

# Structural Steel Design Project

## Calculation Sheet

Job No:	Sheet 1 of 10	Rev
Job Title: TRUSS GIRDER RAIL BRIDGE		
Worked Example - 1		
	Made by SSSR	Date 8-10-00
	Checked by VK	Date

**PROBLEM:**

Design a through type single lane truss bridge for broad gauge main line loading. The effective span length of the bridge is 50 m. Consider  $g_n = 1.15$ .

**(1) TRUSS ARRANGEMENT [See Fig. E1]:**

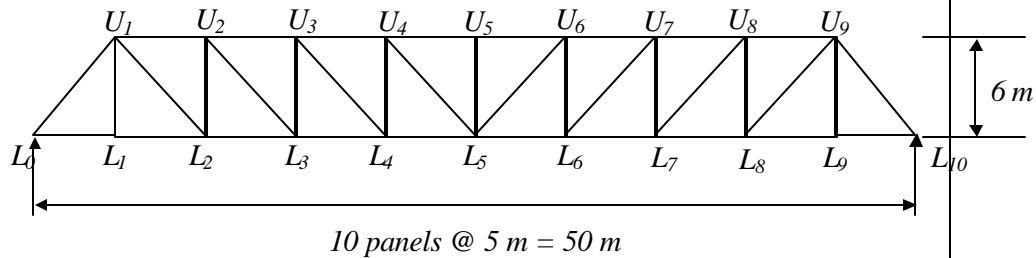
Effective Span of truss girder = 50 m.

Assume 10 panels @ 5 m interval.

Height and truss girder:

For economical considerations, height = { EMBED Equation.3 } to { EMBED Equation.3 } of span

Assume, height = 6m. ( { EMBED Equation.3 } of span ) Hence, O.K.

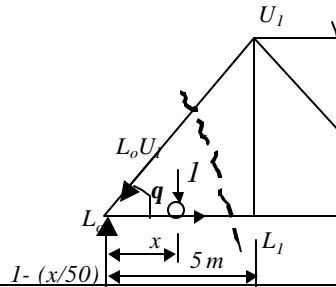


**Fig. E1. Truss arrangement**

**(2) INFLUENCE LINE DIAGRAMS:**

(i) ILD for  $L_0U_1$  (Diagonal member):

**Fig. E2. Free body diagram**



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(a) If, unit load is in between  $L_1$  and  $L_{10}$  (i.e.  $5 \leq x \leq 50$ )

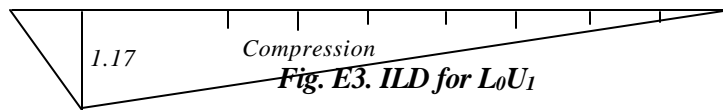
$$\dot{a} V = 0.$$

$$L_0U_1 \sin q = 1 - (x/50) \quad \text{P } L_0U_1 = \{ \text{EMBED Equation.3} \} ( 1 - \{ \text{EMBED Equation.3} \} )$$

(b) If, unit load is in between  $L_0$  and  $L_1$  ( i.e.  $\{ \text{EMBED Equation.3} \} )$

$$L_0U_1 = - \{ \text{EMBED Equation.3} \} \{ \text{EMBED Equation.3} \}$$

Then, we can get ILD as shown in Fig. E3.



(ii) ILD for  $L_1U_1$  (Vertical member): [See free body diagram Fig. E4]

(a) If, unit load is in between  $L_0$  and  $L_1$  (i.e.  $0 \leq x \leq 5$ )

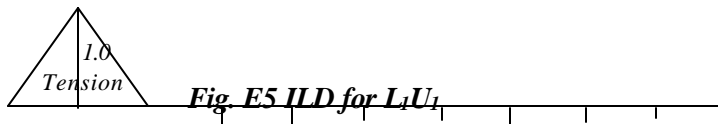
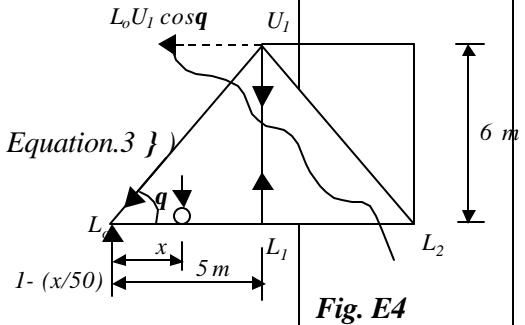
$$\dot{a} M_{L_0} = 0.$$

