acting on Each Lacing plate		
For Single Lacing System	kN	23.54
Min. Radius of gyration of lacing	mm	19.06
Effective Length of Lacing	mm	707.11
Slenderness ratio of lacing		37.10
$f_{cd}$ (for buckling Class c )	Mpa	201.00
Area	mm <sup>2</sup>	976.00
Compressive strength	kN	196.18
Check		OK

Tensile Strength

Due to Rupture	kN	153.50
Due to Gross Yeilding	kN	118.18
	min	118.18
		OK

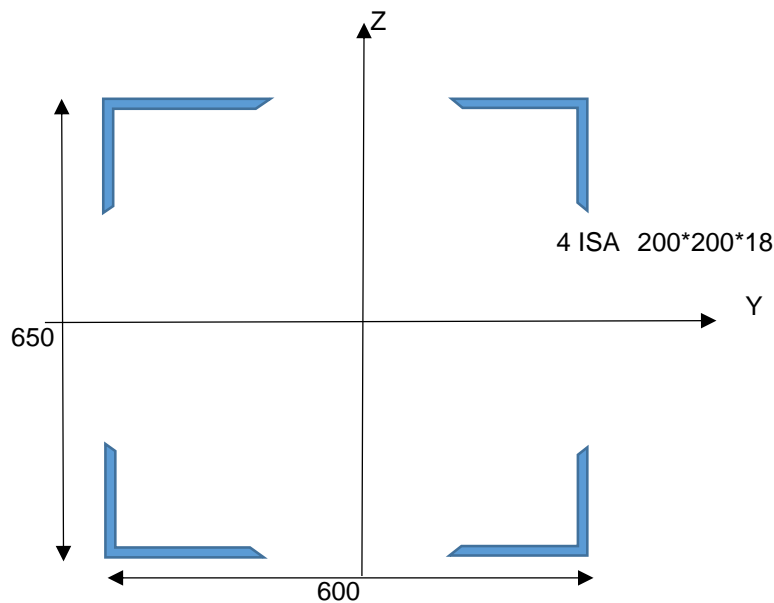


**Calculation for weld Length**

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	6.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	$f_{wd}$	N/mm	404.15
Compressive Force in lacing bar		kN	23.54
Length of weld required		mm	58.26
Available Length of Weld		mm	248.85

**KNEE BRACING**

<b><u>Type of Section</u></b>	<b>Plastic or Semi Compact</b>		<b>200*200*18</b>
Plastic Section Modulus  (For semi Compact or Plastic Sections)	Z <sub>py</sub>	mm <sup>3</sup>	6759350.81
	Z <sub>pz</sub>	mm <sup>3</sup>	7353274.03
	β <sub>b</sub>		1.00
	f <sub>y</sub>		250.00
	Y <sub>m0</sub>		1.10
Partial Safety Factor (CL - IRC : 503.4)	N	kN	3237.58
	M <sub>y</sub>	kNm	196.90
	M <sub>z</sub>	kNm	78.39
	M <sub>dv<sub>y</sub></sub>	kNm	1536.22
	M <sub>dv<sub>z</sub></sub>	kNm	1671.20
Cross Section Area	A	mm <sup>2</sup>	27524
	N <sub>d</sub>	kN	6255.45
$(N/N_d) + (M_y/M_{dy}) + (M_z/M_{dz})$			0.69
Check			OK

**Design of Lacing (for Top and Bottom face)**

Arrangement of Lacing	size	100x12
Total Length of Lateral member	mm	13100.00
Radius of Gyration	mm	252.63
Max slenderness Ratio		51.85
Dia of Rivet Hole		0.00
Width of Lacing	mm	100.00
Angle of Lacing	Degree	45.00
Required min. Thickness of Lacing	mm	10.54
Provided Thickness of Lacing		12.00
Effective Horizontal span for lacing	mm	298.00
Inclined Length of Lacing	mm	596.00
Radius of Gyration	mm	21.12
Slenderness Ratio	l/r	28.22
	criteria 1	< 50.00
	criteria 2	< 36.30
Check		OK

**Design Force in Lacing**

Max Axial Force		kN	809.40
Design Axial Force for lacing ( 2.5 %)		kN	20.23
Transverse Shear in Each Plane		kN	10.12
Force acting on Lacing plate			14.31
Min. Radius of gyration of lacing		mm	3.46
Effective Length of Lacing		mm	421.44
Slenderness ratio of lacing			121.66
fcd (for buckling Class c )		Mpa	82.14
Compressive strength		kN	86.54
criteria	>	14.308	check OK
Tensile Strength			
Due to Rupture		kN	216.00
Due to Gross Yeilding		kN	272.73
criteria	>	14.308	check OK

**Calculation for weld Length**

Minimum thickness of weld		mm	3.00
Size of weld provided		mm	8.00
Ultimate stress of weld material		Mpa	250.00
Design strength of weld	fwd	M/mm	538.86
Compressive Force in lacing bar		kN	572.33
Length of weld required		mm	1062.11
Provide Length of Weld		mm	1112.11

**STADD INPUT FOR 80 M TRUSS**

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 07-July-16

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

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8 20 0 0; 9 25 0 0; 10 30 0 0; 11 35 0 0; 12 40 0 0; 13 45 0 0; 14 50 0 0;  
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#### MEMBER INCIDENCES

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DEFINE MATERIAL START  
 ISOTROPIC STEEL  
 E 2.05e+008  
 POISSON 0.3  
 DENSITY 76.8195  
 ALPHA 1.2e-005  
 DAMP 0.03  
 TYPE STEEL  
 STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2  
 ISOTROPIC CONCRETE  
 E 2.17185e+007  
 POISSON 0.17  
 DENSITY 23.5616  
 ALPHA 1e-005  
 DAMP 0.05  
 TYPE CONCRETE  
 STRENGTH FCU 27579  
 END DEFINE MATERIAL  
 MEMBER PROPERTY AMERICAN  
 54 56 69 70 79 80 87 89 102 103 112 113 638 TO 640 642 TO 644 652 -  
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 IZ 0.003835 YD 0.1644 ZD 0.0988 YB 1e-005 ZB 1e-005  
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 IZ 0.00326 YD 0.1705 ZD 0.1101 YB 1e-005 ZB 1e-005  
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 43 PRIS AX 0.052416 AY 0.052416 AZ 0.052416 IX 1e-007 IY 0.001518 -  
 IZ 0.003487 YD 0.1667 ZD 0.1082 YB 1e-005 ZB 1e-005  
 81 82 114 115 197 TO 200 219 TO 226 245 TO 247 -  
 248 PRIS AX 0.024728 AY 0.024728 AZ 0.024728 IX 1e-007 IY 0.0005114 -  
 IZ 0.0007531 YD 0.1523 ZD 0.1034 YB 1e-005 ZB 1e-005  
 201 TO 204 215 TO 218 227 TO 230 241 TO 243 -  
 244 PRIS AX 0.016012 AY 0.016012 AZ 0.016012 IX 1e-007 IY 0.000258 -  
 IZ 0.000519 YD 0.1621 ZD 0.0921 YB 1e-005 ZB 1e-005  
 205 206 209 TO 214 231 232 235 TO 239 -  
 240 PRIS AX 0.007752 AY 0.007752 AZ 0.007752 IX 1e-007 IY 4.148e-005 -  
 IZ 0.0002586 YD 0.1668 ZD 0.0535 YB 1e-005 ZB 1e-005  
 52 53 85 86 173 185 186 613 615 TO 617 -  
 618 PRIS AX 0.032424 AY 0.032424 AZ 0.032424 IX 1e-007 IY 0.0004406 -  
 IZ 0.0009531 YD 0.1 ZD 0.0535 YB 1e-005 ZB 1e-005  
 58 59 67 68 91 92 100 101 171 172 175 183 184 187 195 -

196 PRIS AX 0.021224 AY 0.021224 AZ 0.021224 IX 1e-007 IY 0.0003262 -  
 IZ 0.0006511 YD 0.1534 ZD 0.08784 YB 1e-005 ZB 1e-005  
 60 61 65 66 93 94 98 99 176 177 181 182 188 189 193 -  
 194 PRIS AX 0.015624 AY 0.015624 AZ 0.015624 IX 1e-007 IY 0.0002691 -  
 IZ 0.0004777 YD 0.1529 ZD 0.09841 YB 1e-005 ZB 1e-005  
 62 TO 64 95 TO 97 178 TO 180 190 TO 191 -  
 192 PRIS AX 0.008072 AY 0.008072 AZ 0.008072 IX 1e-007 IY 5.268e-005 -  
 IZ 0.0002709 YD 0.16783 ZD 0.05933 YB 1e-005 ZB 1e-005  
 118 120 122 124 -  
 126 PRIS AX 0.004552 AY 0.004552 AZ 0.004552 IX 1e-007 IY 1.563e-005 -  
 IZ 0.000216 YD 0.19984 ZD 0.0458 YB 1e-005 ZB 1e-005  
 116 117 119 121 123 125 127 132 138 140 142 144 146 401 411 -  
 631 PRIS AX 0.004552 AY 0.004552 AZ 0.004552 IX 1e-007 IY 5.29e-006 -  
 IZ 0.000216 YD 0.19984 ZD 0.0145 YB 1e-005 ZB 1e-005  
 147 TO 169 -  
 170 PRIS AX 0.003806 AY 0.003806 AZ 0.003806 IX 1e-007 IY 5.31e-006 -  
 IZ 8.63e-006 YD 0.0254 ZD 0.01721 YB 1e-005 ZB 1e-005  
 446 TO 476 -  
 477 PRIS AX 0.005012 AY 0.005012 AZ 0.005012 IX 1e-007 IY 1.231e-005 -  
 IZ 1.75e-005 YD 0.0313 ZD 0.0235 YB 1e-005 ZB 1e-005  
 207 208 233 -  
 234 PRIS AX 0.007552 AY 0.007552 AZ 0.007552 IX 1e-007 IY 2.126e-005 -  
 IZ 0.000247 YD 0.1633 ZD 0.03753 YB 1e-005 ZB 1e-005  
 17 249 TO 332 429 TO 445 479 TO 483 485 487 489 491 493 495 497 499 501 503 -  
 505 507 509 511 513 515 517 519 521 523 525 527 529 531 533 535 537 539 541 -  
 543 545 547 TO 549 551 553 555 557 559 561 563 565 567 569 571 573 575 577 -  
 579 581 583 585 587 589 591 593 595 597 599 601 603 605 607 609 -  
 611 PRIS AX 0.037524 AY 0.037524 AZ 0.037524 IX 1e-007 IY 0.0001974 -  
 IZ 0.006392 YD 0.3407 ZD 0.0257 YB 1e-005 ZB 1e-005  
 333 TO 395 -  
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 YD 0.2076 ZD 0.0175 YB 1e-005 ZB 1e-005  
 MEMBER PROPERTY AMERICAN  
 484 486 488 490 492 494 496 498 500 502 504 506 508 510 512 514 516 518 520 -  
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 562 564 566 568 570 572 574 576 578 580 582 584 586 588 590 592 594 596 598 -  
 600 602 604 606 608 610 -  
 612 PRIS AX 2.5e-006 AY 2.5e-006 AZ 2.5e-006 IX 1e-007 IY 4.32e-006 -  
 IZ 4.25e-006 YD 2e-005 ZD 0.0003 YB 1e-005 ZB 1e-005  
 MEMBER PROPERTY AMERICAN  
 645 TO 651 654 TO 659 -  
 660 PRIS AX 0.002276 AY 0.002276 AZ 0.002276 IX 1e-007 IY 1.126e-005 -  
 IZ 2.64e-005 YD 0.0145 ZD 0.02381 YB 1e-005 ZB 1e-005  
 CONSTANTS  
 MATERIAL STEEL ALL  
 SUPPORTS  
 1 PINNED  
 3 FIXED BUT FZ MX MY MZ  
 4 FIXED BUT FX FZ MX MY MZ  
 2 FIXED BUT FX MX MY MZ



5 TO 12 14 TO 64 FIXED BUT FX FY MX MY  
 MEMBER RELEASE  
 1 TO 16 34 TO 49 52 TO 54 56 58 TO 82 85 TO 87 89 91 TO 115 171 TO 173 175 -  
 176 TO 248 613 615 TO 618 638 TO 640 642 TO 644 652 653 START MX MY MZ  
 1 TO 16 34 TO 49 52 TO 54 56 58 TO 82 85 TO 87 89 91 TO 115 171 TO 173 175 -  
 176 TO 248 613 615 TO 618 638 TO 640 642 TO 644 652 653 END MX MY MZ  
 DEFINE MOVING LOAD  
 TYPE 1 LOAD 85 85 85 85 60 60 40  
 DIST 1.37 3.055 1.37 2.13 1.52 3.96 WID 1.97  
 TYPE 2 LOAD 34 34 34 34 57 57 13.5 13.5  
 DIST 3 3 3 4.3 1.2 3.2 1.1 WID 1.8  
 TYPE 3 LOAD 85 85 85 85 60 60 40 85 85 85 85 60 60 40  
 DIST 1.37 3.05 1.37 2.13 1.52 3.96 30 1.37 3.05 1.37 2.13 1.52 3.96 WID 1.97  
 TYPE 4 LOAD 34 34 34 34 57 57 13.5 13.5 34 34 34 34 57 57 13.5 13.5  
 DIST 3 3 3 4.3 1.2 3.2 1.1 20 3 3 3 4.3 1.2 3.2 1.1 WID 1.8  
 TYPE 5 LOAD 90 47.5 -  
 47.5 30  
 DIST 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 -  
 1.5 5.389 1.37 3.2 -  
 WID 2.55  
 DEFINE WIND LOAD  
 TYPE 1 WIND 1  
 <! STAAD PRO GENERATED DATA DO NOT MODIFY !!!  
 ASCE-7-2010:PARAMS 30.500 M/SEC 0 1 1 0 0.000 FT 0.000 FT 0.000 FT 1 -  
 1 23.000 M 12.800 M 80.000 M 2.000 0.050 2 -  
 0 0 0 0 0.912 1.000 1.000 0.850 0 -  
 0 0 0 0.803 -0.700 0.550  
 !> END GENERATED DATA BLOCK  
 INT -0.491824 -0.491824 HEIG 0 23  
 EXP -1 JOINT 1 TO 64 66 68 70 72 74 76 TO 170 173 178 183 TO 277  
 LOAD 1 LOADTYPE Dead TITLE DEAD  
 SELFWEIGHT Y -1.4  
 LOAD 2 LOADTYPE Live TITLE RAILING AND KERB  
 MEMBER LOAD  
 484 488 492 496 500 504 508 512 516 520 524 528 532 536 540 544 552 556 560 -  
 564 568 572 576 580 584 588 592 596 600 604 608 612 UNI GY -10  
 LOAD 3 LOADTYPE Live TITLE DECK SLAB  
 MEMBER LOAD  
 253 TO 327 430 TO 444 483 485 487 489 491 493 495 497 499 501 503 505 507 -  
 509 511 513 515 517 519 521 523 525 527 529 531 533 535 537 539 541 549 551 -  
 553 555 557 559 561 563 565 567 569 571 573 575 577 579 581 583 585 587 589 -  
 591 593 595 597 599 601 603 605 607 UNI GY -28.725  
 249 TO 252 328 TO 331 429 445 479 481 482 543 547 609 UNI GY -14.36  
 LOAD 4 LOADTYPE Live TITLE W.C  
 MEMBER LOAD  
 253 TO 327 430 TO 444 483 485 487 489 491 493 495 497 499 501 503 505 507 -  
 509 511 513 515 517 519 521 523 525 527 529 531 533 535 537 539 541 549 551 -  
 553 555 557 559 561 563 565 567 569 571 573 575 577 579 581 583 585 587 589 -  
 591 593 595 597 599 601 603 605 607 UNI GY -9.375  
 249 TO 252 328 TO 331 429 445 479 481 482 543 547 609 UNI GY -4.69

LOAD GENERATION 350 ADD LOAD 3  
TYPE 3 -56.8 0 4.45 XINC 0.5  
LOAD GENERATION 350 ADD LOAD 3  
TYPE 3 -56.8 0 7.7 XINC 0.5  
LOAD GENERATION 350  
TYPE 4 -57.6 0 3.109 XINC 0.5  
TYPE 4 -57.6 0 6.609 XINC 0.5  
TYPE 4 -57.6 0 10.109 XINC 0.5  
LOAD GENERATION 350  
TYPE 4 -57.6 0 5.1 XINC 0.5  
TYPE 4 -57.6 0 8.6 XINC 0.5  
TYPE 4 -57.6 0 12.1 XINC 0.5  
LOAD GENERATION 240  
TYPE 5 -38.459 0 7.625 XINC 0.5  
LOAD GENERATION 240  
TYPE 5 -38.459 0 7.325 XINC 0.5  
LOAD GENERATION 300  
TYPE 4 -57.6 0 8.11 XINC 0.5  
LOAD GENERATION 300  
TYPE 4 -57.6 0 11.36 XINC 0.5  
PERFORM ANALYSIS  
PERFORM ANALYSIS PRINT ALL  
PERFORM ANALYSIS PRINT ALL  
FINISH

**STADD INPUT FOR 80 M TRUSS( WIND , SEISMIC AND TEMPERATURE)**

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 07-June-17

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 80 0 0; 3 0 0 12.8; 4 80 0 12.8; 5 5 0 0; 6 10 0 0; 7 15 0 0;  
8 20 0 0; 9 25 0 0; 10 30 0 0; 11 35 0 0; 12 40 0 0; 13 45 0 0; 14 50 0 0;  
15 55 0 0; 16 60 0 0; 17 65 0 0; 18 70 0 0; 19 75 0 0; 20 5 0 12.8;  
21 10 0 12.8; 22 15 0 12.8; 23 20 0 12.8; 24 25 0 12.8; 25 30 0 12.8;  
26 35 0 12.8; 27 40 0 12.8; 28 45 0 12.8; 29 50 0 12.8; 30 55 0 12.8;  
31 60 0 12.8; 32 65 0 12.8; 33 70 0 12.8; 34 75 0 12.8; 35 5 5 0; 36 10 10 0;  
37 70 10 0; 38 75 5 0; 39 15 10 0; 40 20 10 0; 41 25 10 0; 42 30 10 0;  
43 35 10 0; 44 40 10 0; 45 45 10 0; 46 50 10 0; 47 55 10 0; 48 60 10 0;  
49 65 10 0; 50 5 5 12.8; 51 10 10 12.8; 52 70 10 12.8; 53 75 5 12.8;  
54 15 10 12.8; 55 20 10 12.8; 56 25 10 12.8; 57 30 10 12.8; 58 35 10 12.8;  
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74 25 10 6.4; 76 15 10 6.4; 77 15 5 0; 78 15 5 12.8; 79 10 5 0; 80 70 5 0;  
81 20 5 0; 82 25 5 0; 83 30 5 0; 84 35 5 0; 85 40 5 0; 86 45 5 0; 87 50 5 0;  
88 55 5 0; 89 60 5 0; 90 65 5 0; 91 10 5 12.8; 92 70 5 12.8; 93 20 5 12.8;  
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99 50 5 12.8; 100 55 5 12.8; 101 60 5 12.8; 102 65 5 12.8; 103 0 0 2.5;  
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#### MEMBER INCIDENCES

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657 277 178; 658 277 37; 659 276 52; 660 276 277;

```

DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
TYPE STEEL
STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27579
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
54 56 69 70 79 80 87 89 102 103 112 113 638 TO 640 642 TO 644 652 -
653 PRIS AX 0.058316 AY 0.058316 AZ 0.058316 IX 1e-007 IY 0.001766 -
IZ 0.003835 YD 0.1644 ZD 0.0988 YB 1e-005 ZB 1e-005
71 72 77 78 104 105 110 -
111 PRIS AX 0.065516 AY 0.065516 AZ 0.065516 IX 1e-007 IY 0.00193 -
IZ 0.004196 YD 0.1601 ZD 0.099 YB 1e-005 ZB 1e-005
73 TO 76 106 TO 108 -
109 PRIS AX 0.074716 AY 0.074716 AZ 0.074716 IX 1e-007 IY 0.002042 -
IZ 0.004855 YD 0.1616 ZD 0.1466 YB 1e-005 ZB 1e-005
1 TO 4 13 TO 16 34 TO 37 46 TO 48 -
49 PRIS AX 0.035712 AY 0.035712 AZ 0.035712 IX 1e-007 IY 0.001137 -
IZ 0.002201 YD 0.1576 ZD 0.1062 YB 1e-005 ZB 1e-005
5 6 11 12 38 39 44 -
45 PRIS AX 0.047916 AY 0.047916 AZ 0.047916 IX 1e-007 IY 0.001433 -
IZ 0.00326 YD 0.1705 ZD 0.1101 YB 1e-005 ZB 1e-005
7 TO 10 40 TO 42 -
43 PRIS AX 0.052416 AY 0.052416 AZ 0.052416 IX 1e-007 IY 0.001518 -
IZ 0.003487 YD 0.1667 ZD 0.1082 YB 1e-005 ZB 1e-005
81 82 114 115 197 TO 200 219 TO 226 245 TO 247 -
248 PRIS AX 0.024728 AY 0.024728 AZ 0.024728 IX 1e-007 IY 0.0005114 -
IZ 0.0007531 YD 0.1523 ZD 0.1034 YB 1e-005 ZB 1e-005
201 TO 204 215 TO 218 227 TO 230 241 TO 243 -
244 PRIS AX 0.016012 AY 0.016012 AZ 0.016012 IX 1e-007 IY 0.000258 -
IZ 0.000519 YD 0.1621 ZD 0.0921 YB 1e-005 ZB 1e-005
205 206 209 TO 214 231 232 235 TO 239 -
240 PRIS AX 0.007752 AY 0.007752 AZ 0.007752 IX 1e-007 IY 4.148e-005 -
IZ 0.0002586 YD 0.1668 ZD 0.0535 YB 1e-005 ZB 1e-005
52 53 85 86 173 185 186 613 615 TO 617 -
618 PRIS AX 0.032424 AY 0.032424 AZ 0.032424 IX 1e-007 IY 0.0004406 -
IZ 0.0009531 YD 0.1 ZD 0.0535 YB 1e-005 ZB 1e-005
58 59 67 68 91 92 100 101 171 172 175 183 184 187 195 -