$$5L_1U_1 = x$$

$$L_1U_1 = \{ \text{EMBED Equation.3} \}$$

(b) If, unit load is in between  $L_2$  and  $L_{10}$  (i.e.  $\{ \text{EMBED Equation.3} \} )$

$$L_1U_1 = 0$$

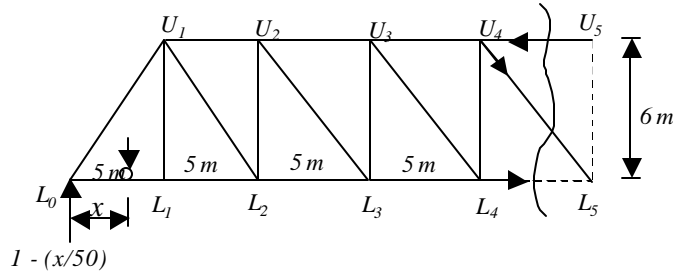


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(iii) ILD for  $U_4U_5$  and  $L_4L_5$ : (Top and Bottom chord members respectively)



**Fig. E6 Free body diagram**

(a) If, the unit load is in between  $L_0$  and  $L_4$  (i.e.  $0 \leq x \leq 20$  )

{ EMBED Equation.3 } = 0

$$6U_4U_5 + (25 - x) * 1 = 25 * [1 - (x/50)]$$

$$U_4U_5 = \{ \text{EMBED Equation.3} \} [ 25 ( 1 - \{ \text{EMBED Equation.3} \} ) - ( 25 - x ) ]$$

{ EMBED Equation.3 } = 0

$$6L_4L_5 + (20 - x) * 1 = 20 * [1 - (x/50)]$$

$$L_4L_5 = \{ \text{EMBED Equation.3} \} [ 20 ( 1 - \{ \text{EMBED Equation.3} \} ) - ( 20 - x ) ]$$

(b) If, unit load is in between  $L_5$  and  $L_{10}$  (i.e. { EMBED Equation.3 } )

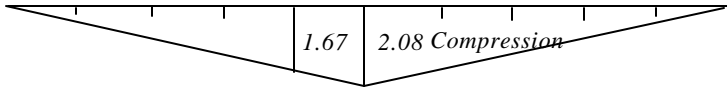
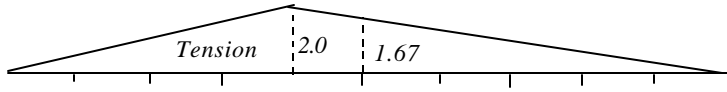
Then,  $U_4U_5 = \{ \text{EMBED Equation.3} \} [ 25 ( 1 - \{ \text{EMBED Equation.3} \} ) ]$

$$L_4L_5 = \{ \text{EMBED Equation.3} \} [ 20 ( 1 - \{ \text{EMBED Equation.3} \} ) ]$$

ILDs for  $U_4U_5$  and  $L_4L_5$  are shown in Fig. E7 and Fig. E8 respectively.