```

196 PRIS AX 0.021224 AY 0.021224 AZ 0.021224 IX 1e-007 IY 0.0003262 -  
 IZ 0.0006511 YD 0.1534 ZD 0.08784 YB 1e-005 ZB 1e-005  
 60 61 65 66 93 94 98 99 176 177 181 182 188 189 193 -  
 194 PRIS AX 0.015624 AY 0.015624 AZ 0.015624 IX 1e-007 IY 0.0002691 -  
 IZ 0.0004777 YD 0.1529 ZD 0.09841 YB 1e-005 ZB 1e-005  
 62 TO 64 95 TO 97 178 TO 180 190 TO 191 -  
 192 PRIS AX 0.008072 AY 0.008072 AZ 0.008072 IX 1e-007 IY 5.268e-005 -  
 IZ 0.0002709 YD 0.16783 ZD 0.05933 YB 1e-005 ZB 1e-005  
 118 120 122 124 -  
 126 PRIS AX 0.004552 AY 0.004552 AZ 0.004552 IX 1e-007 IY 1.563e-005 -  
 IZ 0.000216 YD 0.19984 ZD 0.0458 YB 1e-005 ZB 1e-005  
 116 117 119 121 123 125 127 132 138 140 142 144 146 401 411 -  
 631 PRIS AX 0.004552 AY 0.004552 AZ 0.004552 IX 1e-007 IY 5.29e-006 -  
 IZ 0.000216 YD 0.19984 ZD 0.0145 YB 1e-005 ZB 1e-005  
 147 TO 169 -  
 170 PRIS AX 0.003806 AY 0.003806 AZ 0.003806 IX 1e-007 IY 5.31e-006 -  
 IZ 8.63e-006 YD 0.0254 ZD 0.01721 YB 1e-005 ZB 1e-005  
 446 TO 476 -  
 477 PRIS AX 0.005012 AY 0.005012 AZ 0.005012 IX 1e-007 IY 1.231e-005 -  
 IZ 1.75e-005 YD 0.0313 ZD 0.0235 YB 1e-005 ZB 1e-005  
 207 208 233 -  
 234 PRIS AX 0.007552 AY 0.007552 AZ 0.007552 IX 1e-007 IY 2.126e-005 -  
 IZ 0.000247 YD 0.1633 ZD 0.03753 YB 1e-005 ZB 1e-005  
 17 249 TO 332 429 TO 445 479 TO 483 485 487 489 491 493 495 497 499 501 503 -  
 505 507 509 511 513 515 517 519 521 523 525 527 529 531 533 535 537 539 541 -  
 543 545 547 TO 549 551 553 555 557 559 561 563 565 567 569 571 573 575 577 -  
 579 581 583 585 587 589 591 593 595 597 599 601 603 605 607 609 -  
 611 PRIS AX 0.037524 AY 0.037524 AZ 0.037524 IX 1e-007 IY 0.0001974 -  
 IZ 0.006392 YD 0.3407 ZD 0.0257 YB 1e-005 ZB 1e-005  
 333 TO 395 -  
 396 PRIS AX 0.1828 AY 0.1828 AZ 0.1828 IX 1e-007 IY 3.35e-005 IZ 0.00117 -  
 YD 0.2076 ZD 0.0175 YB 1e-005 ZB 1e-005  
 MEMBER PROPERTY AMERICAN  
 484 486 488 490 492 494 496 498 500 502 504 506 508 510 512 514 516 518 520 -  
 522 524 526 528 530 532 534 536 538 540 542 544 546 550 552 554 556 558 560 -  
 562 564 566 568 570 572 574 576 578 580 582 584 586 588 590 592 594 596 598 -  
 600 602 604 606 608 610 -  
 612 PRIS AX 2.5e-006 AY 2.5e-006 AZ 2.5e-006 IX 1e-007 IY 4.32e-006 -  
 IZ 4.25e-006 YD 2e-005 ZD 0.0003 YB 1e-005 ZB 1e-005  
 MEMBER PROPERTY AMERICAN  
 645 TO 651 654 TO 659 -  
 660 PRIS AX 0.002276 AY 0.002276 AZ 0.002276 IX 1e-007 IY 1.126e-005 -  
 IZ 2.64e-005 YD 0.0145 ZD 0.02381 YB 1e-005 ZB 1e-005  
 CONSTANTS  
 MATERIAL STEEL ALL  
 SUPPORTS  
 1 PINNED  
 3 FIXED BUT FZ MX MY MZ  
 4 FIXED BUT FX FZ MX MY MZ  
 2 FIXED BUT FX MX MY MZ

# **Design of Cross girder**



## **CONTENTS**

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# Introduction

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Design Report of a End cross girder For Truss at various stages.

Code Refered

IRC: 24-2010

IS: 2062-2011

# Steel Design Data

## DESIGN OF PLATE GIRDER

### DIMENSIONAL PARAMETER

#### Dimensioning of web

Assuming girder is laterally supported throughout the span i.e stiffeners are provided

Assuming the web thickness	t2	mm	32.00
Depth of plate girder only	d	mm	850.00
Length of girder		mm	13318.00
Thickness of top flange plate -1	t1	mm	0.00
Thickness of top flange plate -2	t2	mm	32.00
Thickness of bottom flange plate -1	t3	mm	32.00
Thickness of bottom flange plate -2	t4	mm	0.00
Depth of web plate	dw	mm	786.00
Thickness of web	t5	mm	32.00
Assuming Spacing of Stiffener	c	mm	800.00

### BASIC PARAMETERS

Yield Strength of steel	(IS 2062:2011)	Fy	Mpa	250.00
Partial factor of safety for materials		$\gamma_m$		1.10
Proportioning of different Components				
Max permissible bending stress in tension or compression			Mpa	227.27

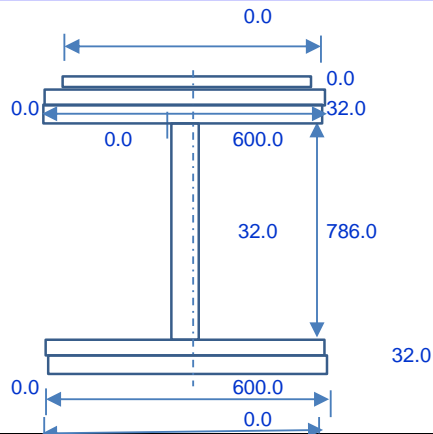
### Servicability Creteria

IRC 24-2010 ( clause 509.6)

SI.No	Case	Ref.	condition	Thk.	units	Value	check
1	Web connected to flange along both long. Edges	cl. 509.6	Service	$3d \geq C \geq d$ therefore(d/tw)	mm	24.6	OK
2			Buckling	$C \leq 1.5d$ therefore(d/tw)	mm	24.5625	OK

## Section Properties

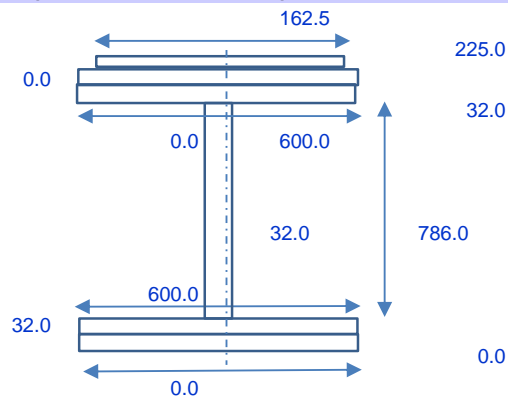
### Section properties (Steel Only)



S.No.	Breadth	Depth (D)	Area (A)	cg from TOP.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	I Z
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	0.00	0.00	0.00	0.00	0.00	425.00	0.00E+00	0.00E+00
2	0.00	0.00	0.00E+00	0.00	0.00E+00	425.00	0.00E+00	0.00E+00
3	600.00	32.00	1.92E+04	16.00	3.07E+05	409.00	3.21E+09	1.64E+06
4	32.00	786.00	2.52E+04	425.00	1.07E+07	0.00	0.00E+00	1.29E+09
5	600.00	32.00	1.92E+04	834.00	1.60E+07	409.00	3.21E+09	1.64E+06
6	0.00	0.00	0.00	850.00	0.00E+00	425.00	0.00E+00	0.00E+00
		850.00	6.36E+04		2.70E+07		6.42E+09	7.72E+09

Distance of cg. of comb. section from top	mm	425.0
MOI of comb. section about its centroidal axis	mm <sup>4</sup>	7.7E+09
Dist. of top fibre of slab from centroidal axis	mm	425.0
Dist. of Bottom fibre of slab from centroidal axis	mm	425.0
Moment of Inertia(about zz)	mm <sup>4</sup>	7.7E+09
Elastic section modulus (TOP)	mm <sup>3</sup>	1.82E+07
Plastic section modulus		
<u>Plastic section modulus</u>	Zp.zt	mm <sup>3</sup> <b>2.06E+07</b>

### SHORT TERM PROPERTIES (Steel with Deck slab)



Elem ent	Breadth	Depth (D)	Area (A)	cg from bott.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	IZ
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	162.50	225.00	3.66E+04	112.50	4.11E+06	341.20	4.26E+09	1.54E+08
2	0.00	0.00	0.00E+00	0.00	0.00E+00	453.70	0.00E+00	0.00E+00
3	600.00	32.00	1.92E+04	241.00	4.63E+06	212.70	8.69E+08	1.64E+06
4	32.00	786.00	2.52E+04	650.00	1.63E+07	-196.30	9.69E+08	1.29E+09
5	600.00	32.00	1.92E+04	1059.00	2.03E+07	605.30	7.03E+09	1.64E+06
6	0.00	0.00	0.00	0.00	0.00E+00	-453.70	0.00E+00	0.00E+00
		1075.00	1.00E+05	2.06E+03	4.54E+07		1.31E+10	1.46E+10

Distance of cg. of comb. section from bott.

mm 453.7

MOI of comb. section about its centroidal axis

mm<sup>4</sup> 1.5E+10

Dist. of top fibre of slab from centroidal axis

yt mm 453.7

Dist. of Bottom fibre of slab from centroidal axis

yb mm 621.3

Moment of Inertia(about zz)

lzz mm<sup>4</sup> 1.5E+10

Elastic section modulus (bottom)

Ze.zb mm<sup>3</sup> 2.3E+07

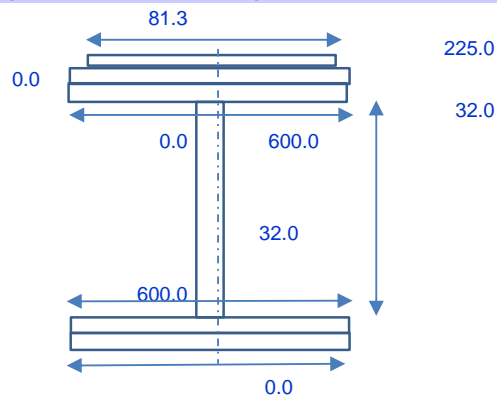
Elastic section modulus (top.)

Ze.zt mm<sup>3</sup> 3.2E+07

Plastic section modulus

Zp.zt mm<sup>3</sup> 2.99E+07

#### LONG TERM PROPERTIES (Steel with Deck slab)



Elem ent	Breadth	Depth (D)	Area (A)	cg from bott.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	I self
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	81.25	225.00	1.83E+04	112.50	2.06E+06	417.42	3.19E+09	7.71E+07
2	0.00	0.00	0.00E+00	0.00	0.00E+00	529.92	0.00E+00	0.00E+00
3	600.00	32.00	1.92E+04	241.00	4.63E+06	288.92	1.60E+09	1.64E+06
4	32.00	786.00	2.52E+04	650.00	1.63E+07	-120.08	3.63E+08	1.29E+09
5	600.00	32.00	1.92E+04	1059.00	2.03E+07	529.08	5.37E+09	1.64E+06
6	0.00	0.00	0.00	0.00	0.00E+00	-529.92	0.00E+00	0.00E+00
		1075.00	8.18E+04	2.06E+03	4.34E+07		1.05E+10	1.19E+10

Distance of cg. of comb. section from bott.

$\Sigma(A \times cg) / \Sigma A$  mm 529.9

MOI of comb. section about its centroidal axis

{AH<sup>2</sup> + Iself } mm<sup>4</sup> 1.2E+10

Dist. of top fibre of slab from centroidal axis

yt mm 529.9

Dist. of Bottom fibre of slab from centroidal axis

yb mm 545.1

Moment of Inertia(about zz)

lzz mm<sup>4</sup> 1.2E+10

Elastic section modulus (top.)

Ze.zt mm<sup>3</sup> 2.2E+07

Elastic section modulus (bottom)

Ze.zb mm<sup>3</sup> 2.2E+07

Plastic section modulus

Zp.zt mm<sup>3</sup> 2.79E+07



## Design of plate girder

### CHECK FOR SELF WEIGHT + GREEN CONC.

#### Bending Moment & Shear Force (BM & SF)

Self Weight of girder	extra 15%	kN / m	9.44
wet concrete		kN / m	18.98
Max. Bending Moment (BM)	due to self wt.	kN-m	193.25
	due to wet conc.	kN-m	388.80
Max. Shear Force (SF)	due to self wt.	kN	60.39
	due to wet conc.	kN	121.50

### CHECKS FOR SHEAR AND BENDING MOMENT

**V(factored design shear force )** **V** KN 181.89

**B.M(factored design bending moment)** **B.M** KNm 582.05

Calculation of Design shear strength

**(Post critical method )**

When transverse stiffeners are provided only at supports

	$k_v$	5.35
	for $c/d < 1.0$	9.16
	for $c/d > 1.0$	9.21
	$\gamma_{mo}$	1.10
Possion,s ratio	$\mu$	0.30
elastic critical shear stress of the web	$T_{cr}$	1.60E+03
shear buckling stress	$\lambda_w$	2.18
Shear stress corresponding to web bukling		
(a) when $\lambda_w \leq 0.8$	$T_b$	144.34
(b) when $0.8 < \lambda_w < 1.2$	$T_b$	-14.81
(c) when $\lambda_w \geq 1.2$	$T_b$	30.42
Shear force corrsponding to web bukling		
Critical shear strength(Vcr)	$A_w T_b$	KN 765.17
Nominal shear strength(Vr)		3300.44

**Design shear strength**

$V < .6V_d$  MPa 181.89

**LOW SHEAR**

< 1980.26

**SAFE**

**OK**

### Design bending strength of the section

clause 509.2.1.2

Md(design bending strength of the section) KNm 4692.72

Also,  $M_d \geq M_z$

**Md(design bending strength of the section)  $\geq$  Mz(Maximum bending moment)**

4692.72 > 582.05

**SAFE**

### CHECKS CONCEPTUAL DESIGN

**Check for the Local Capacity of the section -**

Table 2 -IRC 24-10

Yield stress ratio for flanges	$\epsilon$	Mpa	1.00
Yield stress ratio for web	$\epsilon$	Mpa	1.00
Top flange ratio	(PLASTIC)		8.88
Bottom flange ratio	(PLASTIC)		8.88
Web ratio			24.56

cond. : Web need stiffening and Web Buckling need to be checked

clause 509.6

## Design of Intermediate transverse Web Stiffeners -

Intermediate Stiffeners are not required

### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore  $(d/t_w)$  clause 509.6

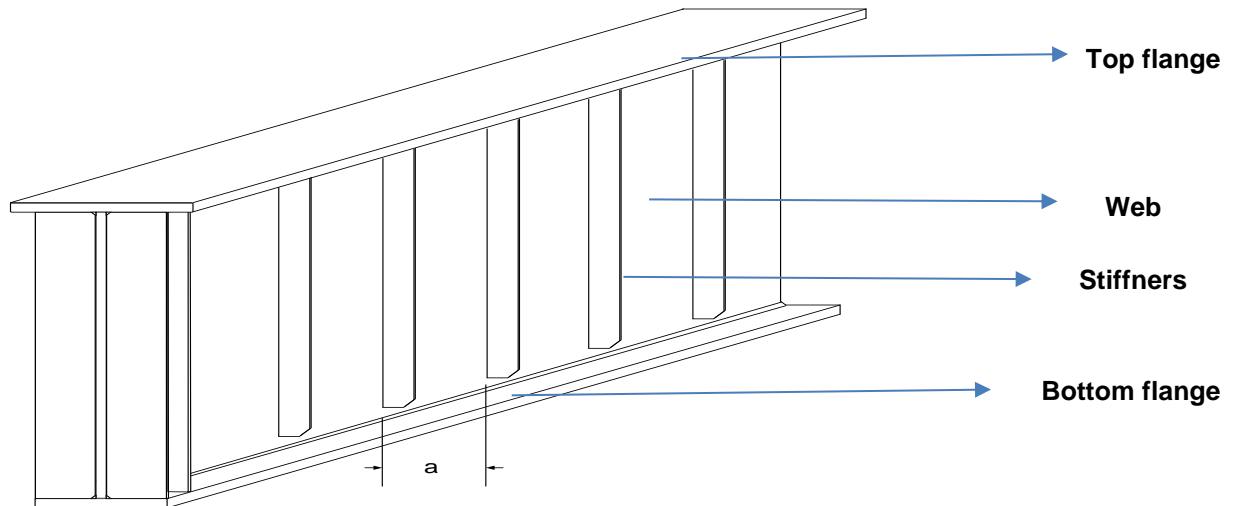
assume  $C$  = spacing of transverse stiffener

$d$  = depth of the web

Now,	$d$	mm	786.00
	$3*d$	mm	2358.00
assume	$c$	mm	800.00

### Check for minimum Stiffeners -

cl-509.7.2.4



Check	$c/d$	$\leq \sqrt{2}$	1.02
$I_{min}$	minimum moment of inertia required		

$I_{min}$  mm<sup>4</sup> 3.73E+07

Let a single stiffener on only one side of the web is provided

thickness of the plate stiffener

$t_s$  mm 16.00

outstand

$a$  mm 250.00

moment of inertia about face of the web

$t_s \times a^3/3$  mm<sup>4</sup> 8.33E+07

The stiffener has more than the minimum required stiffeners

ok

HENCE, provide 250mm x 16 mm as vertical web stiffener

Buckling resistance of the intermediate transvers stiffeners

IRC 24-2010 clause-509.7.1.5

Design as a strut

The effective length of web equal to  $20 \times t_w$  on each side of the centre line of the stiffener can be considered along with the stiffener

$20 \times t_w$  mm 640.00

MI about centre line of the stiffener

mm<sup>4</sup> 2.01E+08

Area

$a$  mm<sup>2</sup> 24480.00

radius of gyration

$\sqrt{I/A}$   $r_x$  mm 90.55

effective length

IRC 24-2010 clause 509.7.1.5

$L_{ef}$

$.7 \times L$  550.20

slenderness ratio

$L_{ef}/r_x$   $\lambda$  6.08

from table 4 IRC 24-2010

Buckling class

b

from table 6C IRC 24-2010

$f_{cd}$  Mpa 370.00



	buckling resistance	KN	9057.60
<b>Buckling check on intermediate transverse stiffeners</b>			
Factored shear force adjacent to the stiffener		clause 509.7.2.5	
	<b>v</b>	kN	181.89
	<b>Vcr</b>	kN	765.17
	<b>Fq</b>	kN	530.25
		<	9057.60
It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we, propose the couples of stiffeners at the c/c distance less than 20 tw for shearing the critical load in between two.			ok
<b>Check for outstand -</b>		clause 509.7.1.2	
Outstand of the stiffener max		mm	320.00
check	14tq		224.00
			HENCE OK

### Welding requirement for stiffener -

High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used

shear force on weld connecting the stiffener to web (q1) **CL-509.7.2.6**

**Shear force** N/mm 1.82E+05

The shear strength of the fillet weld(p)

Assume size of fillet weld p mm 10.00

permissible stress in fillet weld Mpa 131.00

throat thickness Tt mm 7.00

p 9170.00

The welding is done on both faces, than the weld length per metre length of plate

The required length of the weld for 1000mm length on each side

181891.0 x 1000 mm 9917.72

2 9170

52.81 mm/1000mm length

### Check for stresses

#### Check for Bending -

M Nmm 5.82E+08

Z mm 1.82E+07

**Maximum bending stress** 32.04

**HENCE OK**

#### Check for shear stress -

**Avg shear stress** Tva 7.23

≤ 131.22

**HENCE OK**

### Design of joint between Flange and Web -

Assuming fillet weld on each side of the web

Assume size of the fillet weld mm 10.00

Permissible strength of the fillet weld N/mm<sup>2</sup> 131.22

throat thickness mm 7.00

The shear strength of fillet weld p N/mm<sup>2</sup> 9185.39

first moment of area of top flange plate @c.g. Is

Q 0.00E+00

The shear flow q N/mm 125.90

providing 10mm fillet weld whose strength is 930.1 N/mm

be used at both faces, than the required length of weld for 1000mm length of girder is

weld length 125.90 x 1000

2 x 9185.387361 mm 6.85

253.76 mm/1000mm length **SAFE**

## Design of plate girder

### CHECK FOR SHORT TERM

#### CHECKS FOR SHEAR AND BENDING MOMENT

<b>V(factored design shear force )</b>	<b>V</b>	KN	1273.80
<b>B.M(factored design bending moment)</b>	<b>B.M</b>	KNm	2458.53
Calculation of Design shear strength (Post critical method ) When transverse stiffeners are provided only at supports			
	$k_v$		5.35
	for $c/d < 1.0$		9.16
	for $c/d > 1.0$		9.21
	$\gamma_{mo}$		1.10
Possion,s ratio	$\mu$		0.30
elastic critical shear stress of the web	$\tau_{cr}$		1.60E+03
shear buckling stress	$\lambda_w$		2.18
Shear stress corresponding to web bukling			
(a) when $\lambda_w \leq 0.8$	$\tau_b$		144.34
(b) when $0.8 < \lambda_w < 1.2$	$\tau_b$		-14.81
(c) when $\lambda_w \geq 1.2$	$\tau_b$		30.42
Shear force corrsponding to web bukling			
Critical shear strength( $V_{cr}$ )	$A_w \tau_b$	KN	765.17
Nominal shear strength( $V_r$ )			3300.44
			<b>SAFE</b>
<b>Design shear strength</b>	$V < .6V_d$	MPa	1273.80
	<b>LOW SHEAR</b>		< 1980.26
			<b>OK</b>

#### Design bending strength of the section

clause 509.2.1.2

Md(design bending strength of the section)		KNm	6787.28
Also, $M_d \geq M_z$			
<b>Md(design bending strength of the section) <math>\geq</math> Mz(Maximum bending moment)</b>	6787.28	>	2458.53
			<b>SAFE</b>

### CHECKS CONCEPTUAL DESIGN

<b>Check for the Local Capacity of the section -</b>		Table 2 -IRC 24-10
Top flange ratio	(PLASTIC)	8.88
Bottom flange ratio	(PLASTIC)	8.9
Web ratio		24.56
<b>cond. : Web need stiffening and Web Buckling need to be checked</b>		clause 509.6
<b>Design of Intermediate transverse Web Stiffeners -</b>		

#### Intermediate Stiffners are required

##### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore(d/tw) clause 509.6

assume C= spacing of transverse stiffener

d=depth of the web

Now,	d	mm	786.00
	3*d	mm	2358.00
assume	c	mm	800.00

## Check for minimum Stiffeners -

cl-509.7.2.4

Check	c/d	$\leq \sqrt{2}$	1.02
Imin	minimum moment of inertia required		
	Imin	mm <sup>4</sup>	3.73E+07
Let a single stiffener on only one side of the web is provided			
thickness of the plate stiffener	ts	mm	16.00
outstand	a	mm	250.00
moment of inertia about face of the web			
	$ts \times a^3/3$	mm <sup>4</sup>	8.33E+07
The stiffener has more than the minimum required stiffeners			ok
HENCE, provide 250mm x 16 mm as vertical web stiffener			
Buckling resistance of the intermediate transvers stiffeners		IRC 24-2010	clause-509.7.1.5
Design as a strut			
The effective length of web equal to 20*tw on each side of the centre line of the stiffener can be considered along with the stiffener			
	20xtw	mm	640.00
MI about centre line of the stiffener		mm <sup>4</sup>	2.01E+08
Area	a	mm <sup>2</sup>	24480.00
radius of gyration	$\sqrt{I/A}$	mm	90.55
effective length		IRC 24-2010	clause 509.7.1.5
Lef	.7*L		550.20
slenderness ratio	Lef/rx	$\lambda$	6.08
Buckling class			from table 4 IRC 24-2010
		b	
		from table 6C IRC 24-2010	
	fcd	Mpa	370.00
buckling resistance		KN	9057.60
Buckling check on intermediate transverse stiffeners			
Factored shear force adjacent to the stiffener		clause 509.7.2.5	
	v	kN	1273.80
	Vcr	kN	765.17
	Fq	kN	462.39
		<	9057.60
It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we, propose the couples of stiffeners at the c/c distance less than 20 tw for shearing the critical load in between two.			ok
Check for outstand -		clause 509.7.1.2	
Outstand of the stiffener max		mm	320.00
check	14tq		224.00
			HENCE OK

### Welding requirement for stiffener -

High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used  
shear force on weld connecting the stiffener to web

(q1)

CL-509.7.2.6

#### Shear force

N/mm

1.27E+06

The shear strength of the fillet weld(p)

Assume size of fillet weld

p

mm

10.00

permissible stress in fillet weld

Mpa

131.00

throat thickness

Tt

mm

7.00

p

9170.00

The welding is done on both faces, than the weld length per metre length of plate

The required length of the weld for 1000mm length on each side

$$\frac{1273800.0}{2} \times \frac{1000}{9170} \text{ mm} = 69454.74$$

52.81 mm/1000mm length

#### Check for stresses

##### Check for Bending -

$$\begin{aligned} M &= 2.46\text{E}+09 \text{ Nmm} \\ Z &= 2.35\text{E}+07 \text{ mm} \\ \text{Maximum bending stress} &= 104.76 \end{aligned}$$

**HENCE OK**

##### Check for shear stress -

$$\begin{aligned} \text{Avg shear stress } T_{va} &= 50.64 \\ &\leq 131.22 \end{aligned}$$

**HENCE OK**

#### Design of joint between Flange and Web -

Assuming fillet weld on each side of the web

$$\text{Assumin size of the fillet weld} = 10.00 \text{ mm}$$

$$\text{Permissible strength of the fillet weld} = 131.22 \text{ N/mm}^2$$

$$\text{throat thickness} = 7.00 \text{ mm}$$

$$\text{The shear strength of fillet weld } p = 9185.39 \text{ N/mm}^2$$

first moment of area of top flange plate @c.g. Is

$$Q = 0.00\text{E}+00$$

$$\text{The shear flow } q = 881.69 \text{ N/mm}$$

providing 10mm fillet weld whose strength is 930.1 N/mm

be used at both faces, than the required length of weld for 1000mm length of girder is

$$\begin{aligned} \text{weld length} &= \frac{881.69 \times 1000}{2 \times 9185.387361} \text{ mm} = 47.99 \end{aligned}$$

253.76 mm/1000mm length **SAFE**

## Design of plate girder

### CHECK FOR LONG TERM

#### CHECKS FOR SHEAR AND BENDING MOMENT

<b>V(factored design shear force )</b>	<b>V</b>	KN	636.90
<b>B.M(factored design bending moment)</b>	<b>B.M</b>	KNm	1229.27

Calculation of Design shear strength

**(Post critical method )**

When transverse stiffeners are provided only at supports

	$k_v$		5.35
	for $c/d < 1.0$		9.16
	for $c/d > 1.0$		9.21
	$\gamma_{mo}$		1.10
Possion,s ratio	$\mu$		0.30
elastic critical shear stress of the web	$\tau_{cr}$		1.60E+03
shear buckling stress	$\lambda_w$		2.18
Shear stress corresponding to web bukling			
(a) when $\lambda_w \leq 0.8$	$\tau_b$		144.34
(b) when $0.8 < \lambda_w < 1.2$	$\tau_b$		-14.81
(c) when $\lambda_w \geq 1.2$	$\tau_b$		30.42
Shear force corrsponding to web bukling			
Critical shear strength(Vcr)	$A_w \tau_b$	KN	765.17
Nominal shear strength(Vr)			3300.44

<b>Design shear strength</b>	$V < .6V_d$	MPa	636.90
	<b>LOW SHEAR</b>		< 1980.26
			<b>OK</b>

#### Design bending strength of the section clause 509.2.1.2

Md(design bending strength of the section)		KNm	5572.22
--	--	-----	---------

Also,  $M_d \geq M_z$

<b>Md(design bending strength of the section) <math>\geq</math> Mz(Maximum bending moment)</b>	5572.22	>	1229.27
			<b>SAFE</b>

#### CHECKS CONCEPTUAL DESIGN

<b>Check for the Local Capacity of the section -</b>			Table 2 -IRC 24-10
Yield stress ratio for flanges	$\epsilon$	Mpa	1.00
Yield stress ratio for web	$\epsilon$	Mpa	1.00
Top flange ratio	<b>(PLASTIC)</b>		8.88
Bottom flange ratio	<b>(PLASTIC)</b>		8.88
Web ratio			24.56
cond. : Web need stiffening and Web Buckling need to be checked			clause 509.6

## Design of Intermediate transverse Web Stiffeners -

### Intermediate Stiffeners are not required

#### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore  $(d/t_w)$

clause 509.6

assume  $C$  = spacing of transverse stiffener

$d$  = depth of the web

Now,	$d$	mm	786.00
	$3 \cdot d$	mm	2358.00
assume	$c$	mm	800.00

#### Check for minimum Stiffeners -

cl-509.7.2.4

Check	$c/d$	$\leq \sqrt{2}$	1.02
$I_{min}$	minimum moment of inertia required		

$I_{min}$  mm<sup>4</sup> 3.73E+07

Let a single stiffener on only one side of the web is provided

thickness of the plate stiffener

$t_s$  mm 16.00

outstand

$a$  mm 250.00

moment of inertia about face of the web

$t_s \times a^3/3$  mm<sup>4</sup> 8.33E+07

The stiffener has more than the minimum required stiffeners

ok

HENCE, provide 250mm x 16 mm as vertical web stiffener

Buckling resistance of the intermediate transvers stiffeners

IRC 24-2010

clause-509.7.1.5

Design as a strut

The effective length of web equal to  $20 \cdot t_w$  on each side of the centre line of the stiffener can be considered along with the stiffener

$20 \cdot t_w$  mm 640.00

MI about centre line of the stiffener

mm<sup>4</sup> 2.01E+08

Area

$a$  mm<sup>2</sup> 24480.00

radius of gyration

$\sqrt{I/A}$   $r_x$  mm 90.55

effective length

IRC 24-2010 clause 509.7.1.5

$L_{ef}$

$.7 \cdot L$  550.20

slenderness ratio

$L_{ef}/r_x$   $\lambda$  6.08

from table 4 IRC 24-2010

Buckling class

b

from table 6C IRC 24-2010

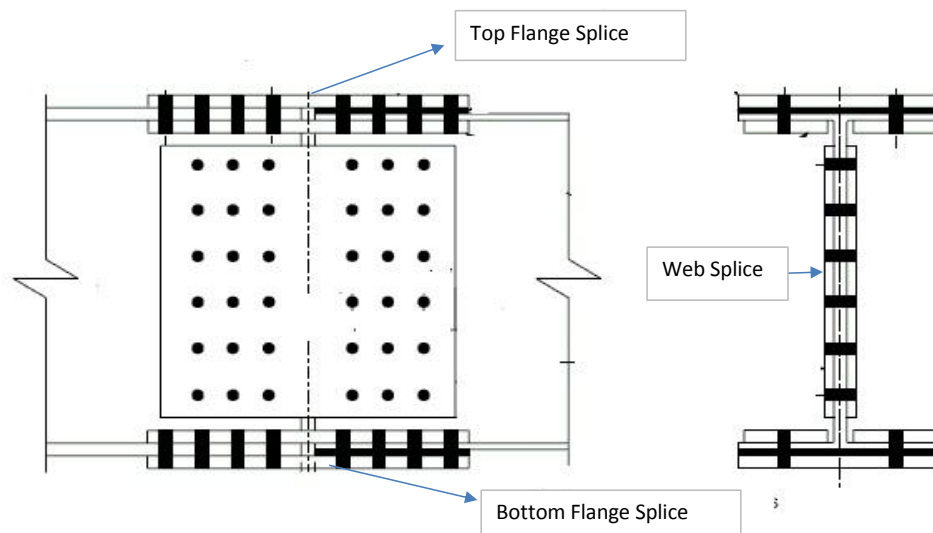
$f_{cd}$  Mpa 370.00



buckling resistance		KN	9057.60
<b>Buckling check on intermediate transverse stiffeners</b>			
Factored shear force adjacent to the stiffener		clause 509.7.2.5	
	v	KN	636.90
	Vcr	KN	765.17
	Fq	KN	116.61
		<	9057.60
It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we,propose the couples of stiffners at the c/c distance less than 20 tw for shearing the critical load in between two.			ok
<b>Check for outstand -</b>		clause 509.7.1.2	
Outstand of the stiffener max		mm	320.00
check	14tqe		224.00
		HENCE OK	
<b>Design of End Panel</b>		Irc 24-2010	clause 509.5.3
Longitudinal shear	(Hq)	KN	4031.61
Plastic shear resistance	(Vp)	KN	3630.48
Critical shear strength	(Vcr)	KN	765.17
Resultant longitudinal shear	Rtf	KN	2015.81
Area of web		mm^2	25152.00
Design shear strength		KN	3300.44
		End Panel is safe	
<b>Check for moment capacity of end panel</b>		Irc 24-2010	clause 509.5.3
Moment	Mtf=Hqd/10	Knm	316.88
Moment of resistance	Mq = I*fy/YYm0	KNm	7.76E+08
Moment of inertia	I = twc^3/12	mm^4	1.37E+09
	y	mm	400.00
		safe	
<b>Design of End bearing Stiffners</b>			
Max Shear		KN	636.90
Force due to moment Mtf	Ftf=Mtf/c	KN	396.11
Total compressive force	Fc	KN	1033.01
Required area of stiffener	Aq = 0.8FcYm0/fy	mm^2	3636.18
Assume stiffners to be 250mmx25mm			
Width	a	mm	250.00
thickness	ts	mm	25.00
Area of stiffners provided			12500.00
		ok	
<b>Check for outstand -</b>		clause 509.7.1.2	
Outstand of the stiffener max		mm	500.00
check	14tqe		350.00
moment of inertia about face of the web			
	ts x a^3/3	mm4	1.30E+08
The stiffener has more than the minimum required stiffnerss			ok
HENCE, provide 250mm x 25mm as vertical end bearing stiffener			
Buckling resistance of the end bearing stiffeners			
moment of inertia about centre line of stiffner			5.62E+08
Area	A	mm^2	32980.00
radius of gyration	√I/A	mm	130.55
effective length			
Lef	.7*L	mm	550.20
slenderness ratio	Lef/rx	λ	4.21

fcd		Mpa	370.00
buckling resistance		KN	12202.60
			safe in bucking
Local capacity of web	$F_w = (b_1+n_2)t_w f_{yw}$	KN	1636
Stiff bearing length	$b_1$	mm	100
Length obtained by dispersion through the flange to the web	$n_2$	mm	125
Thickness of web	$t_w$	mm	32.00
Yield stress of web	$f_{yw}$		250.00
Bearing stiffener will designed for the load	$F_c - F_w$	KN	-603
Bearing capacity of stiffener alone			12500.0
Criteria	Stiffener is safe as load bearing stiffener		
Welding requirement for stiffener -			
High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used			
shear force on weld connecting the stiffener to web	(q1)		CL-509.7.2.6
Shear force		N/mm	6.37E+05
The shear strength of the fillet weld(p)			
Assume size of fillet weld	p	mm	10.00
permissible stress in fillet weld		Mpa	131.00
thorath thickness	$T_t$	mm	7.00
		p	9170.00
The welding is done on both faces, than the weld length per metre length of plate			
The required length of the weld for 1000mm length on each side			
	636900.0	x	1000
	2		9170
		mm	34727.37
			52.81 mm/1000mm length
Check for stresses			
Check for Bending -			
	M	Nmm	1.23E+09
	Z	mm	2.18E+07
Maximum bending stress			56.30
			HENCE OK
Check for shear stress -			
Avg shear stress	$\tau_{va}$		25.32
		$\leq$	131.22
			HENCE OK
Design of joint between Flange and Web -			
Assuming fillet weld on each side of the web			
Assumin size of the fillet weld		mm	10.00
Permissible strength of the fillet weld		N/mm2	131.22
throat thickness		mm	7.00
The shear strength of fillet weld	p	N/mm2	9185.39
first moment of area of top flange plate @c.g. Is	Q		0.00E+00
The shear flow	q	N/mm	440.85
providing 10mm fillet weld whose strength is 930.1 N/mm			
be used at both faces, than the required length of weld for 1000mm length of girder is			
weld length	440.85 x	1000	
	2 x	9185.387361	mm
		253.76 mm/1000mm length	SAFE

## DESIGN OF SPLICE FOR FLEXURE MEMBER



### FLANGE SPLICE TOP

For the design it is assumed that flange splices carry all the moments and web splices carry all the shear

#### Sectional properties of flexure member

Width of flange	600.00 mm
Thickness of flange	32.00 mm
<b>TOP FLANGE FORCE</b>	4176 KN

Assume width of splice plate equal to flange width

Width of splice plate	600.00
sectional area of splice plate	10185.37 mm <sup>2</sup>
thickness of splice plate	16.97561 mm

Therefore thickness of splice plate

20 mm

Permissible stress in bending

227.27 Mpa

Stress in top flange

217.5 Mpa

safe

For bolts of 10.9 grade and 24 mm dia

Diameter of bolts 24 mm

diameter of hole 26 mm

$f_{ub}$  1040 Mpa

$f_y$  410 Mpa

$\phi_{mb}$  1.25

$\phi_{m0}$  1.1

#### DESIGN OF BOLT AS PER (Bearing Type)

##### Strength of bolt in double shear

$A_{nb}$  (Net area of thread region) 352.9094 mm<sup>2</sup>

Strength of bolt in single shear 339.0539 KN

##### Strength of bolt in bearing

MIN Pitch(p) 60 mm

Min Edge distance (e) 39 mm

$K_b$ (min of  $p/3d_0 - 0.25, e/3d_0, f_u/f_{ub}, 1$ ) 0.5

Strength of bolt on bearing 259.2 KN

Strength of bolt in tearing  $(0.9 * f_{ub} * A_{nb} / \phi_{mb})$  264.2586 KN

BOLT VALUE 259.2 KN

**DESIGN OF BOLT AS PER (FRICTION TYPE)**

Nominal diameter of bolt	24 mm
Nominal diameter of hole	26 mm
Minimum Edge Distance for 24 mm dia Bolt = $1.5 \times 26$	39 mm
Provided Minimum Edge Distance	40 mm
Minimum Pitch Distance for 24 mm dia Bolt = $2.5 \times 24$	60 mm
Provided Minimum Pitch Distance	70 mm
Ultimate Strength of Bolt (Grade 10.9)	1040 Mpa
Thickness Of Splice Plate	20 mm
Coefficient Of Friction ( $\mu_f$ )	0.35
Number Of Effective Interfaces Offering Friction Resistance to Slip ( $n_e$ )	2
$K_h$	1
$\gamma_{mf}$ (For Service Load)	1.1
$\gamma_{mf}$ (For Ultimate Load)	1.25
Net area Of The Bolt At Treaded ( $A_{nb}$ )	352.9094 mm <sup>2</sup>
Proof Stress ( $= 0.70 f_{ub}$ )	728 Mpa
$F_0$ (Minimum Bolt Tension)	256.9181 KN
Maximun Shear Capacity Of Bolt ( $\phi \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	163.4933 KN
Maximun Shear Capacity Of Bolt ( $\phi \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	143.8741 KN

**NO. OF BOLTS req**

29.03

**NO. OF BOLTS provided**

56

assume 5 bolts In each row bolts are provided at a pitch 60mm and edge distance 40mm

**No. of rows provided**

8

**SO MIN SIZE OF SPLICE PLATE REQ**

(refer drawing)

500mmx320mmx20mm

**FLANGE SPLICE BOTTOM****For the design it is assumed that flange splices carry all the moments and web splices carry all the shear****BENDING MOMENT**

Sectional properties of flexure member

Width of flange 600.00

Thickness of flange 32.00

TOP FLANGE FORCE 4176 KN

Assume width of splice plate equal to flange width

Width of splice plate 600.00

sectional area of splice plate 16704.00 mm<sup>2</sup>

thickness of splice plate 27.84 mm

Therefore thickness of splice plate 30 mm

**Permissible stress in bending** 227.2727 Mpa**Stress in BOTTOM flange** 217.5 Mpa

safe

For bolts of 10.4 grade and 24mm dia

Diameter of bolts 24 mm

diameter of hole 26 mm

 $f_u$  540 Mpa $f_{ub}$  1040 Mpa $f_y$  410 Mpa $\phi_{mb}$  1.25 $\phi_{m0}$  1.1**DESIGN OF BOLT AS PER (Bearing Type)****Strength of bolt in double shear** $A_{nb}$  (Net area of thread region) 352.9094 mm<sup>2</sup>

Strength of bolt in single shear 339.0539 KN

**Strength of bolt in bearing**

MIN Pitch(p) 60 mm

Min Edge distance (e) 39 mm

 $K_b$ (min of  $p/3d_0$ ,  $0.25e/3d_0$ ,  $f_u/f_{ub}$ , 1) 0.5

Strength of bolt on bearing 388.8 KN

**Strength of bolt in tearing** ( $0.9 * f_{ub} * A_{nb} / \gamma_{mb}$ ) 264.2586 KN**BOLT VALUE** 264.2586 KN

**DESIGN OF BOLT AS PER (FRICTION TYPE)**

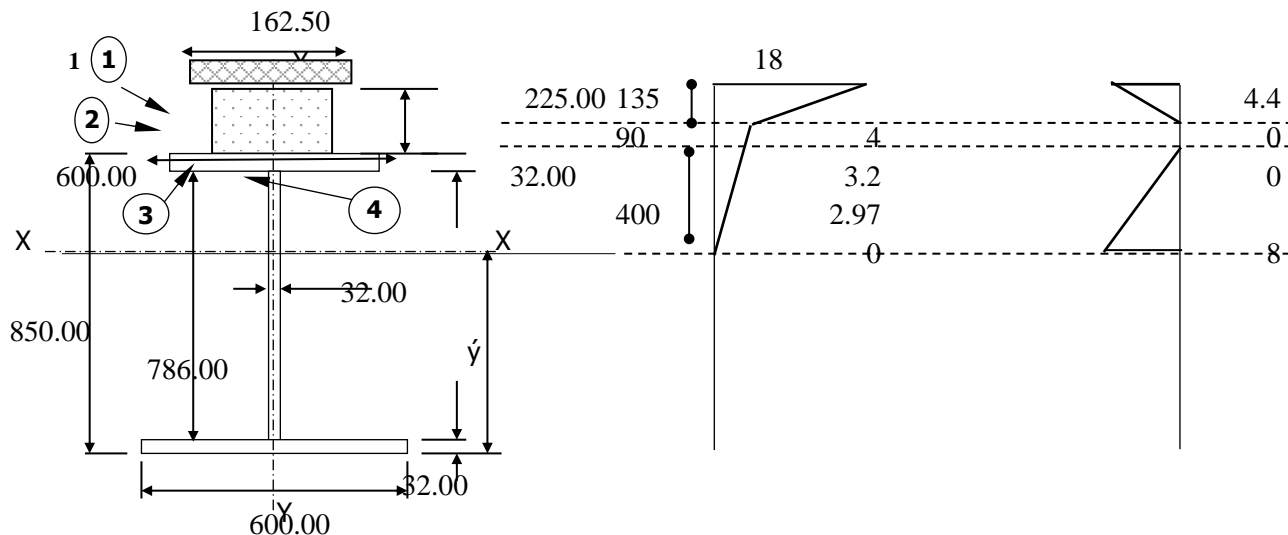
Nominal diameter of bolt	24 mm
Nominal diameter of hole	26 mm
Minimum Edge Distance for 24 mm dia Bolt = $1.5 \times 26$	39 mm
Provided Minimum Edge Distance	40 mm
Minimum Pitch Distance for 24 mm dia Bolt = $2.5 \times 24$	60 mm
Provided Minimum Pitch Distance	70 mm
Ultimate Strength of Plate	410
Ultimate Strength of Bolt (Grade 10.9)	1040 Mpa
Thickness Of Splice Plate	30 mm
Coefficient Of Friction ( $\mu_f$ )	0.35
Number Of Effective Interfaces Offering Friction Resistance to Slip ( $n_e$ )	2
$K_h$	1
$\gamma_{mf}$ (For Service Load)	1.1
$\gamma_{mf}$ (For Ultimate Load)	1.25
Net area Of The Bolt At Treaded ( $A_{nb}$ )	352.9094 mm <sup>2</sup>
Proof Stress (= $0.70 f_{ub}$ )	728 Mpa
$F_0$ (Minimum Bolt Tension)	256.9181 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	163.4933 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	143.8741 KN
NO. OF BOLTS req	29.02537
<b>NO. OF BOLTS provided</b>	40
assume 5 bolts In each row bolts are provided at a pitch 60mm and edge distance 40mm	
no. of rows provided	8
<b>SO MIN SIZE OF SPLICE PLATE REQ</b>	(refer drawing) 500mmx350mmx30mm

**DESIGN OF WEB SPLICE**

SINCE BOLT IS IN DOUBLE SHEAR	
ASSUME thickness of web splice plate	16 mm
SHEAR FORCE	1273.80 KN
<b>STRENGTH OF BOLT IN DOUBLE SHEAR</b>	678.1077 KN
<b>STRENGTH OF BOLT IN BEARING</b>	235.6364 KN
<b>BOLT VALUE</b>	235.6364 KN
<b>NO.OF BOLTS REQ</b>	5.405787
<b>BOLT PROVIDED ON EACH SIDE</b>	21
Try 3 bolts in eachrows at 60 mm vertical pitch and 45 mm from the center of joint.	
<b>No of rows</b>	7
PITCH	60 mm
distance from edge (N)	45 mm
$r_n$	189.73 mm
summation of square of r	345581.1 mm <sup>2</sup>
<b>Horizontal shear force on bolt due to moment due to ecc.</b>	31.47022 KN
<b>VERTICAL SHEAR ON BOLT</b>	60.65714 KN
<b>RESULTANT FORCE</b>	68.33494 KN
<b>SO Min size of web splice plate REQ</b>	(refer drawing) OK 400mmx210mmx16mm

## DUE TO TEMPERATURE GRADIENT

In this case it is assumed that the super-structure is free to translate in the longitudinal direction and that the steel and concrete have the same co-efficient of thermal expansion, so that uniform changes of temperature cause no stresses in the superstructure. Thus only the effects of temperature differences through the depth of cross-section is considered. The nominal temperature differences are shown below.