on.3 } = 0

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 <p><b>Fig. E7 ILD for U<sub>4</sub>U<sub>5</sub></b></p>  <p><b>Fig. E8 ILD for L<sub>4</sub>L<sub>5</sub></b></p>			RDSO Specifications
<p><b>(3) LOADS:</b></p> <p><b>(i) Dead load - Dead loads acting on truss girder are as follows:</b></p> <p>Weight of rails = 2 { EMBED Equation.3 } 0.6 = 1.2 kN/m.</p> <p>*Weight of sleepers = 0.25 { EMBED Equation.3 } 0.25 { EMBED Equation.3 } { EMBED Equation.3 } = 2.34 kN/m.</p> <p>Weight of fastenings (assumed) = 0.25 kN/m.</p> <p>Weight of stringers (assumed) = 3.0 kN/m</p> <p>Weight of cross girders (assumed) = 5.0 kN/m.</p> <p>**Self-weight of truss by Fuller's Formula = 13.0 kN/m</p> <p>Total dead load per track = 24.8 kN/m</p> <p>Therefore, Total dead load per girder = { EMBED Equation.3 } = 12.4 kN/m</p> <p>*[Assume 250 mm { EMBED Equation.3 } 250 mm { EMBED Equation.3 } 2m wooden sleepers @ 400 mm apart and weight of 7.5 kN/m<sup>3</sup>]</p> <p>**[ Fuller's Formula = { EMBED Equation.3 } = { EMBED Equation.3 } = 13.0 kN/m]</p>			
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<p><b>(ii) Live load</b></p> <p><i>(a) Areas of Influence line diagrams for truss members discussed:</i></p> <p>Area of influence line for <math>L_0U_1 = \{ \text{EMBED Equation.3} \} = - 29.3</math>                  (Compression)</p> <p>Area of influence line for <math>L_1U_1 = \{ \text{EMBED Equation.3} \} = + 5.0</math> (Tensile)</p> <p>Area of influence line for <math>U_4U_5 = \{ \text{EMBED Equation.3} \} = - 52</math>                  (Compression)</p> <p>Area of influence line for <math>L_4L_5 = \{ \text{EMBED Equation.3} \} = + 50</math>                  (Tensile)</p> <p><b>(b) Live loads and impact loads from IRS Bridge Rules - 1982:</b></p> <p>Live loads and impact factors for each loaded length are found from <b>IRS Bridge Rules - 1982</b>. For maximum forces in chord members, the whole of the span should be loaded and Live load is determined corresponding to maximum B.M. For other diagonal and vertical members, part of the span as indicated by influence line diagrams, should be loaded and the live load is determined corresponding to S.F. The impact factor is found corresponding to loaded length.</p> <p>For maximum force in members <math>L_4L_5</math> and <math>U_4U_5</math>:</p> <p>Load length <span style="float: right;">= 50 m</span></p> <p>Live load for B.M. <span style="float: right;">= 3895.2 kN</span></p> <p>Impact factor = <math>\{ \text{EMBED Equation.3} \} = 0.293</math></p> <p>(LL+ IL) per m per girder = <math>\{ \text{EMBED Equation.3} \} = 50.36 \text{ kN/m}</math></p>			
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For maximum force in members  $L_0U_1$  and  $L_1U_1$ :

$L_0U_1$ :

Load length = 50 m  
 Live load for B.M. = 4184.6 kN  
 Impact factor = { EMBED Equation.3 } = 0.293  
 (LL+ IL) per m per girder = { EMBED Equation.3 } = 54.1 kN/m

$L_1U_1$ :

Load length = 10 m  
 Live load for S.F. = 1227.8 kN  
 Impact factor = { EMBED Equation.3 } = 0.65  
 (LL+ IL) per m per girder = { EMBED Equation.3 } = 101.3 kN/m

**(c) Longitudinal Loads from IRS Bridge Rules - 1982**

Assume, there exist rail expansion joints in the bridge and prevent the transfer of longitudinal loads to approaches. It may be noted that for broad gauge bridges upto a loaded length of 44 m, the tractive effort is more than the braking force and for loaded lengths more than 44 m the braking force is more than the tractive effort.

Assume truss under consideration is simply supported by a hinge at  $L_0$  and a roller at  $L_{10}$ . The longitudinal force in a member can be tensile or compressive depending on the direction of movement of train.

Panel  $L_4L_5$ :

Loaded length = 30 m  
 Tractive effort = 637.4 kN  
 Force per chord =  $637.4/2$  = { EMBED Equation.3 } kN

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Unfactored loads:

Member	Area of ILD	Load in kN/m		Forces in members (kN)		
		DL	LL+IL	DL	LL+IL	Long.L
$L_0U_1$	- 29.3	12.4	54.1	-363.3	-1585.1	-
$L_1U_1$	+5.0	12.4	101.3	+ 62	+ 506.5	-
$U_4U_5$	- 52.0	12.4	50.36	-644.8	-2618.7	-
$L_4L_5$ Equation.3 }	+ 50.0	12.4	50.36	+620	+2518	{ EMBED