The temperature at various levels of the composite girder is taken from IRC 6-2014

Calculating for Central segment

Required parameters

Cross sectional area of the composite section (A) =	1.0E+05 mm <sup>2</sup>
Moment of Inertia of the composite section (I) =	1.46E+10 mm <sup>4</sup>
Coefficient of thermal expansion (a) =	1.2E-05 /°C
Modulus of Elasticity of Steel (E <sub>s</sub> ) =	2.1E+05 Mpa
Modulus of elasticity of concrete (E <sub>c</sub> ) =	32000 Mpa

ZONE	Area (A) of equivalent steel sec	y (From top)	Ay	Ay <sup>2</sup>	T (Rise Case)	αAT	aATY
1	2.19E-02	6.75E-02	1.48E-03	1.00E-04	11.00	2.9E-06	2.0E-07
2	1.46E-02	1.80E-01	2.63E-03	4.74E-04	3.6	6.3E-07	1.13724E-07
3	1.92E-02	2.41E-01	4.63E-03	1.12E-03	3.09	7.1E-07	1.7E-07
4	1.18E-02	4.41E-01	5.19E-03	2.29E-03	1.49	2.1E-07	9.25431E-08
SUM	6.75E-02	9.30E-01	1.39E-02	3.98E-03	19.17	4.44818E-06	5.73029E-07

$$q = 3.12E-04$$

$$\varepsilon_0 = 1.30E-04$$

## Eigen stresses (steel)

SL.No.	Location	y	t	a	a t	Eigen Stresses	Equivalent Concrete Stress
i	tp.of slab	0	1.80E+01	1.20E-05	2.16E-04	-2.74	-2.74
ii	bt.of slab	0.225	3.20E+00	1.20E-05	3.84E-05	0.69	

ZONE	Area (A) of equivalent steel sec	y (From top)	Ay	Ay <sup>2</sup>	T (Fall Case)	aAT	aATY
i	2.19E-02	0.068	1.48E-03	1.00E-04	2.2	5.7915E-07	3.90926E-08
ii	1.46E-02	1.80E-01	2.63E-03	4.74E-04	0	0.0E+00	0.0E+00
iii	1.92E-02	0.241	4.63E-03	1.12E-03	0.64	1.5E-07	3.6E-08
iv	1.18E-02	4.41E-01	5.19E-03	2.29E-03	4.32	6.1E-07	2.7E-07
<b>SUM</b>	<b>6.75E-02</b>		<b>1.39E-02</b>	<b>3.98E-03</b>		<b>1.33707E-06</b>	<b>3.43846E-07</b>

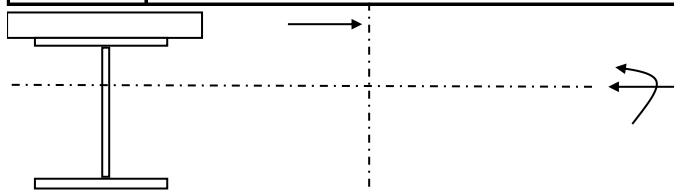
q -6.16E-05  
ε 0 7.09655E-06

### Eigen stresses (steel)

SL.No.	Location	y	t	a	a t	Eigen Stresses	Equivalent Concrete Stress
i	tp.of slab	0	-4.4	1.20E-05	-5.28E-05	1.92	1.92
ii	bt.of slab	0.225	0	1.20E-05	0.00E+00	0.67	

### DUE TO SHRINKAGE OF THE DECK SLAB

Sl.No	Description	Units	Symbol	Value
i	Shrinkage strain in concrete			2.00E-04
ii	Modulus of elasticity	N/mm <sup>2</sup>	Ec	3.20E+04
iii	Modular ratio		m	6.6E+00
iv	Modified Modulus of elasticity	N/mm <sup>2</sup>	Ec'	1.60E+04
v	Stress in deck <b>0.0002*16000</b>	Nmm <sup>2</sup>		3.20E+00
vi	Force in concrete <b>3.2*162.5*225</b>	N	T	1.17E+05



Sl.No	Description	Units	Symbol	Value
i	M, moment due to shrinkage forces	Nmm	M	5.06E+07
ii	Stress at Top of Concrete	Mpa		0.36
iii	Stress at Interface of Conc & Steel	Mpa		2.16
iv	Stress at the bottom of steel	Mpa		2.32
v	Axial Stress	Mpa		1.43
vi	Total Stress at the Interface of Conc & Steel	Mpa		3.59
vii	Total Stress at the Bottom of Steel	MPa		0.89

PROP.	Load				Total Stress	Perm.Bend. Stresses*	check
	DL	SIDL	LL	SHRINKAG			
<b>STEEL</b>	32.04	32.04	103.28	-3.59	163.76	250.125	OK

## Check for Deflection

### DEFLECTION CHECK

Ref: Cl.504.5.1 of IRC-24:2010

Sl.No	Description	Units	Symbol	Value	
i	Span of the girder	m	L	13318	
ii	a) Deflection due to DL	mm	defl_DL	1.3	
iii	b) Deflection due to SIDL	mm	defl_SDL	8.1	
iv	c) Deflection due to LL	mm	defl_LL	0.72	
v	Total defl. due to DL+LL+SIDL	mm	defl_total	10.12	
	Permissible defl. due to DL+LL+SI	mm	defl_total	21.33333	No camber
	Permissible defl. due to LL	mm	defl_LL	16	ok



# Design of Stringer

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# Introduction

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Design Report of Stringer for 80m truss at various stages.

Code Refered

IRC: 24-2010

IS: 2062-2011

# Steel Design Data

## DESIGN OF PLATE GIRDER

### DIMENSIONAL PARAMETER

#### Dimensioning of web

Assuming girder is laterally supported throughout the span i.e stiffeners are provided

Assuming the web thickness	t2	mm	12.00
Depth of plate girder only	d	mm	504.00
Length of girder		mm	5000.00
Thickness of top flange plate -1	t1	mm	0.00
Thickness of top flange plate -2	t2	mm	20.00
Thickness of bottom flange plate -1	t3	mm	20.00
Thickness of bottom flange plate -2	t4	mm	0.00
Depth of web plate	dw	mm	464.00
Thickness of web	t5	mm	12.00
Assuming Spacing of Stiffener	c	mm	600.00

### BASIC PARAMETERS

Yield Strength of steel	Fy	Mpa	250.00
Partial factor of safety for materials	γm		1.10
Proportioning of different Components			
Max permissible bending stress in tension or compression		Mpa	227.27

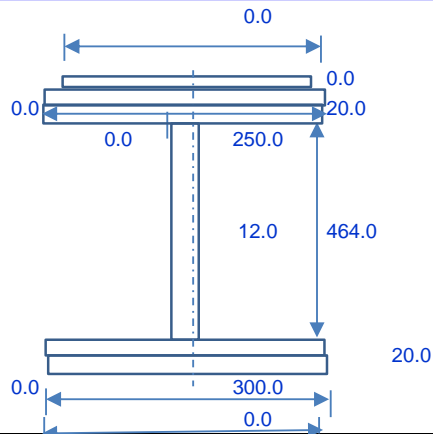
### Servicability Creteria

IRC 24-2010 ( clause 509.6)

SI.No	Case	Ref.	condition	Thk.	units	Value	check
1	Web connected to flange along both long. Edges	cl. 509.6	Service	$3d \geq C \geq d$ therefore(d/tw)	mm	38.7	OK
2			Buckling	$C \leq 1.5d$ therefore(d/tw)	mm	38.66666667	OK

## Section Properties

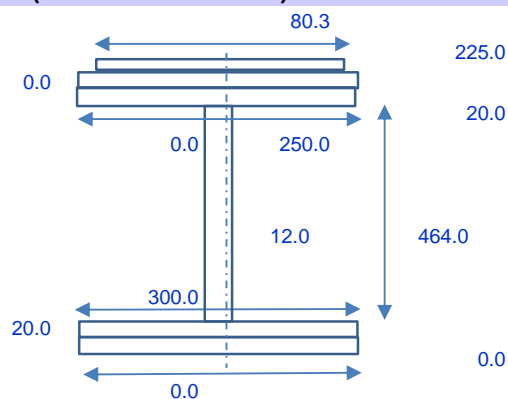
### Section properties (Steel Only)



S.No.	Breadth	Depth (D)	Area (A)	cg from TOP.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	I Z
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	0.00	0.00	0.00	0.00	0.00	266.61	0.00E+00	0.00E+00
2	0.00	0.00	0.00E+00	0.00	0.00E+00	266.61	0.00E+00	0.00E+00
3	250.00	20.00	5.00E+03	10.00	5.00E+04	256.61	3.29E+08	1.67E+05
4	12.00	464.00	5.57E+03	252.00	1.40E+06	14.61	1.19E+06	9.99E+07
5	300.00	20.00	6.00E+03	494.00	2.96E+06	227.39	3.10E+08	2.00E+05
6	0.00	0.00	0.00	504.00	0.00E+00	237.39	0.00E+00	0.00E+00
		504.00	1.66E+04		4.42E+06		6.41E+08	7.41E+08

Distance of cg. of comb. section from top		mm	266.6
MOI of comb. section about its centroidal axis		mm^4	7.4E+08
Dist. of top fibre of slab from centroidal axis	yt	mm	266.6
Dist. of Bottom fibre of slab from centroidal axis	yb	mm	237.4
Moment of Inertia(about zz)	Izz	mm^4	7.4E+08
Elastic section modulus (TOP)	Ze.zt	mm^3	2.78E+06
Plastic section modulus			
<u>Plastic section modulus</u>	Zp.zt	mm^3	3.29E+06

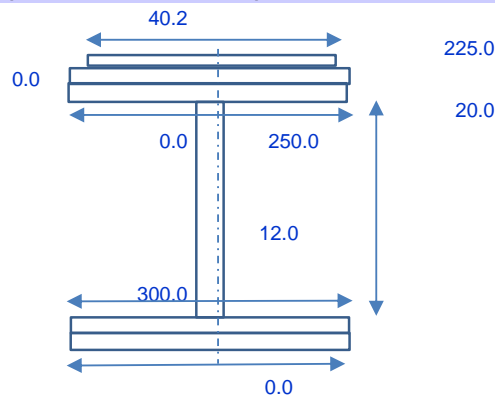
### SHORT TERM PROPERTIES (Steel with Deck slab)



Element	Breadth	Depth (D)	Area (A)	cg from bott.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	IZ
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	80.30	225.00	1.81E+04	112.50	2.03E+06	181.35	5.94E+08	7.62E+07
2	0.00	0.00	0.00E+00	0.00	0.00E+00	293.85	0.00E+00	0.00E+00
3	250.00	20.00	5.00E+03	235.00	1.18E+06	58.85	1.73E+07	1.67E+05
4	12.00	464.00	5.57E+03	477.00	2.66E+06	-183.15	1.87E+08	9.99E+07
5	300.00	20.00	6.00E+03	719.00	4.31E+06	425.15	1.08E+09	2.00E+05
6	0.00	0.00	0.00	0.00	0.00E+00	-293.85	0.00E+00	0.00E+00
		<b>729.00</b>	<b>3.46E+04</b>	<b>1.54E+03</b>	<b>1.02E+07</b>		<b>1.88E+09</b>	<b>2.06E+09</b>

Distance of cg. of comb. section from bott.		mm	293.8
MOI of comb. section about its centroidal axis		mm <sup>4</sup>	2.1E+09
Dist. of top fibre of slab from centroidal axis	yt	mm	293.8
Dist. of Bottom fibre of slab from centroidal axis	yb	mm	435.2
Moment of Inertia(about zz)	lzz	mm <sup>4</sup>	2.1E+09
<u>Elastic section modulus (bottom)</u>	Ze.zb	mm <sup>3</sup>	4.7E+06
<u>Elastic section modulus (top.)</u>	Ze.zt	mm <sup>3</sup>	7.0E+06
<u>Plastic section modulus</u>	Zp.zt	mm <sup>3</sup>	<b>5.98E+06</b>

#### LONG TERM PROPERTIES (Steel with Deck slab)



Element	Breadth	Depth (D)	Area (A)	cg from bott.	A * cg	Dist. from cg (H)	A*H <sup>2</sup>	I self
No.	mm	mm	mm <sup>2</sup>	mm	mm <sup>2</sup>	mm	mm <sup>3</sup>	mm <sup>4</sup>
1	40.15	225.00	9.03E+03	112.50	1.02E+06	245.34	5.44E+08	3.81E+07
2	0.00	0.00	0.00E+00	0.00	0.00E+00	357.84	0.00E+00	0.00E+00
3	250.00	20.00	5.00E+03	235.00	1.18E+06	122.84	7.54E+07	1.67E+05
4	12.00	464.00	5.57E+03	477.00	2.66E+06	-119.16	7.91E+07	9.99E+07
5	300.00	20.00	6.00E+03	719.00	4.31E+06	361.16	7.83E+08	2.00E+05
6	0.00	0.00	0.00	0.00	0.00E+00	-357.84	0.00E+00	0.00E+00
		<b>729.00</b>	<b>2.56E+04</b>	<b>1.54E+03</b>	<b>9.16E+06</b>		<b>1.48E+09</b>	<b>1.62E+09</b>

Distance of cg. of comb. section from bott.	$\Sigma(A \times cg) / \Sigma A$	mm	357.8
MOI of comb. section about its centroidal axis	{AH <sup>2</sup> + Iself }	mm <sup>4</sup>	1.6E+09
Dist. of top fibre of slab from centroidal axis	yt	mm	357.8
Dist. of Bottom fibre of slab from centroidal axis	yb	mm	371.2
Moment of Inertia(about zz)	lzz	mm <sup>4</sup>	1.6E+09
<u>Elastic section modulus (top.)</u>	Ze.zt	mm <sup>3</sup>	4.5E+06
<u>Elastic section modulus (bottom)</u>	Ze.zb	mm <sup>3</sup>	4.4E+06
<u>Plastic section modulus</u>	Zp.zt	mm <sup>3</sup>	<b>5.26E+06</b>

## Design of plate girder

### CHECK FOR SELF WEIGHT + GREEN CONC.

#### Bending Moment & Shear Force (BM & SF)

Self Weight of girder	extra 15%	kN / m	2.46
wet concrete		kN / m	14.06
Max. Bending Moment (BM)	due to self wt.	kN-m	7.69
	due to wet conc.	kN-m	43.95
Max. Shear Force (SF)	due to self wt.	kN	6.15
	due to wet conc.	kN	35.16

### CHECKS FOR SHEAR AND BENDING MOMENT

<b>V(factored design shear force )</b>	<b>V</b>	KN	41.31
<b>B.M(factored design bending moment)</b>	<b>B.M</b>	KNm	51.63
Calculation of Design shear strength (Post critical method )			
When transverse stiffeners are provided only at supports			
	$k_v$		5.35
	for $c/d < 1.0$		7.20
	for $c/d > 1.0$		7.74
	$\gamma_{mo}$		1.10
Possion,s ratio	$\mu$		0.30
elastic critical shear stress of the web	$\tau_{cr}$		6.47E+02
shear buckling stress	$\lambda_w$		2.73
Shear stress corresponding to web bukling			
(a) when $\lambda_w \leq 0.8$	$\tau_b$		144.34
(b) when $0.8 < \lambda_w < 1.2$	$\tau_b$		-78.87
(c) when $\lambda_w \geq 1.2$	$\tau_b$		19.33
Shear force corrsponding to web bukling			
Critical shear strength( $V_{cr}$ )	$A_w \tau_b$	KN	107.60
Nominal shear strength( $V_r$ )			730.63
			<b>SAFE</b>
Design shear strength	$V < .6V_d$	MPa	41.31
<b>LOW SHEAR</b>			< 438.38
			<b>OK</b>

#### Design bending strength of the section

clause 509.2.1.2

Md(design bending strength of the section)	KNm	747.06
Also, $M_d \geq M_z$		
Md(design bending strength of the section) $\geq$ Mz(Maximum bending moment)		
747.06	>	51.63
<b>SAFE</b>		

### CHECKS CONCEPTUAL DESIGN

#### Check for the Local Capacity of the section -

Table 2 -IRC 24-10

Yield stress ratio for flanges	$\epsilon$	Mpa	1.00
Yield stress ratio for web	$\epsilon$	Mpa	1.00
Top flange ratio	(plastic)		5.95
Bottom flange ratio	(plastic)		7.00
Web ratio			38.67
cond. : Web need stiffening and Web Buckling need to be checked			clause 509.6

## Design of Intermediate transverse Web Stiffeners -

Intermediate Stiffeners are not required

### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore  $(d/t_w)$  clause 509.6

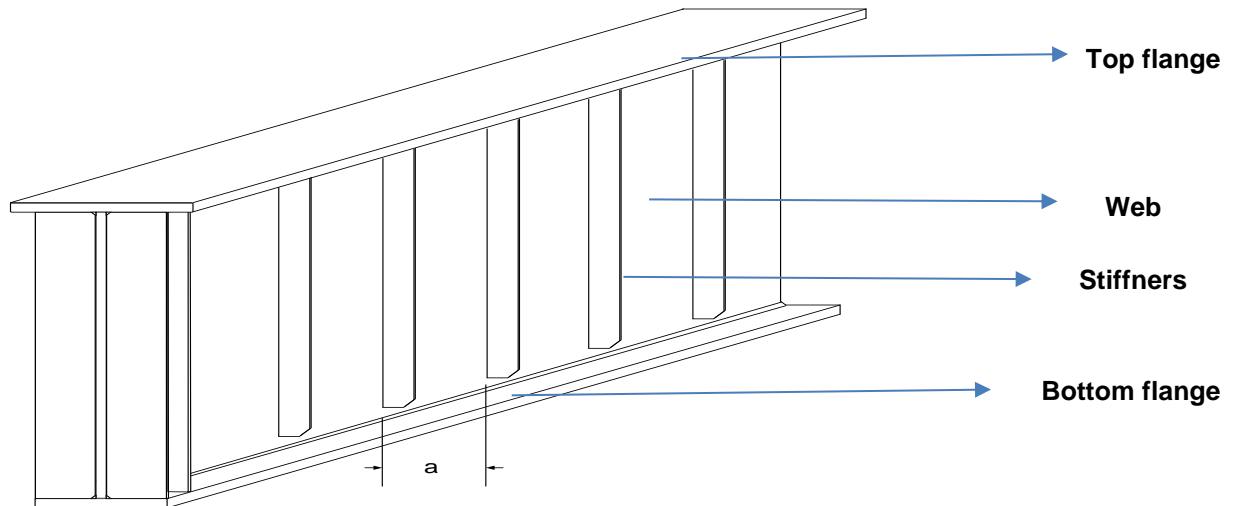
assume  $C$  = spacing of transverse stiffener

$d$  = depth of the web

Now,	$d$	mm	464.00
	$3*d$	mm	1392.00
assume	$c$	mm	600.00

### Check for minimum Stiffeners -

cl-509.7.2.4



Check	$c/d$	$\leq \sqrt{2}$	1.29
$I_{min}$	minimum moment of inertia required		

$I_{min}$  mm<sup>4</sup> 7.19E+05

Let a single stiffener on only one side of the web is provided

thickness of the plate stiffener

$t_s$  mm 12.00

outstand

$a$  mm 100.00

moment of inertia about face of the web

$t_s \times a^3/3$  mm<sup>4</sup> 4.00E+06

The stiffener has more than the minimum required stiffeners

ok

HENCE provide 100mm x 12mm as vertical web stiffener

Buckling resistance of the intermediate transverse stiffeners

IRC 24-2010 clause-509.7.1.5

Design as a strut

The effective length of web equal to  $20 \times t_w$  on each side of the centre line of the stiffener can be considered along with the stiffener

$20 \times t_w$  mm 240.00

MI about centre line of the stiffener

mm<sup>4</sup> 9.53E+06

Area

$a$  mm<sup>2</sup> 4080.00

radius of gyration

$\sqrt{I/A}$   $r_x$  mm 48.32

effective length

IRC 24-2010 clause 509.7.1.5

$L_{ef}$

$.7 \times L$  324.80

slenderness ratio

$L_{ef}/r_x$   $\lambda$  6.72

from table 4 IRC 24-2010

Buckling class

b

from table 6C IRC 24-2010

$f_{cd}$  Mpa 370.00



	buckling resistance	KN	1509.60
<b>Buckling check on intermediate transverse stiffeners</b>			
Factored shear force adjacent to the stiffener		clause 509.7.2.5	
	<b>v</b>	kN	41.31
	<b>Vcr</b>	kN	107.60
	<b>Fq</b>	kN	60.27
		<	1509.60
It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we, propose the couples of stiffeners at the c/c distance less than 20 tw for shearing the critical load in between two.			ok
<b>Check for outstand -</b>		clause 509.7.1.2	
Outstand of the stiffener max		mm	240.00
check	14tqε		168.00
			HENCE OK

### Welding requirement for stiffener -

High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used

shear force on weld connecting the stiffener to web (q1) **CL-509.7.2.6**

**Shear force** N/mm 4.13E+04

The shear strength of the fillet weld(p)

Assume size of fillet weld p mm 10.00

permissible stress in fillet weld Mpa 131.00

throat thickness Tt mm 7.00

p 9170.00

The welding is done on both faces, than the weld length per metre length of plate

The required length of the weld for 1000mm length on each side

41306.2 x 1000 mm 2252.25

2 9170

52.81 mm/1000mm length

### Check for stresses

#### Check for Bending -

M Nmm 5.16E+07

Z mm 2.78E+06

**Maximum bending stress** 18.58

**HENCE OK**

#### Check for shear stress -

**Avg shear stress** Tva 7.42

≤ 131.22

**HENCE OK**

### Design of joint between Flange and Web -

Assuming fillet weld on each side of the web

Assume size of the fillet weld mm 10.00

Permissible strength of the fillet weld N/mm<sup>2</sup> 131.22

throat thickness mm 7.00

The shear strength of fillet weld p N/mm<sup>2</sup> 9185.39

first moment of area of top flange plate @c.g. Is

Q 8.13E+04

The shear flow q N/mm 41.38

providing 10mm fillet weld whose strength is 930.1 N/mm

be used at both faces, than the required length of weld for 1000mm length of girder is

weld length 41.38 x 1000

2 x 9185.387361 mm 2.25

253.76 mm/1000mm length **SAFE**

## Design of plate girder

### CHECK FOR SHORT TERM

#### CHECKS FOR SHEAR AND BENDING MOMENT

<b>V(factored design shear force )</b>	<b>V</b>	KN	430.37
<b>B.M(factored design bending moment)</b>	<b>B.M</b>	KNm	550.32
Calculation of Design shear strength <b>(Post critical method )</b> When transverse stiffeners are provided only at supports			
	$k_v$		5.35
	for $c/d < 1.0$		7.20
	for $c/d > 1.0$		7.74
	$\gamma_{mo}$		1.10
Possion,s ratio	$\mu$		0.30
elastic critical shear stress of the web	$\tau_{cr}$		6.47E+02
shear buckling stress	$\lambda_w$		2.73
Shear stress corresponding to web bukling			
(a) when $\lambda_w \leq 0.8$	$\tau_b$		144.34
(b) when $0.8 < \lambda_w < 1.2$	$\tau_b$		-78.87
(c) when $\lambda_w \geq 1.2$	$\tau_b$		19.33
Shear force corrsponding to web bukling			
Critical shear strength( $V_{cr}$ )	$A_w \tau_b$	KN	107.60
Nominal shear strength( $V_r$ )			730.63
			<b>SAFE</b>
<b>Design shear strength</b>	$V < .6V_d$	MPa	430.37
	<b>LOW SHEAR</b>		< 438.38
			<b>OK</b>

#### Design bending strength of the section

clause 509.2.1.2

Md(design bending strength of the section)		KNm	1359.12
Also, $M_d \geq M_z$			
<b>Md(design bending strength of the section) <math>\geq</math> Mz(Maximum bending moment)</b>	1359.12	>	436.62
			<b>SAFE</b>

### CHECKS CONCEPTUAL DESIGN

#### Check for the Local Capacity of the section -

Table 2 -IRC 24-10

Top flange ratio	(plastic)	5.95
Bottom flange ratio	(plastic)	7.0
Web ratio		38.67
cond. : Web need stiffening and Web Buckling need to be checked		

clause 509.6

#### Design of Intermediate transverse Web Stiffeners -

#### Intermediate Stiffners are required

##### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore  $(d/t_w)$  clause 509.6

assume  $C$ = spacing of transverse stiffener

$d$ =depth of the web

Now,	$d$	mm	464.00
	$3*d$	mm	1392.00
assume	$c$	mm	600.00

## Check for minimum Stiffeners -

cl-509.7.2.4

Check	c/d	$\leq \sqrt{2}$	1.29
<b>I<sub>min</sub></b>	<b>minimum moment of inertia required</b>		
	<b>I<sub>min</sub></b>	mm <sup>4</sup>	7.19E+05
<b>Let a single stiffener on only one side of the web is provided</b>			
<b>thickness of the plate stiffener</b>	ts	mm	12.00
<b>outstand</b>	a	mm	100.00
<b>moment of inertia about face of the web</b>	$ts \times a^3/3$	mm <sup>4</sup>	4.00E+06
The stiffener has more than the minimum required stiffeners			ok
<b>HENCE provide 100mm x 12mm as vertical web stiffener</b>			
<b>Buckling resistance of the intermediate transvers stiffeners</b>		IRC 24-2010	clause-509.7.1.5
Design as a strut			
The effective length of web equal to 20*tw on each side of the centre line of the stiffener can be considered along with the stiffener			
	20*tw	mm	240.00
<b>MI about centre line of the stiffener</b>		mm <sup>4</sup>	9.53E+06
Area	a	mm <sup>2</sup>	4080.00
radius of gyration	$\sqrt{I/A}$	mm	48.32
effective length		IRC 24-2010	clause 509.7.1.5
Lef	.7*L		324.80
<b>slenderness ratio</b>	<b>Lef/rx</b>	$\lambda$	6.72
			from table 4 IRC 24-2010
<b>Buckling class</b>			b
			from table 6C IRC 24-2010
	<b>fcd</b>	Mpa	370.00
	buckling resistance	KN	1509.60
<b>Buckling check on intermediate transverse stiffeners</b>			
Factored shear force adjacent to the stiffener			clause 509.7.2.5
	v	kN	430.37
	Vcr	kN	107.60
	Fq	kN	293.43
		<	1509.60
It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we, propose the couples of stiffeners at the c/c distance less than 20 tw for shearing the critical load in between two.			ok
<b>Check for outstand -</b>		clause 509.7.1.2	
<b>Outstand of the stiffener max</b>		mm	240.00
<b>check</b>	14tq		168.00
			HENCE OK

### Welding requirement for stiffener -

High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used  
shear force on weld connecting the stiffener to web

(q1)

CL-509.7.2.6

#### Shear force

N/mm

4.30E+05

The shear strength of the fillet weld(p)

Assume size of fillet weld

p

mm

10.00

permissible stress in fillet weld

Mpa

131.00

thorax thickness

Tt

mm

7.00

p

9170.00

The welding is done on both faces, than the weld length per metre length of plate

The required length of the weld for 1000mm length on each side

$$\frac{430370.0}{2} \times \frac{1000}{9170} \text{ mm} = 23466.19$$

52.81 mm/1000mm length

#### Check for stresses

##### Check for Bending -

$$\begin{aligned} M &= 4.37\text{E}+08 \text{ Nmm} \\ Z &= 4.73\text{E}+06 \text{ mm} \\ \text{Maximum bending stress} &= 92.26 \end{aligned}$$

**HENCE OK**

##### Check for shear stress -

$$\begin{aligned} \text{Avg shear stress } T_{va} &= 77.29 \\ &\leq 131.22 \end{aligned}$$

**HENCE OK**

#### Design of joint between Flange and Web -

Assuming fillet weld on each side of the web

$$\text{Assumin size of the fillet weld} = 10.00 \text{ mm}$$

$$\text{Permissible strength of the fillet weld} = 131.22 \text{ N/mm}^2$$

$$\text{throat thickness} = 7.00 \text{ mm}$$

$$\text{The shear strength of fillet weld } p = 9185.39 \text{ N/mm}^2$$

first moment of area of top flange plate @c.g. Is

$$Q = 8.13\text{E}+04$$

$$\text{The shear flow } q = 431.12 \text{ N/mm}$$

providing 10mm fillet weld whose strength is 930.1 N/mm

be used at both faces, than the required length of weld for 1000mm length of girder is

$$\begin{aligned} \text{weld length} &= \frac{431.12 \times 1000}{2 \times 9185.387361} \text{ mm} = 23.47 \end{aligned}$$

253.76 mm/1000mm length **SAFE**

## Design of plate girder

### CHECK FOR LONG TERM

#### CHECKS FOR SHEAR AND BENDING MOMENT

<b>V(factored design shear force )</b>	<b>V</b>	KN	215.19
<b>B.M(factored design bending moment)</b>	<b>B.M</b>	KNm	218.31

Calculation of Design shear strength

**(Post critical method )**

When transverse stiffeners are provided only at supports

	$k_v$		5.35
	for $c/d < 1.0$		7.20
	for $c/d > 1.0$		7.74
	$\gamma_{mo}$		1.10
Possion,s ratio	$\mu$		0.30
elastic critical shear stress of the web	$\tau_{cr}$		6.47E+02
shear buckling stress	$\lambda_w$		2.73
Shear stress corresponding to web bukling			
(a) when $\lambda_w \leq 0.8$	$\tau_b$		144.34
(b) when $0.8 < \lambda_w < 1.2$	$\tau_b$		-78.87
(c) when $\lambda_w \geq 1.2$	$\tau_b$		19.33
Shear force corrsponding to web bukling			
Critical shear strength(Vcr)	$A_w \tau_b$	KN	107.60
Nominal shear strength(Vr)			730.63

**SAFE**

<b>Design shear strength</b>	$V < .6V_d$	MPa	215.19
	<b>LOW SHEAR</b>		< 438.38

**OK**

#### Design bending strength of the section

clause 509.2.1.2

Md(design bending strength of the section)		KNm	1194.56
--	--	-----	---------

Also,  $M_d \geq M_z$

**Md(design bending strength of the section)  $\geq$  Mz(Maximum bending moment)**

1194.56 > 218.31

**SAFE**

#### CHECKS CONCEPTUAL DESIGN

**Check for the Local Capacity of the section -**

Table 2 -IRC 24-10

Yield stress ratio for flanges	$\epsilon$	Mpa	1.00
Yield stress ratio for web	$\epsilon$	Mpa	1.00
Top flange ratio	(plastic)		5.95
Bottom flange ratio	(plastic)		7.00
Web ratio			38.67

cond. : Web need stiffening and Web Buckling need to be checked

clause 509.6

## Design of Intermediate transverse Web Stiffeners -

### Intermediate Stiffeners are required

#### When only transverse stiffeners are provided

(Web connected to flange along both longitudinal edges)

Condition  $3d \geq C \geq d$  therefore  $(d/t_w)$

clause 509.6

assume  $C$  = spacing of transverse stiffener

$d$  = depth of the web

Now,	$d$	mm	464.00
	$3 \cdot d$	mm	1392.00
assume	$c$	mm	600.00

#### Check for minimum Stiffeners -

cl-509.7.2.4

Check	$c/d$	$\leq \sqrt{2}$	1.29
$I_{min}$ minimum moment of inertia required	$I_{min}$	mm <sup>4</sup>	7.19E+05

Let a single stiffener on only one side of the web is provided

thickness of the plate stiffener

$t_s$  mm 12.00

outstand

$a$  mm 100.00

moment of inertia about face of the web

$t_s \times a^3/3$  mm<sup>4</sup> 4.00E+06

The stiffener has more than the minimum required stiffeners

ok

HENCE provide 100mm x 12mm as vertical web stiffener

Buckling resistance of the intermediate transverse stiffeners

IRC 24-2010

clause-509.7.1.5

Design as a strut

The effective length of web equal to  $20 \cdot t_w$  on each side of the centre line of the stiffener can be considered along with the stiffener

$20 \cdot t_w$  mm 240.00

MI about centre line of the stiffener

mm<sup>4</sup> 9.53E+06

Area

$a$  mm<sup>2</sup> 4080.00

radius of gyration

$\sqrt{I/A}$   $r_x$  mm 48.32

effective length

IRC 24-2010 clause 509.7.1.5

$L_{ef}$

$.7 \cdot L$  324.80

slenderness ratio

$L_{ef}/r_x$   $\lambda$  6.72

from table 4 IRC 24-2010

Buckling class

b

from table 6C IRC 24-2010

$f_{cd}$  Mpa 370.00



buckling resistance	KN	1509.60
<b>Buckling check on intermediate transverse stiffeners</b>		
Factored shear force adjacent to the stiffener		clause 509.7.2.5
$v$	KN	215.19
$V_{cr}$	KN	107.60
$F_q$	KN	97.80
	<	1509.60

It is clear by calculation given above that transverse stiffeners are safe in buckling alone but we propose the couples of stiffeners at the c/c distance less than 20 tw for shearing the critical load in between two.

<b>Check for outstand -</b>		clause 509.7.1.2
Outstand of the stiffener max	mm	240.00
check	$14t_{qc}$	168.00
		<b>HENCE OK</b>

<b>Design of End Panel</b>		Irc 24-2010	clause 509.5.3
Longitudinal shear	(Hq)	KN	934.95
Plastic shear resistance	(Vp)	KN	803.70
Critical shear strength	(Vcr)	KN	107.60
Resultant longitudinal shear	Rtf	KN	467.48
Area of web		mm <sup>2</sup>	5568.00
Design shear strength		KN	730.63
		<b>End Panel is safe</b>	

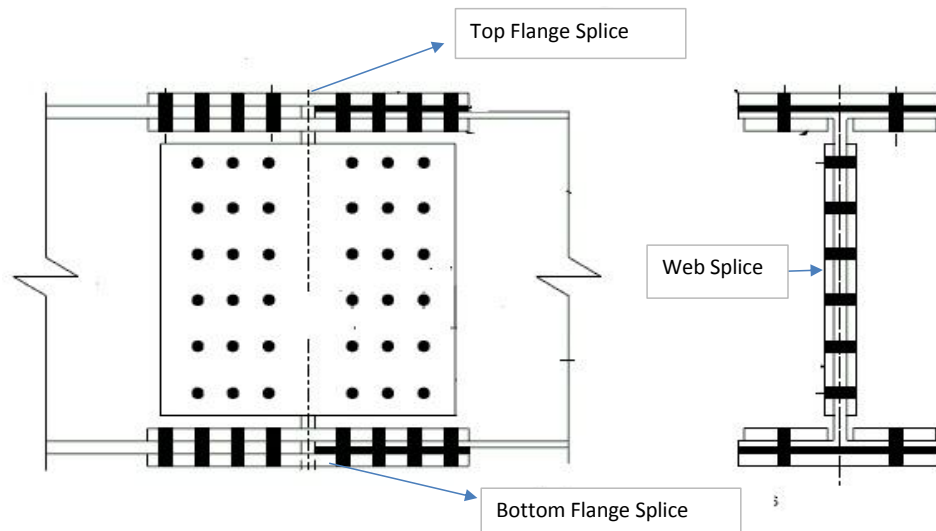
<b>Check for moment capacity of end panel</b>		Irc 24-2010	clause 509.5.3
Moment	$M_{tf} = H_{qd}/10$	Knm	43.38
Moment of resistance	$M_q = I^*f_y/Y_{m0}$	KNm	1.64E+08
Moment of inertia	$I = twc^3/12$	mm <sup>4</sup>	2.16E+08
	y	mm	300.00
		<b>safe</b>	

<b>Design of End bearing Stiffeners</b>			
Max Shear		KN	215.19
Force due to moment M <sub>tf</sub>	$F_{tf} = M_{tf}/c$	KN	72.30
Total compressive force	F <sub>c</sub>	KN	287.49
Required area of stiffener	$A_q = 0.8F_c Y_{m0}/f_y$	mm <sup>2</sup>	1011.96
Assume stiffeners to be 250mmx25mm			
Width	a	mm	250.00
thickness	ts	mm	25.00
Area of stiffeners provided			12500.00
		<b>ok</b>	

Check for outstand -			clause 509.7.1.2	
Outstand of the stiffener max			mm	500.00
check		14tqε		350.00
moment of inertia about face of the web				
	ts x a^3/3		mm4	1.30E+08
The stiffener has more than the minimum required stiffeners				ok
HENCE, provide 250mm x 25mm as vertical end bearing stiffener				
Buckling resistance of the end bearing stiffeners				
moment of inertia about centre line of stiffner				4.94E+08
Area		A	mm^2	15380.00
radius of gyration	√I/A	rx	mm	179.24
effective length				
Lef	.7*L		mm	324.80
slenderness ratio	Lef/rx	λ		1.81

fcd		Mpa	370.00
buckling resistance		KN	5690.60
			safe in bucking
Local capacity of web	$F_w = (b_1+n_2)t_w f_{yw}$	KN	614
Stiff bearing length	$b_1$	mm	100
Length obtained by dispersion through the flange to the web	$n_2$	mm	125
Thickness of web	$t_w$	mm	12.00
Yield stress of web	$f_{yw}$		250.00
Bearing stiffener will designed for the load	$F_c - F_w$	KN	-326
Bearing capacity of stiffener alone			12500.0
Criteria	Stiffener is safe as load bearing stiffener		
Welding requirement for stiffener -			
High strength fillet weld of 70 ksi electrode Futs= 480 Mpa is used			
shear force on weld connecting the stiffener to web	(q1)		CL-509.7.2.6
Shear force		N/mm	2.15E+05
The shear strength of the fillet weld(p)			
Assume size of fillet weld	p	mm	10.00
permissible stress in fillet weld		Mpa	131.00
thorath thickness	$T_t$	mm	7.00
		p	9170.00
The welding is done on both faces, than the weld length per metre length of plate			
The required length of the weld for 1000mm length on each side			
	215185.0	x	1000
	2		9170
		mm	11733.10
		52.81 mm/1000mm length	
Check for stresses			
Check for Bending -			
	M	Nmm	2.18E+08
	Z	mm	4.36E+06
Maximum bending stress			50.04
			HENCE OK
Check for shear stress -			
Avg shear stress	$\tau_{va}$		38.65
		$\leq$	131.22
			HENCE OK
Design of joint between Flange and Web -			
Assuming fillet weld on each side of the web			
Assumin size of the fillet weld		mm	10.00
Permissible strength of the fillet weld		N/mm2	131.22
throat thickness		mm	7.00
The shear strength of fillet weld	p	N/mm2	9185.39
first moment of area of top flange plate @c.g. Is	Q		8.13E+04
The shear flow	q	N/mm	215.56
providing 10mm fillet weld whose strength is 930.1 N/mm			
be used at both faces, than the required length of weld for 1000mm length of girder is			
weld length	215.56 x	1000	
	2 x	9185.387361	mm
		253.76 mm/1000mm length	11.73
			SAFE

## DESIGN OF SPLICE FOR FLEXURE MEMBER



### FLANGE SPLICE TOP

For the design it is assumed that flange splices carry all the moments and web splices carry all the shear

#### Sectional properties of flexure member

Width of flange 250.00 mm

Thickness of flange 20.00 mm

**TOP FLANGE FORCE** 1087.5 KN

Assume width of splice plate equal to flange width

Width of splice plate 250.00

sectional area of splice plate 2652.44 mm<sup>2</sup>

thickness of splice plate 10.60976 mm

**Therefore thickness of splice plate** 16 mm

**Permissible stress in bending** 227.27 Mpa

Stress in top flange 217.5 Mpa

safe

**For bolts of 10.9 grade and 24 mm dia**

Diameter of bolts 24 mm

diameter of hole 26 mm

$f_{ub}$  1040 Mpa

$f_y$  410 Mpa

$\phi_{mb}$  1.25

$\phi_{m0}$  1.1

#### DESIGN OF BOLT AS PER (Bearing Type)

##### Strength of bolt in double shear

$A_{nb}$  (Net area of thread region) 352.9094 mm<sup>2</sup>

Strength of bolt in single shear **339.0539 KN**

##### Strength of bolt in bearing

MIN Pitch(p) 60 mm

Min Edge distance (e) 39 mm

$K_b$ (min of  $p/3d_0 - 0.25, e/3d_0, f_u/f_{ub}, 1$ ) **0.5**

Strength of bolt on bearing **207.36 KN**

**Strength of bolt in tearing**  $(0.9 * f_{ub} * A_{nb} / \phi_{mb})$  **264.2586 KN**

**BOLT VALUE** 207.36 KN

**DESIGN OF BOLT AS PER (FRICTION TYPE)**

Nominal diameter of bolt	24 mm
Nominal diameter of hole	26 mm
Minimum Edge Distance for 24 mm dia Bolt = $1.5 \times 26$	39 mm
Provided Minimum Edge Distance	40 mm
Minimum Pitch Distance for 24 mm dia Bolt = $2.5 \times 24$	60 mm
Provided Minimum Pitch Distance	70 mm
Ultimate Strength of Bolt (Grade 10.9)	1040 Mpa
Thickness Of Splice Plate	16 mm
Coefficient Of Friction ( $\mu_f$ )	0.35
Number Of Effective Interfaces Offering Friction Resistance to Slip ( $n_e$ )	2
$K_h$	1
$\gamma_{mf}$ (For Service Load)	1.1
$\gamma_{mf}$ (For Ultimate Load)	1.25
Net area Of The Bolt At Treaded ( $A_{nb}$ )	352.9094 mm <sup>2</sup>
Proof Stress (= $0.70 f_{ub}$ )	728 Mpa
$F_0$ (Minimum Bolt Tension)	256.9181 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	163.4933 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	143.8741 KN

**NO. OF BOLTS req**

7.56

**NO. OF BOLTS provided**

18

assume 3 bolts In each row bolts are provided at a pitch 60mm and edge distance 40mm

**No. of rows provided**

6

**SO MIN SIZE OF SPLICE PLATE REQ**

(refer drawing)

400mmx200mmx16mm

**FLANGE SPLICE BOTTOM**

For the design it is assumed that flange splices carry all the moments and web splices carry all the shear

**BENDING MOMENT**

Sectional properties of flexure member

Width of flange 300.00

Thickness of flange 20.00

TOP FLANGE FORCE 1305 KN

Assume width of splice plate equal to flange width

Width of splice plate 300.00

sectional area of splice plate 5220.00 mm<sup>2</sup>

thickness of splice plate 17.4 mm

Therefore thickness of splice plate 20 mm

Permissible stress in bending 227.2727 Mpa

Stress in BOTTOM flange 217.5 Mpa

safe

For bolts of 10.4 grade and 24mm dia

Diameter of bolts 24 mm

diameter of hole 26 mm

 $f_u$  540 Mpa $f_{ub}$  1040 Mpa $f_y$  410 Mpa $\gamma_{mb}$  1.25 $\gamma_{m0}$  1.1**DESIGN OF BOLT AS PER (Bearing Type)****Strength of bolt in double shear** $A_{nb}$  (Net area of thread region) 352.9094 mm<sup>2</sup>

Strength of bolt in single shear 339.0539 KN

**Strength of bolt in bearing**

MIN Pitch(p) 60 mm

Min Edge distance (e) 39 mm

 $K_b$ (min of  $p/3d_0$ ,  $e/3d_0$ ,  $f_u/f_{ub}$ , 1) 0.5

Strength of bolt on bearing 259.2 KN

**Strength of bolt in tearing** ( $0.9 * f_{ub} * A_{nb} / \gamma_{mb}$ ) 264.2586 KN**BOLT VALUE** 259.2 KN

**DESIGN OF BOLT AS PER (FRICTION TYPE)**

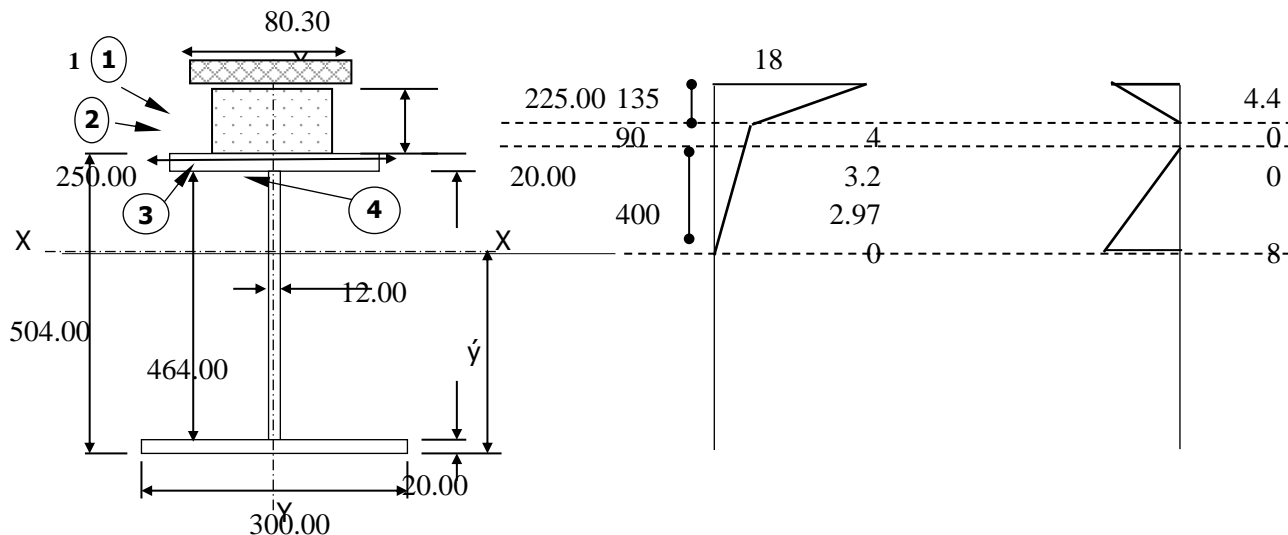
Nominal diameter of bolt	24 mm
Nominal diameter of hole	26 mm
Minimum Edge Distance for 24 mm dia Bolt = $1.5 \times 26$	39 mm
Provided Minimum Edge Distance	40 mm
Minimum Pitch Distance for 24 mm dia Bolt = $2.5 \times 24$	60 mm
Provided Minimum Pitch Distance	70 mm
Ultimate Strength of Plate	410
Ultimate Strength of Bolt (Grade 10.9)	1040 Mpa
Thickness Of Splice Plate	20 mm
Coefficient Of Friction ( $\mu_f$ )	0.35
Number Of Effective Interfaces Offering Friction Resistance to Slip ( $n_e$ )	2
$K_h$	1
$\gamma_{mf}$ (For Service Load)	1.1
$\gamma_{mf}$ (For Ultimate Load)	1.25
Net area Of The Bolt At Treaded ( $A_{nb}$ )	352.9094 mm <sup>2</sup>
Proof Stress (= $0.70 f_{ub}$ )	728 Mpa
$F_0$ (Minimum Bolt Tension)	256.9181 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	163.4933 KN
Maximun Shear Capacity Of Bolt ( $\frac{1}{2} \mu_f * n_e * K_h * F_0 / \gamma_{mf}$ )	143.8741 KN
NO. OF BOLTS req	9.070429
<b>NO. OF BOLTS provided</b>	18
assume 3 bolts In each row bolts are provided at a pitch 60mm and edge distance 40mm	
no. of rows provided	6
<b>SO MIN SIZE OF SPLICE PLATE REQ</b>	(refer drawing) 400mmx200mmx20mm

**DESIGN OF WEB SPLICE**

SINCE BOLT IS IN DOUBLE SHEAR	
ASSUME thickness of web splice plate	16 mm
SHEAR FORCE	430.37 KN
<b>STRENGTH OF BOLT IN DOUBLE SHEAR</b>	678.1077 KN
<b>STRENGTH OF BOLT IN BEARING</b>	235.6364 KN
<b>BOLT VALUE</b>	235.6364 KN
<b>NO.OF BOLTS REQ</b>	1.826416
<b>BOLT PROVIDED ON EACH SIDE</b>	21
Try 3 bolts in eachrows at 60 mm vertical pitch and 45 mm from the center of joint.	
<b>No of rows</b>	7
PITCH	60 mm
distance from edge (N)	45 mm
$r_n$	189.73 mm
summation of square of r	345581.1 mm <sup>2</sup>
<b>Horizontal shear force on bolt due to moment due to ecc.</b>	10.63263 KN
<b>VERTICAL SHEAR ON BOLT</b>	20.49381 KN
<b>RESULTANT FORCE</b>	23.08785 KN
<b>SO Min size of web splice plate REQ</b>	(refer drawing) OK 400mmx210mmx16mm

## DUE TO TEMPERATURE GRADIENT

In this case it is assumed that the super-structure is free to translate in the longitudinal direction and that the steel and concrete have the same co-efficient of thermal expansion, so that uniform changes of temperature cause no stresses in the superstructure. Thus only the effects of temperature differences through the depth of cross-section is considered. The nominal temperature differences are shown below.



The temperature at various levels of the composite girder is taken from IRC 6-2014

Calculating for Central segment

Required parameters

Cross sectional area of the composite section (A) =

3.5E+04 mm<sup>2</sup>

Moment of Inertia of the composite section (I) =

2.06E+09 mm<sup>4</sup>

Coefficient of thermal expansion (α) =

1.2E-05 /°C

Modulus of Elasticity of Steel (E<sub>s</sub>) =

2.1E+05 Mpa

Modulus of elasticity of concrete (E<sub>c</sub>) =

32000 Mpa

ZONE	Area (A) of equivalent steel sec	y (From top)	Ay	Ay <sup>2</sup>	T (Rise Case)	αAT	aATY
1	1.08E-02	6.75E-02	7.32E-04	4.94E-05	11.00	1.4E-06	9.7E-08
2	7.23E-03	1.80E-01	1.30E-03	2.34E-04	3.6	3.1E-07	5.61972E-08
3	5.00E-03	2.35E-01	1.18E-03	2.76E-04	3.09	1.9E-07	4.3E-08
4	4.56E-03	4.35E-01	1.98E-03	8.63E-04	1.49	8.1E-08	3.53478E-08
SUM	2.76E-02	9.18E-01	5.19E-03	1.42E-03	19.17	2.00951E-06	2.31632E-07

q 3.26E-04

ε 0 1.34E-04

## Eigen stresses (steel)

SL.No.	Location	y	t	a	a t	Eigen Stresses	Equivalent Concrete Stress
i	tp.of slab	0	1.80E+01	1.20E-05	2.16E-04	-2.62	-2.62
ii	bt.of slab	0.225	3.20E+00	1.20E-05	3.84E-05	0.71	

ZONE	Area (A) of equivalent steel sec	y (From top)	Ay	Ay <sup>2</sup>	T (Fall Case)	aAT	aATY
i	1.08E-02	0.068	7.32E-04	4.94E-05	2.2	2.86189E-07	1.93178E-08
ii	7.23E-03	1.80E-01	1.30E-03	2.34E-04	0	0.0E+00	0.0E+00
iii	5.00E-03	0.235	1.18E-03	2.76E-04	0.4	2.4E-08	5.6E-09
iv	4.56E-03	4.35E-01	1.98E-03	8.63E-04	4.2	2.3E-07	1.0E-07
<b>SUM</b>	<b>2.76E-02</b>		<b>5.19E-03</b>	<b>1.42E-03</b>		<b>5.40013E-07</b>	<b>1.24931E-07</b>

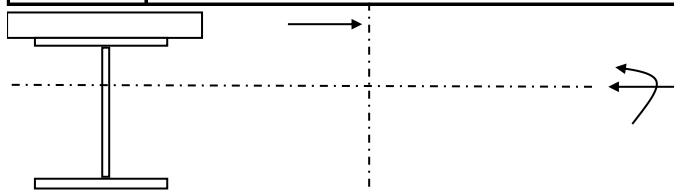
q -5.25E-05  
ε 0 9.68593E-06

#### Eigen stresses (steel)

SL.No.	Location	y	t	a	a t	Eigen Stresses	Equivalent Concrete Stress
i	tp.of slab	0	-4.4	1.20E-05	-5.28E-05	2.00	2.00
ii	bt.of slab	0.225	0	1.20E-05	0.00E+00	0.69	

#### DUE TO SHRINKAGE OF THE DECK SLAB

Sl.No	Description	Units	Symbol	Value
i	Shrinkage strain in concrete			2.00E-04
ii	Modulus of elasticity	N/mm <sup>2</sup>	Ec	3.20E+04
iii	Modular ratio		m	6.6E+00
iv	Modified Modulus of elasticity	N/mm <sup>2</sup>	Ec'	1.60E+04
v	Stress in deck	Nmm <sup>2</sup>		3.20E+00
vi	Force in concrete	N	T	5.78E+04



Sl.No	Description	Units	Symbol	Value
i	M, moment due to shrinkage forces	Nmm	M	1.50E+07
ii	Stress at Top of Concrete	Mpa		0.57
iii	Stress at Interface of Conc & Steel	Mpa		3.16
iv	Stress at the bottom of steel	Mpa		3.43
v	Axial Stress	Mpa		2.26
vi	Total Stress at the Interface of Conc & Steel	Mpa		5.42
vii	Total Stress at the Bottom of Steel	MPa		1.17

PROP.	Load				Total Stress	Perm.Bend. Stresses*	check
	DL	SIDL	LL	SHRINKAG			
<b>STEEL</b>	2.77	18.58	157.11	-5.42	173.03	250.125	OK

## Check for Deflection

### DEFLECTION CHECK

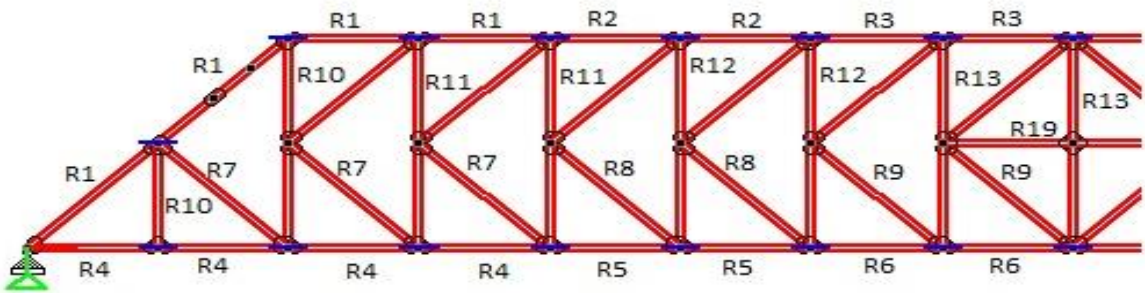
Ref: Cl.504.5.1 of IRC-24:2010

Sl.No	Description	Units	Symbol	Value	
i	Span of the girder	m	L	5000.00	
ii	a) Deflection due to DL	mm	defl_DL	0.9	
iii	b) Deflection due to SIDL	mm	defl_SDL	0.8	
iv	c) Deflection due to LL	mm	defl_LL	4.68	
v	Total defl. due to DL+LL+SIDL	mm	defl_total	6.38	
	Permissible defl. due to DL+LL+SI	mm	defl_total	8.333333	No camber
	Permissible defl. due to LL	mm	defl_LL	6.25	ok



# **Bolt Summary**

BOLTS CALACULATIONS



DETAILS OF FORCES

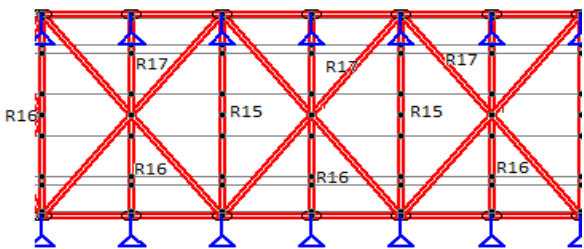
Description	List	ULS (kN)	Comp/Ten.	Des. Value (kN)
R1	TOP CHORD	15958.0 0.4	C T	15958
R2	TOP CHORD	19960.7 0.3	C T	19961
R3	TOP CHORD	22413.8 0.3	C T	22414
R4	BOTTOM CHORD	0.3 9824.3	C T	9824
R5	BOTTOM CHORD	0.3 11362.7	C T	11363
R6	BOTTOM CHORD	0.3 12725.4	C T	12725
R7	DIAGONAL	6021.7 4563.1	C T	6022
R8	DIAGONAL	4066.7 2962.2	C T	4067
R9	DIAGONAL	1933.0 1472.5	C T	1933
R10	Vertical	2306.6 7955.3	C T	7955
R11	Vertical	2973.3 3178.3	C T	3178
R12	Vertical	1569.5 2027.5	C T	2027
R13	Vertical	2343.3 1068.3	C T	2343
R14	END RACKER	16007.0 0.0	C T	16007
R15	TOP LATERAL	43.8 43.8	C T	44
R16	TOP LATERAL(int)	53.4 44.3	C T	53
R17	TOP BRACING	374.1 3.3	C T	374
R18	BOTTOM BRACING	1226.9 1616.3	C T	1616
R19	HORIZONTAL MEMBER	1883.6 142.5	C T	1884
R22	KNEE BRACING	3237.6 1927.0	C T	3238

DESIGN OF BOLT AS PER (BEARING TYPE)	Double shear plane	Single shear plane	Units
Nominal diameter of bolt	24	24	mm
Nominal diameter of hole	26	26	mm
Minimum Edge Distance for 24 mm dia Bolt = 1.75 x 26	45.5	45.5	mm
Provided Minimum Edge Distance	53	53	mm
Minimum Pitch Distance for 24 mm dia Bolt = 2.5 x 24	60	60	mm
Provided Minimum Pitch Distance	68	68	mm
ThickNess Of Gusset Plate	16	16	mm
Number Of Shear Plane in Shank (N <sub>s</sub> )	0	0	
As Per IRC 24:2010 Clause No. 512.5.5.3 (pg.no. 144)			
Number Of Shear Plane in Threaded Region (N <sub>n</sub> )	2	1	
As Per IRC 24:2010 Clause No. 512.5.5.4 (pg.no. 145)			
Area Of Bolt At Shank (A <sub>sb</sub> )	452.39	452.39	mm <sup>2</sup>
As Per IRC 24:2010 Clause No. 512.5.6.5 (pg.no. 147)			
Area Of Bolt At Threaded Region (A <sub>nb</sub> )	352.86	352.86	mm <sup>2</sup>
Utimate Strength of Plate	410	410	N/mm <sup>2</sup>
Utimate Strength of Bolt (Grade 10.9)	1040	1040	N/mm <sup>2</sup>
Partial Factor Of Safety (γ <sub>mb</sub> )	1.25	1.25	
Factor (k <sub>b</sub> )	0.62	0.62	
Maximum Shear Strength Of Bolt $F_{ub}*((N_n*A_{nb})+(N_s*A_{sb}))/((3^{0.5})*\gamma_{mb})$	339.00	169.50	kN
Maximum Bearing Strength Of Bolt $2.5*k_b*d*t*f_u/\gamma_{mb}$	195.23	195.23	kN
Maximum Tensile Strength Of Bolt $0.9*f_{ub}*A_{nb}/\gamma_{mb}$	264.22	264.22	kN
Reduction Factor For Long Joint (β <sub>lj</sub> )	1	1	
Reduction Factor For Grip Length (β <sub>lg</sub> )	1	1	
Reduction Factor For Packing Plate (β <sub>pkg</sub> )	1	1	

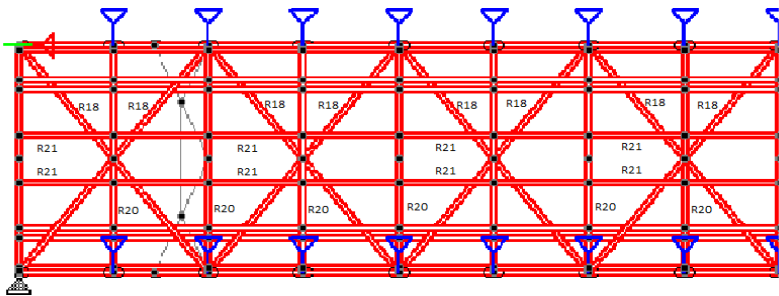
DESIGN OF BOLT AS PER (FRICTION TYPE)	Double shear	Single shear	Units
Nominal diameter of bolt	24	24	mm
Nominal diameter of hole	26	26	mm
Minimum Edge Distance for 24 mm dia Bolt = 1.75 x 26	45.5	45.5	mm
Provided Minimum Edge Distance	55	55	mm
Minimum Pitch Distance for 24 mm dia Bolt = 2.5 x 24	60	60	mm
Provided Minimum Pitch Distance	70	70	mm
Utimate Strength of Plate	410	410	N/mm <sup>2</sup>
Utimate Strength of Bolt (Grade 10.9)	1040	1040	N/mm <sup>2</sup>
ThickNess Of Gusset Plate	16	16	mm
Coefficient Of Friction (μ <sub>f</sub> )	0.35	0.35	
Number Of Effective Interfaces Offering Friction Resistance to Slip (n <sub>e</sub> )	2	1	
K <sub>h</sub>	1	1	
γ <sub>mf</sub> (For Service Load)	1.1	1.1	
γ <sub>mf</sub> (For Ultimate Load)	1.25	1.25	
Net area Of The Bolt At Treaded (A <sub>nb</sub> )	352.86	352.86	mm <sup>2</sup>
Proof Stress (= 0.70 f <sub>ub</sub> )	728	728	N/mm <sup>2</sup>
F <sub>0</sub> (Minimum Bolt Tension)	256.88	256.88	kN
Maximun Shear Capacity Of Bolt (At Service) $\mu_f*n_e*K_h*F_0/\gamma_{mf}$	163.47	81.74	kN
Maximun Shear Capacity Of Bolt (At Ultimate) $\mu_f*n_e*K_h*F_0/\gamma_{mf}$	143.86	71.93	kN

DESIGN OF CONNECTIONS

SR. No.	Member	Design Force (kN)	No. OF BOLTS Reqd.		TOTAL (required.)	No of interface
			Bearing	H.S.F.G.		
R1	TOP CHORD	15958	82	111	120	2
R2	TOP CHORD	19961	103	139	150	2
R3	TOP CHORD	22414	115	156	170	2
R4	BOTTOM CHORD	9824	51	69	80	2
R5	BOTTOM CHORD	11363	59	79	80	2
R6	BOTTOM CHORD	12725	66	89	90	2
R7	DIAGONAL	6022	31	84	90	1
R8	DIAGONAL	4067	21	57	60	1
R9	DIAGONAL	1933	10	27	40	1
R10	Vertical	7955	41	111	120	1
R11	Vertical	3178	17	45	50	1
R12	Vertical	2027	11	29	30	1
R14	END RACKER	16007	82	112	120	2
R15	TOP LATERAL	44	1	1	4	1
R16	TOP LATERAL(int)	53	1	1	4	1
R17	TOP BRACING	374	2	3	8	2
R18	BOTTOM BRACING	1616	9	12	16	2
R19	HORIZONTAL MEMBER	1884	10	14	16	2
R22	KNEE BRACING	3238	17	23	24	2



TOP PLAN 80M SPAN



BOTTOM PLAN 80 M SPAN

# DESIGN OF DECK SLAB

**Overall width : 12.5 m**  
**Span c/c bearings : 80 m**

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# CHAPTER - 1

## Introduction

**For Design of Deck Slab**

**Code of reference**

IRC: 5-2015

IRC: 6-2014

IRC: 112-2014

# 1.INTRODUCTION

The Design of RCC Deck Slab for 12.5m overall width and span 80 m c-c of bearing

## 2. Design Data

### 2.1 Superstructure Data

Type of superstructure	Steel Truss	
Span c/c of expansion joints	<i>span.ej</i>	81.50 m
Span c/c of bearings	<i>span.bea</i>	80.00 m
Overall width	<i>owidth</i>	12.50 m
Railing width(at bottom)	<i>rw</i>	0.000 m
Crash barrier width	<i>cbw</i>	0.500 m
Footpath width	<i>fpw</i>	0.000 m
Carriageway width	<i>carw</i>	11.50 m
cross slope for drainage	<i>cslope</i>	0.025
number of longitudinal girder(Stringer)	<i>ngirder</i>	4
c/c spacing of longitudinal girder (Stringer)	<i>spacing</i>	2.500 m
thk. of slab at center of bridge	<i>thk.1</i>	0.225 m
thk. of slab at edge of cantilever	<i>thk.2</i>	0.225 m
thk. of slab at edge of cantilever and girder end	<i>thk.3</i>	0.225 m
thk. of wearing coat	<i>thk.4</i>	0.065 m

### 2.2 Material Data

Grade of concrete	$f_{ck}$	35
Partial safety factor for concrete      Basic & Siesmic	$\gamma_m$	1.5
Partial safety factor for steel          Basic & Siesmic	$\gamma_s$	1.15
Design compressive strength of concrete	$f_{cd}$	15.63 N/mm <sup>2</sup>
Tensile strength of concrete	$f_{ctm}$	2.80 N/mm <sup>2</sup>
Grade of flexure reinforcement	$f_y$	500 N/mm <sup>2</sup>
Design tensile strength of flexure reinforcement	$f_{yd}$	434.8 N/mm <sup>2</sup>
Modulus of elasticity of concrete	$E_{cm}$	32000 N/mm <sup>2</sup>
Modulus of elasticity of reinforcement	$E$	2.00E+05 N/mm <sup>2</sup>
Modular ratio	$m$	6.250
Ultimate compressive strain in flexure	$\epsilon_{cu2}$	0.0035
clear cover	$ccov$	0.040 m
Density of concrete		25 kN/m <sup>3</sup>
Density of wearing concrete		25 kN/m <sup>3</sup>

Design constants:

neutral axis depth factor	x/d	0.46 (For balanced
moment of resistance factor	Q	4.68 section)



### 3 Live Load Analysis

#### 3.1 Details of wheel loads causing design moments at critical section

<u>Class</u>	<u>load</u>	<u>tyre pressure</u>	<u>width</u>	<u>tread width</u>	<u>contact length</u>	<u>impact factor</u>
	<u>(kN)</u>	<u>(kg/cm<sup>2</sup>)</u>	<u>(m)</u>	<u>(m)</u>	<u>(m)</u>	
<u>A wheel</u>	57	4.56	0.5	0.5	0.25	0.168
<u>70R bogie</u>	100	5.273	0.86	0.81	0.23	0.154
<u>70R track</u>	350	0.91	0.84	0.84	4.57	0.1
<u>Special</u>	45	10.53	0.156	0.156	0.274	-

Table 3.1 Details of wheel load

Distance of nearest axle for class A wheel loading	<i>dist.1</i>	1.20	m
Distance of nearest axle for class 70R bogie loading	<i>dist.2</i>	1.22	m
Distance between tyres of bogie		1.93	m
Distance between tyres of Class A		1.80	m
Distance between tyres of shovel		5.70	m
Distance between tyres of Special		1.05	m
Distance nearest axle of Special	<i>dist.3</i>	1.37	m

#### 3.2 Mathematical modelling

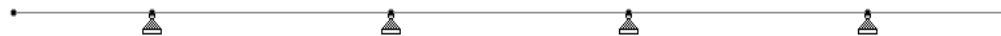


Figure 7.1 – General Model( The overall width of deck slab)

#### 3.3 Transverse Analysis of Deck Slab (by effective width)

For a single concentrated load, the effective width of slab spanning in one direction is given by:

$$b_{ef} = \alpha \quad a \quad \left( 1 - \frac{a}{l_0} \right) + b_1$$

For a single concentrated load, the effective width of cantilever slab is given by:

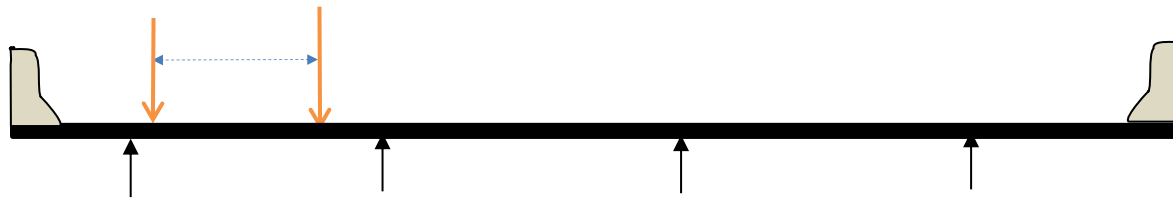
$$b_{ef} = 1.2a + b_1$$

where,

$l_0$	effective span		
$a$	distance of c.g. of load from nearer support face		
$b_1$	width of concentration area of load		
$\alpha$	a constant depending upon the ratio $b/l_0$ , $b$ is the width of slab		
effective span	$l_a$	3.000	m
width of slab	$b$	40.000	m
constant	$\alpha$	2.600	
$b_1$ for class A wheel load of 57 kN	<u><math>b1.1</math></u>	0.380	m
$b_1$ for class 70R bogie load of 100 kN	<u><math>b1.2</math></u>	0.364	m
$b_1$ for class 70R track load of 350 kN	<u><math>b1.3</math></u>	4.700	m
$b_1$ for special Vechile	<u><math>b1.4</math></u>	0.404	m

**3.4 For the design bending moment in deck slab (sagging and hogging) due to live load, critical section have been identified as,**

**Case-1:** 70R wheel placed at min ecc.from C.B

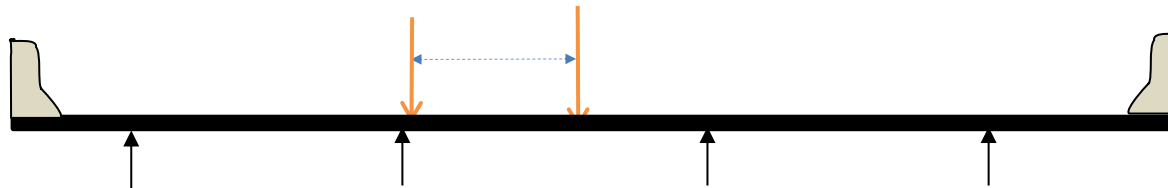


**Figure 7.2 – Loading Case 1**

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersion length (m)	load intensity(Kn/m <sup>2</sup> )
P1	100	0.360	1.188	1.188	1.390	69.895
P2	100	0.710	1.773	1.497	1.390	55.473

Table 3.2 Calculation of dispersion length and intensity for case 1

**Case-2:** 70R wheel placed at girder

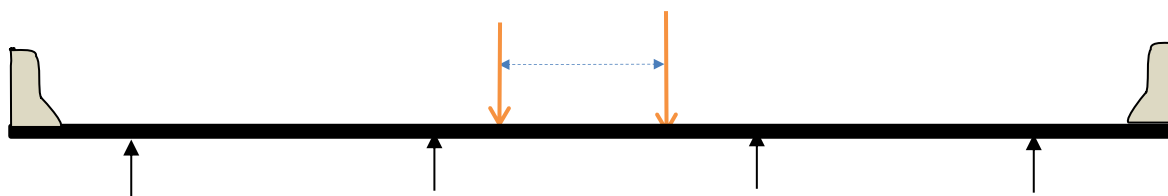


**Figure 7.3– Loading Case 2**

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersion length (m)	load intensity(Kn/m <sup>2</sup> )
P1	100	0.000	0.364	0.364	1.390	228.000
P2	100	1.070	2.154	1.687	1.390	49.214

Table 3.3 Calculation of dispersion length and intensity for case2

**Case-3:** 70R wheel placed symmetric in b/w girder



**Figure 7.4– Loading Case 3**

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	100	0.535	1.507	1.364	1.390	60.887
P2	100	0.535	1.507	1.364	1.390	60.887

Table 3.4 Calculation of dispersion length and intensity for case2

**Case-4:** Class A wheel placed at min ecc.from C.B



Figure 7.5– Loading Case 4

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	57	0.550	1.548	1.374	1.080	44.868
P2	57	0.950	2.068	1.634	1.080	37.728

Table 3.2 Calculation of dispersion length and intensity for case 1

**Case-5:** Class A wheel placed at girder

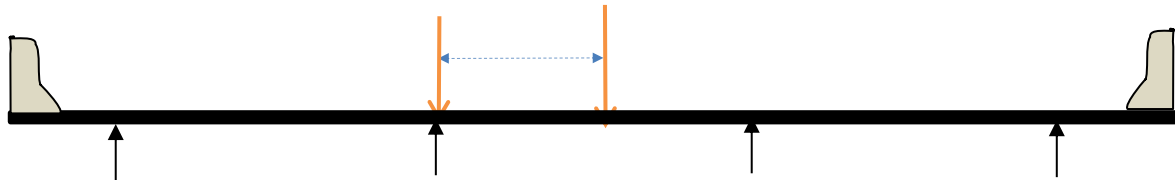


Figure 7.6– Loading Case 5

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	57	0.000	0.380	0.380	1.080	162.222
P2	57	1.200	2.252	1.726	1.080	35.715

Table 3.3 Calculation of dispersion length and intensity for case2

**Case-6:** Class A wheel placed symmetric in b/w girder

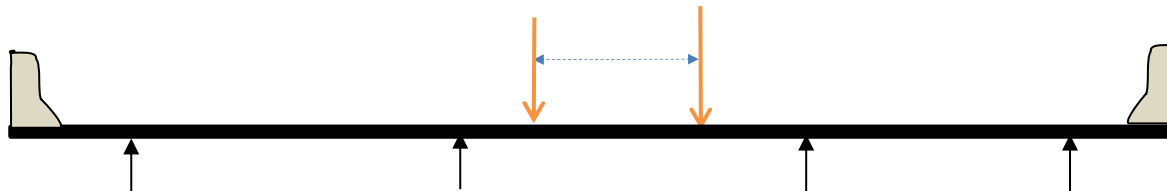
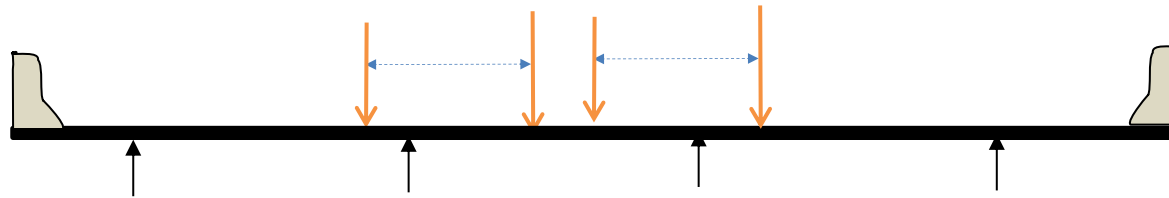


Figure 7.7– Loading Case 6

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	57	0.600	1.628	1.414	1.080	43.596
P2	57	0.600	1.628	1.414	1.080	43.596

Table 3.4 Calculation of dispersion length and intensity for case2

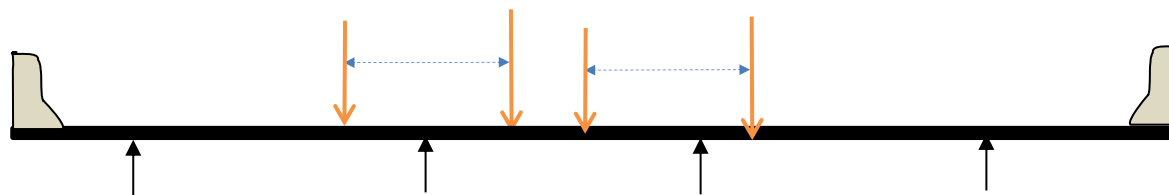
**Case-7:** Special Vech. C.g of wheel placed at c.g of Carriageway



**Figure 7.8– Loading Case 7**

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	45	0.225	0.945	0.945	0.854	55.753
P2	45	0.975	2.115	1.743	0.854	30.239
P3	45	0.975	2.115	1.743	0.854	30.239
P4	45	0.225	0.945	0.945	0.854	55.753

**Case-7:** Special Vech. C.g of wheel placed at 300mm ecc from c.g of Carriageway



**Figure 7.9– Loading Case 8**

wheel ID	wheel load (KN)	a (m)	b <sub>ef</sub>	actual b <sub>ef</sub>	Dispersio n length (m)	load intensity(Kn/ m <sup>2</sup> )
P1	45	0.075	0.594	0.594	0.854	88.690
P2	45	0.675	1.764	1.567	0.854	33.625
P3	45	1.275	2.310	1.840	0.854	28.637
P4	45	0.525	1.530	1.450	0.854	36.339

## 4 .Dead Load Analysis

<u>S.No</u>	<u>Description</u>	<u>b</u> <u>(m)</u>	<u>h</u> <u>(m)</u>	<u>Area</u> <u>(m<sup>2</sup>)</u>	<u>Density</u> <u>(kN/m<sup>3</sup>)</u>	<u>Load</u> <u>(kN/m)</u>
<u>1</u>	<u>SIDL(w/o surfacing)</u>					<u>AS UDL</u>
	<u>Railing</u>	<u>0</u>	<u>1.000</u>	<u>0.000</u>	<u>25</u>	<u>0.000</u>
	<u>Crash Barrier</u>	<u>0.500</u>	<u>0.900</u>	<u>0.450</u>	<u>25</u>	<u>11.250</u>
<u>2</u>	<u>SIDL(only surfacing)</u>					
	<u>Wearing Coat</u>		<u>0.065</u>		<u>22</u>	<u>1.43</u>

Table 3.4 Calculation of dead loads

## DESIGN OF DECK SLAB

### 5 Design of Deck Slab

#### 5.1 Design of Deck Slab for Bending Moment

Main reinforcement details

Slab Type		Cantilever Slab (Member 1/8)	Continuous Slab (Member 2/3/4/5/6/7)	
Moment		hogging	sagging	hogging
Dist. from girder center	unit	support	centre	support
<b>Tension reinforcement</b>				
design bending moment	kN-m	86.1	38.3	86.1
effective depth required	mm	136	90	136
overall depth available	mm	225	225	225
dia of bar1	mm	16	16	16
dia of bar2	mm	0	0	0
effective depth available bar	mm	177	177	177
required area of reinforcement	mm <sup>2</sup>	1243	519	1243
minimum area of reinforcement	mm <sup>2</sup>	258	258	258
required spacing of reinforcement	mm	162	388	162
provided spacing of reinforcement	mm	150	200	150
Ast provided	mm <sup>2</sup>	1340	1005	1340
CHECKS				
1.Check for effective depth	Criteria:	Effective depth available > Effective req		
		OK	OK	OK
2.Check for spacing	Criteria:	max spacing = lesser of 2h and 250 mm		
CI 16.6.1.1, IRC 112		OK	OK	OK
3.Check for area of steel	Criteria:	Ast provided > Max(Ast req , Ast min)		
CI 16.5.1.1, IRC 112		OK	OK	OK

Table 5.1 for Calculation for design of deck slab

Provide 16mm @ 150c/c spacing at top of slab

Provide 16mm @ 200c/c spacing at bottom of slab

#### 5.2 Distribution reinforcement details

Area of main reinforcement provided  $A_{st\text{ prov}}$  Reference: IRC-112  
 Area of transverse reinforcement req  $0.2A_{st\text{ prov}}$   
 Min area of surface reinforcement  $0.01A_{ct,ext}$  , (Act.ext= cover x b ) CI: 16.6.1.1(3)  
 Min area of reinforcement at bottom  $0.12\%bD$  CI: 16.5.4(4)  
 Area of distribution steel req = MAX (  $0.2A_{st\text{ prov}}$  ,  $0.01A_{ct,ext}$  ,  $0.12\%bD$  )

	unit	At Top	At Bottom
$A_{st\text{ prov}}$	mm <sup>2</sup>	1340	1005
$0.2A_{st\text{ prov}}$	mm <sup>2</sup>	268	201
$0.01A_{ct,ext}$	mm <sup>2</sup>	400	400
$0.12\%bD$	mm <sup>2</sup>	270	270
Ast Dist Req	mm <sup>2</sup>	400	400
Dia	mm	12	12
Spacing	mm	125	125
Ast Dist prov	mm <sup>2</sup>	904	904

CHECK	At Top	At Bot
Spacing	OK	OK
Ast prov	OK	OK

CI 16.6.1.1(4) IRC 112:2014

Table 5.2 for Calculation of Reinforcement

Provide 12mm @ 125c/c spacing at top of slab

Provide 12mm @ 125c/c spacing at bottom of slab

### 5.3 Design of Deck Slab for Shear Force

Dist from Girder	Cantilever Span	Continuous Span
	at support	at d dist from support
Shear(kN)	87.600	154.65
Eff Depth	177	177
Web wid	1000	1000
K	2.063	2.063
$\rho_1$	0.008	0.008
$\sigma_{cp}$	3.127	3.127
$V_{Rd.cmin}$	179.20	179.20
$V_{Rd.c}$	203.05	203.05
CHECK	NOT REQ	NOT REQ

Table 5.3 Design of shear force

## 6 Limit State of Servicibility

### 6.1 Deflection

Deflection check can be broadly classified into following two cases :-

- i. Due to vehicular live load
- ii. Due to sustained loading
  - a.Short term deflection
  - b.Deflection due to creep
  - c.Deflection due to shrinkage

Creep coefficient	$\Phi$	1.3	Pg 47 table 6.9 IRC 112
Relative humidity	$R.H$	50	
Modulus of elasticity of steel	$E_s$	200000	N/mm <sup>2</sup>
Modulus of elasticity of concrete.	$E_c$	32000	N/mm <sup>2</sup>
Eff Modulus of elasticity of conc	$E_{c, eff}$	13913.04	N/mm <sup>2</sup>
Effective modular ratio	$\alpha_e$	14.38	
Autogenous shrinkage strain	$\epsilon_{ca}$	0.000055	Pg 45 table 6.6 IRC 112.
Drying shrinkage strain	$\epsilon_{cd'}$	0.000512	Pg 46 table 6.8 IRC 112.
Final drying shrinkage strain	$\epsilon_{cd}$	0.000369	
First moment of area of the reinf about the centroid of the section	$S$	64809.60	mm <sup>3</sup>

Moment of inertia of section	$I$	9.49E+08	
Cracked moment of inertia	$I_{crack}$	6.64E+08	
Area of crosssection	$A_c$	9000000	
Perimetre exposed to atmosphere	$u$	40450.00	mm
Notional size	$h_o$	444.99	
Coefficient based on notional size	$k_{h,RH=50}$	0.72	Pg 45 table 6.7 IRC 112
	$k_3 =$	0.125	(for simply supported)

Deflection due to	M	L	E	I <sub>crack</sub>	δ	Max Limit	Check
	kN m	m	N/mm <sup>2</sup>	mm <sup>4</sup>	mm	mm	
	21.87	3	32000	6.645E+08	0.96	3.75	OK
1.VehicleLL							
2.DL							
a)Short term	24.31	3	32000	6.645E+08	1.07		
b)Creep							
i.a <sub>icc(perm)</sub>							
ii.a <sub>i(perm)</sub>	24.305	3	13913	664453125	2.46		
	24.305	3	32000	664453125	1.07		
iii.a <sub>cc(perm)</sub>	= a <sub>icc(perm)</sub> - a <sub>i(perm)</sub>				1.39		
c)Shrinkage	Deflection due to shrinkage is given by $k_3 \Psi_{cs} L^2$				0.47		
Total Deflection due to sustained loads					2.93	5.0	OK

Table 6.1 Deflection Check



## 6.2 Stress check

Type of Section		For uncracked section		For cracked section			
		Hogging	Sagging		Hogging	Sagging	
D	mm	225	225		225	225	
d <sub>e</sub>	mm	177	177		177	177	
M	kN-m	86	38		86	38.2528	
A <sub>st</sub>	mm <sup>2</sup>	1340	1005		1340	1005	
I	mm <sup>4</sup>	9.49E+08	9.49E+08		6.6E+08	6.6E+08	
NA <sub>depth</sub>		-	-		46.25	34.69	
Y <sub>top</sub>	mm	112.5	112.5		178.75	34.69	
Y <sub>bottom</sub>	mm	112.5	112.5		46.25	190.31	
σ <sub>top</sub>		10.20	4.53		144.74	2.00	
σ <sub>top,perm</sub>		2.80	16.80	cracked section	400.00	15.61	OK
σ <sub>bottom</sub>	N/mm <sup>2</sup>	10.20	4.53		5.99	68.48	
σ <sub>bot,perm</sub>		16.80	2.80	cracked section	15.63	400.00	OK

Table 6.2 Stress Check

## 6.3 Crack Width

	TOP	BOTTOM
A <sub>st</sub> , mm <sup>2</sup>	1339.7	1004.8
CG of steel	48.0	48.0
b <sub>w</sub>	1000.0	1000.0
Total D	225.0	225.0
Eff Depth	177.0	177.0
Dist of NA	46.3	34.7
$\sum n_i \phi_i^2$	16.0	16.0
$\sum n_i \phi_i$		
σ <sub>sc</sub>	144.7	68.5
h <sub>c,eff</sub>	112.5	112.5
A <sub>c,eff</sub>	112500.0	112500.0
ρ <sub>p,eff</sub>	0.0	0.0
S <sub>r,max</sub>	228.5	304.7
f <sub>ct,eff</sub>	2.8	2.8
ε <sub>sm</sub> - ε <sub>cm</sub>	0.0	0.0
W <sub>k</sub>	0.1	0.1
Limit W <sub>k</sub>	0.3	0.3
Status	OK	OK

Table 6.3 Crack width Check

STAAD RESULTS

STAAD RESULTS

7.1 Unfactored Bending Moment (STAAD Output)

Beam	Dist.	DL		SIDL		SIDL(w.c)		Total	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.58	0.90	0.00	1.88	0.00	0.01	0.00	2.78	0.00
	1.17	3.61	0.00	5.16	0.00	0.32	0.00	9.08	0.00
	1.75	8.12	0.00	8.44	0.00	1.12	0.00	17.67	0.00
2.0	0.00	8.12	0.00	8.44	0.00	1.12	0.00	17.67	0.00
	1.00	1.16	0.00	5.10	0.00	0.65	0.00	6.91	0.00
	2.00	0.00	-0.49	1.70	0.00	0.18	0.00	1.87	-0.49
	3.00	3.16	0.00	0.00	-1.67	0.00	-0.29	3.16	-1.97
3.0	0.00	3.16	0.00	0.00	-1.67	0.00	-0.29	3.16	-1.97
	1.00	0.00	-2.15	0.00	-1.67	0.00	-0.17	0.00	-3.99
	2.00	0.00	-2.15	0.00	-1.67	0.00	-0.05	0.00	-3.87
	3.00	3.16	0.00	0.00	-1.67	0.00	0.07	3.16	-1.60

Table for Staad Results unfactored bending momnet

Results for live load( Unfactored bending moment )

<u>Max Hogging Moment</u>	41.189
<u>Max Sagging Moment</u>	-21.865

Unfactored Shear Force (STAAD Output)

Beam	Dist.	DL		SIDL(no w.c)		SIDL(w.c)		Total	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.58	0.00	-3.09	0.00	-5.63	0.00	-0.12	0.00	-8.84
	1.17	0.00	-6.19	0.00	-5.63	0.00	-0.95	0.00	-12.76
	1.75	0.00	-9.28	0.00	-5.63	0.00	-1.79	0.00	-16.69
2.0	0.00	9.61	0.00	3.37	0.00	0.47	0.00	13.45	0.00
	1.00	4.31	0.00	3.37	0.00	0.47	0.00	8.15	0.00
	2.00	0.00	-1.00	3.37	0.00	0.47	0.00	2.84	-1.00
	3.00	0.00	-6.30	3.37	0.00	0.47	0.00	-2.46	-6.30
3.0	0.00	7.95	0.00	0.00	0.00	0.00	-0.12	7.95	-0.12
	1.00	2.65	0.00	0.00	0.00	0.00	-0.12	2.65	-0.12
	2.00	0.00	-2.65	0.00	0.00	0.00	-0.12	0.00	-2.77
	3.00	0.00	-7.95	0.00	0.00	0.00	-0.12	0.00	-8.07

Table Staad Results unfactored shear force

Results for live load (shear force)

<u>Max shear force</u>	-87.60
------------------------	--------

7.5.3 Factors as per limit state design

Type of Load	ULS	SLS	
		Rare	Frequent
<u>Dead Load</u>	1.35	1	1
<u>SIDL(wearing only)</u>	1.75	1	1
<u>SIDL(except wearing)</u>	1.35	1	1
<u>Live Load (leading)</u>	1.5	1	0.75
<u>Live Load (accompanying)</u>	1.15	0.75	0.2

Table 7.24 Limit state factors

#### 7.5.4 Factored Bending Moment

Beam	Dist. fr left	DL		SIDL(no w.c)		SIDL(w.c)		Total	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.58	1.22	0.00	2.53	0.00	0.01	0.00	3.76	0.00
	1.17	4.87	0.00	6.96	0.00	0.56	0.00	12.39	0.00
	1.75	10.96	0.00	11.39	0.00	1.95	0.00	24.31	0.00
2.0	0.00	10.96	0.00	11.39	0.00	1.95	0.00	24.31	0.00
	1.00	1.57	0.00	6.89	0.00	1.13	0.00	9.59	0.00
	2.00	0.00	-0.66	2.29	0.00	0.31	0.00	2.60	-0.66
	3.00	4.26	0.00	0.00	-2.26	0.00	-0.51	4.26	-2.77
3.0	0.00	4.26	0.00	0.00	-2.26	0.00	-0.51	4.26	-2.77
	1.00	0.00	-2.90	0.00	-2.26	0.00	-0.30	0.00	-5.46
	2.00	0.00	-2.90	0.00	-2.26	0.00	-0.09	0.00	-5.24
	3.00	4.26	0.00	0.00	-2.26	0.00	0.13	4.26	-2.13

Table for Factored Bending Moment

#### Factored live load (Factored moments )

<u>Max Hogging</u>	61.78
<u>Max Sagging</u>	-32.80

#### 7.5.5 Factored Shear Force

Beam	Dist.	DL		SIDL(no w.c)		SIDL(w.c)		Total	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	-4.17	0.00	-7.59	0.00	-0.21	0.00	-11.98
	0.00	0.00	-8.35	0.00	-7.59	0.00	-1.67	0.00	-17.61
	0.58	0.00	-12.52	0.00	-7.59	0.00	-3.13	0.00	-23.25
2.0	0.00	12.97	0.00	4.55	0.00	0.82	0.00	18.34	0.00
	1.00	5.81	0.00	4.55	0.00	0.82	0.00	11.18	0.00
	2.00	-1.35	-1.35	4.55	0.00	0.82	0.00	4.03	-1.35
	3.00	-8.50	-8.50	4.55	0.00	0.82	0.00	-3.13	-8.50
3.0	0.00	10.74	0.00	0.00	0.00	0.00	-0.21	10.74	-0.21
	1.00	3.58	0.00	0.00	0.00	0.00	-0.21	3.58	-0.21
	2.00	0.00	-3.58	0.00	0.00	0.00	-0.21	0.00	-3.79
	3.00	0.00	-10.74	0.00	-4.95	0.00	-0.21	0.00	-15.90

Table for Factored Shear Force

#### Results for live load (shear force)

<u>Max shear force</u>	-131.4
------------------------	--------

#### Factored Results forces

<u>Max Hogging</u>	kNm	86.09
<u>Max Sagging</u>	kNm	-38.25
<u>Max shear force</u>	kN	-154.65

STAAD RESULTS

---

STAAD SPACE  
START JOB INFORMATION  
ENGINEER DATE 28-Jul-17  
END JOB INFORMATION  
INPUT WIDTH 79  
UNIT METER KN  
JOINT COORDINATES  
1 0 0 0; 2 1.75 0 0; 3 4.75 0 0; 4 7.75 0 0; 5 10.75 0 0; 6 12.5 0 0;  
MEMBER INCIDENCES  
1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 5 6;  
DEFINE MATERIAL START  
ISOTROPIC CONCRETE  
E 2.17185e+007  
POISSON 0.17  
DENSITY 23.5616  
ALPHA 1e-005  
DAMP 0.05  
TYPE CONCRETE  
STRENGTH FCU 35000  
END DEFINE MATERIAL  
MEMBER PROPERTY AMERICAN  
1 TO 5 PRIS YD 0.225 ZD 1  
CONSTANTS  
MATERIAL CONCRETE ALL  
SUPPORTS  
2 TO 5 PINNED  
LOAD 1 LOADTYPE Dead TITLE DEAD  
SELFWEIGHT Y -1  
LOAD 2 LOADTYPE Dead TITLE RAILING  
MEMBER LOAD  
1 UNI GY -11.25 0 0.5  
5 UNI GY -11.25 1.25 1.75  
LOAD 3 LOADTYPE Live TITLE 1  
MEMBER LOAD  
1 UNI GY -69.895 1.415 2.805  
1 UNI GY -55.473 3.345 4.735  
LOAD 4 LOADTYPE Live TITLE 2  
MEMBER LOAD  
1 UNI GY -228 4.055 5.445  
3 UNI GY -49.214 1.235 2.625  
LOAD 5 LOADTYPE Live TITLE 3  
MEMBER LOAD  
1 UNI GY -60.887 1.59 2.98  
2 UNI GY -60.887 1.77 3.16  
LOAD 6 LOADTYPE Live TITLE 4  
MEMBER LOAD

1 UNI GY -44.868 0.36 1.44  
2 UNI GY -37.728 0.41 1.49  
LOAD 7 LOADTYPE Live TITLE 5  
MEMBER LOAD  
1 UNI GY -162.222 1.21 2.29  
2 UNI GY -35.715 1.26 2.34  
LOAD 8 LOADTYPE Live TITLE 6  
MEMBER LOAD  
2 UNI GY -43.596 0.06 1.14  
2 UNI GY -43.596 1.86 2.94  
LOAD 9 LOADTYPE Live TITLE 7  
MEMBER LOAD  
2 UNI GY -55.753 2.79 3.652  
3 UNI GY -30.239 0.548 1.402  
3 UNI GY -30.239 1.598 2.452  
3 UNI GY -55.753 2.348 3.2  
LOAD 10 LOADTYPE Live TITLE 8  
MEMBER LOAD  
2 UNI GY -88.6 2.498 3.352  
3 UNI GY -33.625 0.248 1.102  
3 UNI GY -28.637 1.298 2.152  
3 UNI GY -36.339 2.048 2.902  
LOAD 11 LOADTYPE Live REDUCIBLE TITLE W.C  
MEMBER LOAD  
1 UNI GY -1.43 0.5 12  
PERFORM ANALYSIS PRINT ALL  
FINISH

## DESIGN OF SHEAR CONNECTOR

### DESIGN OF SHEAR CONNECTOR

IRC 22-2008

cl.606 .4.1

#### 1 Design of shear connector for composite bending action

Design shear force	V	kN
depth of deck slab in terms of steel	b	mm
width of deck slab in terms of steel	d	mm
Area of conc. (transformed to steel)	Ac	mm <sup>2</sup>
c.g of deck slab	G	mm
dist. From c.g of composite section to c.g of conc.	yc	mm
First moment of area	Q	mm <sup>3</sup>
moment of area of area of composite section	I	mm <sup>4</sup>
Longitudinal shear	VL	V*Q/I

#### Girder properties

Sec. type	b	d	c.g (G) (mm)	Ac(mm <sup>2</sup> )	Yc(mm)	Q	I	Q/I	VL(kN/mm)
short term	162.5	225	453.7	36562.5	341.2	12475125	1.46E+10	8.54E-04	1.09
Long term	81.25	225	529.9	18281.25	417.4	7630593.8	1.19E+10	6.41E-04	0.82

#### 2 Design shear force

V      kN      1273.8

Type of section used

ISMC 150

Width of flange		mm	75
Thk. Of flange		mm	9
Thk. Of web		mm	5.4
Area of one stud		mm2	2088
Grade of steel	Fy	Mpa	250
Ultimate strength	Fu	Mpa	410
partial factor of safety			1.1
Permissible shear stress		N/mm2	158.776
ultimate static strength of shear connector	Qu	kN	231
spacing of shear connector	SL	mm	212.2
max spacing of shear connector		mm	189.0
provided spacing of shear connector		mm	189.0
Shear capacity of connector		kN	274.0
Longitudinal shear strength of connector		Kn/mm	1.3

safe

#### 3 Design of weld

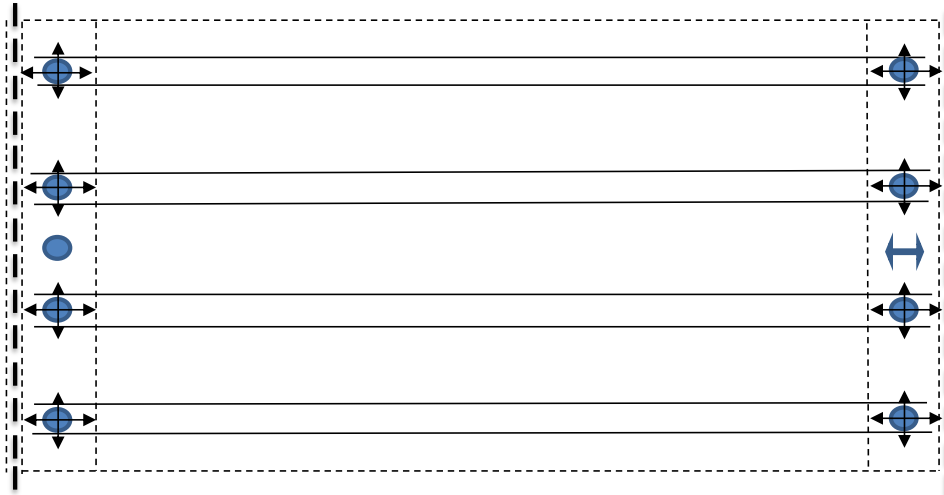
Size of weld		mm	8
Permissible stress in fillet weld		N/mm <sup>2</sup>	115.5
Throat size		mm	5.7
Partial factor of safety	Shop weld		1.25
	Site weld		1.5
length of weld required	Shop weld	mm	1189.2
	Site weld	mm	1427.1

# **Bearing Force Calculations**

## 1.0 INTRODUCTION

This design note pertains to bearing load data for a simply supported span. Superstructure is analysed in STAAD for DL, SIDL, LL, WIND etc. as per provisions in IRC 6(2014). The results for all vertically applied loads are given in Load Summary, for each support node in STAAD. Horizontal loads acting due to braking, wind & thermal actions are calculated in and finally maximum and minimum vertical and horizontal & vertical loads have been tabulated as per the type of bearing.

## 1.1 BEARING LAYOUT



## 1.2 DESIGN DATA

Total Span of Structure	=	80	m
No of Spans	=	1	Nos.
Length of single span bearing to bearing	=	80	m
Total width of Superstructure	=	12.5	m
Number of Girders	=	4	Nos.
Depth of Girder	=	0.850	m
Depth of Slab	=	0.225	m
Type of Bearing	=	POT- PTFE	
Total no. of Bearings	=	4	Nos.

## 1.3 Material Data

Grade of concrete	=	M 35
Grade of flexure reinforcement	=	Fe 500
Grade of shear reinforcement	=	Fe 500
$\mu$	=	0.05



## 1.4 Summary of Bearings

Fixed Bearing	=	<b>1</b>	Nos.
Longitudenally Guided Bearing	=	<b>1</b>	Nos.
Transversely Guided Bearing	=	<b>1</b>	Nos.
Free Bearings	=	<b>1</b>	Nos.

## 1.5 Impact Factor

For 70 R Wheeled Vehicle	=	<b>1.17</b>	Refer fig 9-IRC 6: CL. 208.3
For Class A	=	<b>1.16</b>	
For 70 R Tracked	=	<b>1.10</b>	fig 9-IRC 6: CL. 208.3

## 2.1 Summary of Vertical Loads at Support Nodes (refer STAAD Model).

Sr. No.	Location	Support Nodes (LHS side)		Support Nodes (RHS side)	
		LHS(G1 To G4)		RHS(G5 To G8)	
	Number & Type	1	2	3	4
	Description	kN	kN	kN	kN
1	Self Wt. -Girder	2291.80	2291.80	2291.80	2291.80
2	Self Wt -Slab	1467.40	1467.40	1467.40	1467.40
3	SIDL - Crash Barrier & Railing	399.90	400.10	400.10	399.90
4	SIDL -Wearing Coat	478.72	478.72	478.72	478.72
5	Class A - I Lane	388.69	423.38	393.94	426.42
6	Class A - II Lane	777.38	846.76	787.87	852.83
7	Class A -III Lane	1166.07	1270.14	1181.81	1279.25
8	70 R Wheeled + Claas A	2742.67	2742.40	2400.21	2694.30
9	Special Vehicle	1636.50	1537.80	1549.60	1459.50
Live Load Max with Impact Factor		3208.93	3208.61	2808.25	3152.33
Live Load Min with Impact Factor		0.00	0.00	0.00	0.00
Maximum Load on Bearing		7846.75	7846.63	7446.27	7790.15
Minimum Load on Bearing		4637.82	4638.03	4638.03	4637.82

## 2.2 Summary of Load Combinations

Sr. No.	Location	Support Nodes (LHS side)		Support Nodes (RHS side)	
		LHS(G1 To G4)		RHS(G5 To G8)	
	Number & Type	1	2	5	6
	Description	kN	kN	kN	kN
1	Normal (DL+SIDL)	4637.82	4638.03	4638.03	4637.82
2	Normal (DL+SIDL+LL (max))	7846.75	7846.63	7446.27	7790.15
3	Normal (DL+SIDL+LL (min))	4637.82	4638.03	4638.03	4637.82
4	Normal	7851.75	7851.63	7451.27	7795.15
5	Normal (DL+SIDL+LL(min)+Wind(Up))	4632.82	4633.03	4633.03	4632.82
6	Seismic (DL+SIDL+LL(max))	5629.16	5629.31	5543.93	5617.09
7	Siesmic (DL+SIDL+LL(min))	4944.88	4945.10	4945.10	4944.88

### 3.1 Siesmic Data

Seismic zone	=	V
Ductile detailing	=	YES
Soil Type	=	II
Importance of bridge	=	Important
Vertical Siesmic Force is considered or not	=	yes
Horizontal Seismic force = $F_{eq}$		

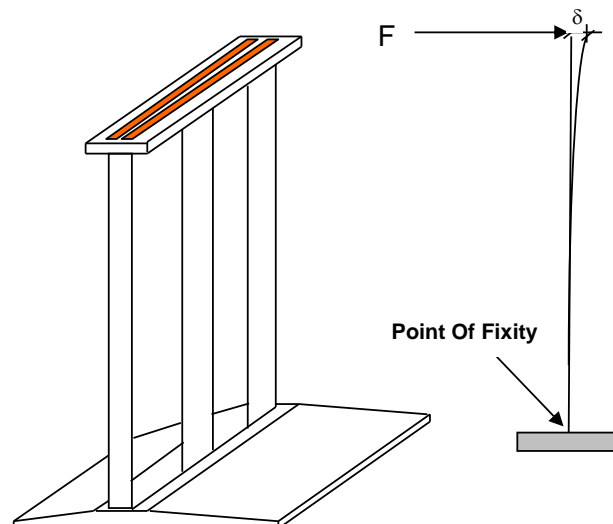
$$F_{eq} = A_h \times (D.L. + b \times L.L.)$$

### 3.2 Calculation of Time Period

Fundamental natural period in seconds

$$T = 2.0 \times \text{SQRT}(D/1000F)$$

Dead Load from the superstructure, D1	=	18551.7	kN
Dead Load from the Pier Cap + Pier Shaft upto Scour Level, D2	=	2500.0	kN
Live Load (considered only when the seismic force is acting parallel to axis of the pier), D3	=	4897.3	kN
Total load, D = D1 + D2 + D3	=	25949.0	kN
Elastic Modulus, E	=	2.96E+07	kN/m <sup>2</sup>
Length of Structure Shaft Bottom level to the Bearing, L	=	9.0	m
Type of Abutment/Pier Shaft	=	Rectangular	
Width/Dia of Shaft	=	2.0	m
Length/Dia of Shaft	=	2.0	m
Moment Of Inertia (Transverse direction), $I_{TT}$	=	1.333	m <sup>4</sup>
Moment Of Inertia (Longitudinal direction) $I_{LL}$	=	1.333	m <sup>4</sup>



Stiffness of member, $F_{LL}$	=	1.62E+05	kN/mm
Stiffness of member, $F_{TT}$	=	1.62E+05	kN/mm
Fundamental natural period in seconds, $T_{LL}$	=	0.03	Sec
Fundamental natural period in seconds, $T_{TT}$	=	0.03	Sec

<b>S<sub>a</sub>/g</b> Longitudinal	<b>T<sub>LL</sub></b>	<	<b>0.55</b>	=	1.38
<b>S<sub>a</sub>/g</b> Transverce	<b>T<sub>TT</sub></b>	<	<b>0.55</b>	=	1.38
Horizontal coefficient is given A <sub>h</sub> by -					

$$A_h = (Z/2) (I/R) (S_a/g)$$

Z = Zone factor	0.36
I = Importance factor	1.2
R = Response reduction factor	3
<b>Seismic Coefficient in longitudinal direction</b>	<b>0.099</b>
<b>Siesmic Coefficient in transeverse direction</b>	<b>0.099</b>
<b>Siesmic Coefficient in vertical direction</b>	<b>0.066</b>

1

## 4.1 LONGITUDINAL FORCES AT BEARING LEVEL

### Calculation of Breaking Force

Total span length	=	80	m
No. of vehicle per span	=	1	
No. of bearing in Longitudinal direction to be considered	=	2	
No. of Bearing to be considered in Transverse direction	=	2	

As per Cl- 211.2 of IRC 6:2016

Class A 3 Lane	=	4872.41 kN
70 R Wheeled + Class A	=	812.07 kN
Special Vehicle	=	3174.30 kN

Load Case	% load to be taken			Braking Force			Total Braking Force (kN)
	I Lane	II Lane	III Lane	I Lane	II Lane	III Lane	
Class A - 3 Lane	20.00%	0.00%	5.00%	162.4138	0	121.8104	284.22415
70 R Wheeled	20.00%			0			0
70 R Tracked	20.00%			0			0
70 R Wheeled + Claas A	20.00%		5.00%	0		40.60345	40.60

Max Braking Force ( $F_H$ ) = 284.22415 kN

### 4.1.1 Calculation of Longitudinal Forces

As per CL- 2.11.5.1

Longitudinal Forces at bearing level for simply supported spans on POT-PTFE bearings is given by

For Fixed Bearings	For Free Bearings	} Whichever is greater
a) $F_h - \mu(R_g + R_q)$	$\mu(R_g + R_q)$	
b) $F_h / 2 + \mu(R_g + R_q)$	$\mu(R_g + R_q)$	

Where,

$F_h$  = Applied Horizontal Force

$R_g$  = Reaction at free bearing due to dead load

$R_q$  = Reaction at free bearing due to live load

$\mu$  = Coefficient of friction at the movable bearing which shall be assumed as per type of bearing.

a) Normal Case

$$R_g = 18551.70 \text{ kN}$$

$$R_q = 12378.11 \text{ kN}$$

$$\mu(R_g + R_q) = 1546.49$$

	For Fixed bearing	For Free Bearing
i)	-1262.27 kN	1546.49 kN
ii)	1688.602 kN	1546.49 kN

Horizontal Force at Bearing Level in longitudinal direction = 844.3012 kN

b) Wind Case

$$R_g = 18551.70 \text{ kN}$$

$$R_q = 12418.11 \text{ kN}$$

1.16

$$\mu(R_g + R_q) = 1548.49$$

	For Fixed bearing	For Free Bearing
i)	-1264.27 kN	1548.49 kN
ii)	1690.602 kN	1548.49 kN

$$\text{Horizontal Force at Bearing Level in longitudinal direction} = \mathbf{845.3012 \text{ kN}}$$

c) Longitudinal Seismic Force

$$F_s = 1842.397 \text{ kN}$$

$$F_h = 56.84483 \text{ kN}$$

$$R_g = 18551.70 \text{ kN}$$

$$R_q = 0 \text{ kN}$$

$$\mu(R_g + R_q) = 927.5849$$

	For Fixed bearing	For Free Bearing
i)	971.6568 kN	927.5849 kN
ii)	1877.206 kN	927.5849 kN

$$\text{Horizontal Seismic Force in longitudinal direction} = \mathbf{938.6029 \text{ kN}}$$

d) Transverse Seismic Load

$$F_s = 2088.255 \text{ kN}$$

$$F_h = 56.84483 \text{ kN}$$

$$R_g = 18551.70 \text{ kN}$$

$$R_q = 2475.621 \text{ kN}$$

$$\mu(R_g + R_q) = 1051.366$$

	For Fixed bearing	For Free Bearing
i)	1093.733	1051.366
ii)	2123.916	1051.366

$$\text{Horizontal Seismic Force in Transverse direction} = \mathbf{1061.9578 \text{ kN}}$$

## 5.1 CALCULATION OF DISPLACEMENT DUE TO TEMP, SHRINKAGE & CREEP

a) Elongation/Contraction due to temp is given by -

$$\delta L_L = \alpha \cdot L_L \cdot \Delta T$$

$$\delta L_T = \alpha \cdot L_T \cdot \Delta T$$

where,

$L_L$	- Length of girder in longitudinal direction	=	80	m
$L_T$	- Length of girder in Transverse direction	=	6.25	m
$\alpha$	- Linear Thermal coefficient	=	1.20E-05	$^{\circ}/C$
$\Delta T$	- Change in Temp	=	40	
$\delta L_L$		=	$\pm$ 38	mm
$\delta L_T$		=	$\pm$ 3	mm

b) Contraction due to Shrinkage is given by -

Longitudinal	-	(2.0 x 10 <sup>-4</sup> ) per metre	=	-	16	mm
Transverse	-	(2.0 x 10 <sup>-4</sup> ) per metre	=	-	1	mm

c) Contraction due to Creep is given by -

Longitudinal	-	(3.5 x 10 <sup>-4</sup> ) per metre	=	-	28	mm
Transverse	-	(2.1 x 10 <sup>-4</sup> ) per metre	=	-	2	mm

Longitudinal elongation due to temprature, shrinkage & creep = 38 mm

Longitudinal contraction due to temprature, shrinkage & creep = -82 mm

Transverse elongation due to temprature, shrinkage & creep = 3 mm

Transverse contraction due to temprature, shrinkage & creep = -6 mm

## 5.2 CALCULATION OF ROTATION

Grade of concrete = **M 35**

For simply supported span rotation may be computed as

$$a_d = \frac{400 M_{max} \cdot L \times 10^{-3}}{(E I)}$$

$E_s$  = 2E+11 Mpa

$E_c$  = 3.40E+10 Pa

= 1.70E+10 Pa for permanent load

S. No.	Load case	Mmax.	E	I	L	$a_d$
		(Nm)	(Pa)	(m <sup>4</sup> )	(m)	
1	DL	193250	1.70E+10	0.007	80.000	5.20E-02
2	SIDL	388800	1.70E+10	0.007	80.000	1.05E-01
3	F.P.L.L	0	3.40E+10	0.007	80.000	0.00E+00
4	CWLL	1845950	3.40E+10	0.015	80.000	1.19E-01

Total 0.2759

Design rotation = 0.2759 X 1.3 = 0.35867 radians

## Summary of loads

Bearing Type		Total Nos.	Vertical Loads per bearing (kN)				Horizontal Load (kN)						Displacement(mm)		Rotation (Radians)
			Max. Vertical Rxn.		Min. Vertical Rxn.		Normal		Long. Seismic		Trans. Seismic		Longitudinal	Transverse	
			Normal	Seismic	Normal	Seismic	HL	HT	HL	HT	HL	HT			
A	fixed	2	7847	5629	0	0	844	-	939	-	-	-	-	-	-
B	Long guid.	2	7847	5629	0	0	-	253	-	282	-	1062	82	-	0.359
C	Tra. Guid.	2	7847	5629	0	0	844	-	939	-	319	-	-	6	0.359
D	Free	2	7847	5629	0	0	-	-	-	-	-	-	82	6	0.359



## DATA FOR DESIGN OF BEARINGS

**General Data :**

1. Structure is Located in Seismic Zone :
2. Material for Substructure : Concrete
3. Material for Superstructure : Concrete

II

If Concrete, Grade: 40  
If Concrete, Grade: 35

Sl. No	Bearing Type	Load Condition	Coexisting Loads, Forces,Movement and Rotation Data										Qty. (Nos.)
			Vertical Load (kN)		Horizontal Force (kN)				Rotation (Rad)		Movement (mm)		
			Case	Magnitude	Longitudinal		Transverse		Case	Magnitude	Longitudinal	Transverse	
					Case	Magnitude	Case	Magnitude					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
P1	Pot fixed bearing	Normal	Maximum	7847	Coexisting	844	Coexisting	-	Coexisting	-	-	-	1
			Minimum	0	Coexisting	844	Coexisting	-	Coexisting				
		Seismic/Wind	Maximum	5629	Coexisting	939	Coexisting	-	Coexisting				
			Minimum	0	Coexisting	939	Coexisting	-	Coexisting				
		Seismic/Wind	Coexisting	5629	Maximum	939	Coexisting	0	Coexisting				
		Seismic/Wind	Coexisting	0	Coexisting	939	Maximum	1062	Coexisting				
G1	Transversely guided pot - PTFE bearing	Normal	Maximum	7847	Coexisting	844	Coexisting	-	Coexisting	0.36	-	6	1
			Minimum	0	Coexisting	844	Coexisting	-	Coexisting				
		Seismic/Wind	Maximum	5629	Coexisting	939	Coexisting	-	Coexisting				
			Minimum	0	Coexisting	939	Coexisting	-	Coexisting				
		Seismic/Wind	Coexisting	5629	Maximum	939	Coexisting	-	Coexisting				
G2	Longitudinally guided pot -PTFE bearing	Normal	Maximum	7847	Coexisting	-	Coexisting	-	Coexisting		82	-	1
			Minimum	0	Coexisting	-	Coexisting	-	Coexisting				
		Seismic/Wind	Maximum	5629	Coexisting	-	Coexisting	-	Coexisting				
			Minimum	0	Coexisting	-	Coexisting	-	Coexisting				
		Seismic/Wind	Coexisting	5629	Maximum	-	Coexisting	0	Coexisting				
		Seismic/Wind	Coexisting	0	Coexisting	-	Maximum	1062	Coexisting				
FB1	Free Pot PTFE bearing	Normal	Maximum	7847	Coexisting	-	Coexisting	-	Coexisting		82	6	1
			Minimum	0	Coexisting	-	Coexisting	-	Coexisting				
		Seismic/Wind	Maximum	5629	Coexisting	-	Coexisting	-	Coexisting				
			Minimum	0	Coexisting	-	Coexisting	-	Coexisting				