Use following Partial safety factors for the loads:

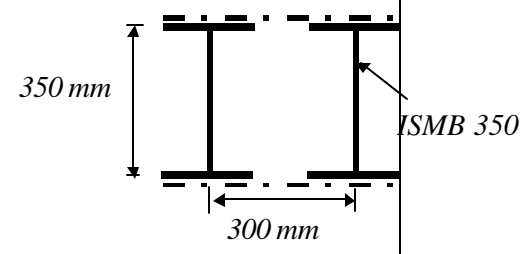
$$g_{DL} = 1.35; g_{LL} = 1.50; g_{LongL} = 1.50$$

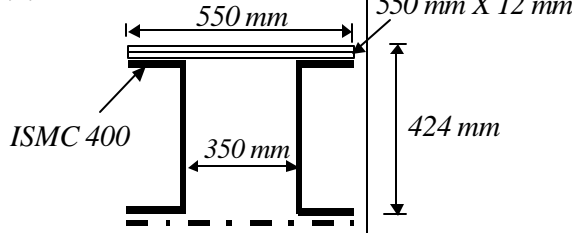
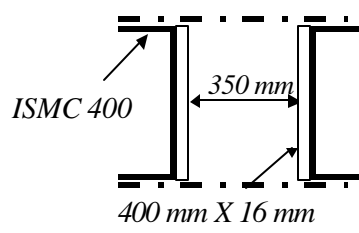
Factored loads:

Member	Factored Forces in members (kN)			Total load (kN)
	DL	LL+IL	Long.L	
$L_0U_1$	-490.4	- 2377.6	-	- 2868.0
$L_1U_1$	+83.7	+ 759.8	-	+ 843.4
$U_4U_5$	-870.5	-3928	-	- 4798.5
$L_4L_5$ 5092 - 478	+ 837	+3777	{ EMBED Equation.3 }	+

Note: Negative sign represents compression and positive sign represents tension.

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<p><b>(4) DESIGN FOR TRUSS MEMBERS:</b></p> <p>(i) <b>Design of diagonal member (<math>L_0U_1</math>):</b> Note that in this illustration of this Member, the portal effect and fatigue are not considered.</p> <p>Length of the chord, <math>L_0U_1 = \ell = 7810 \text{ mm}</math></p> <p>Assume, effective length, <math>\ell_e = 0.7*\ell = 5467\text{mm}</math></p> <p>Try a built up member with two ISHB350 spaced @ 300 mm</p> <p><math>A = 18442 \text{ mm}^2</math></p> <p><math>r_x = 146.5 \text{ mm}</math></p> <p><math>r_y = 158.8 \text{ mm}</math></p> <p><math>I_x = 5467/146.5 = 37.3</math></p> <p>Then, <math>s_c = 221.8 \text{ N/mm}^2</math></p> <p>[See chapter on axially compressed columns using curve c]</p> <p>Axial capacity = <math>(221.8/1.15)*18442/1000 = 3556.5 \text{ kN} &gt; 2868 \text{ kN}</math></p> <p>Hence, section is safe against axial compression</p> <div style="display: flex; align-items: center; justify-content: center;">  <div style="margin-left: 20px;"> <p>350 mm</p> <p>ISMB 350</p> <p>300 mm</p> </div> </div> <p>(ii) <b>Design of vertical member (<math>L_1U_1</math>):</b></p> <p>Maximum tensile force = 843.4 kN</p> <p>Try ISMB 350 @ 0.524 kN/m shown.</p> <p><math>A = 6671 \text{ mm}^2</math></p> <p>Axial tension capacity of the selected section = <math>6671 * 250/1.15 = 1450 \text{ kN} &gt; 843.4 \text{ kN}</math></p> <p>Hence, section is safe in tension.</p> <p>[Note: Welded connection assumed]</p>			
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<p><b>(iii) Design of top chord member (U<sub>4</sub>U<sub>5</sub>):</b></p> <p>Member length, <math>\ell = 5000 \text{ mm}</math></p> <p>Assume, effective length = <math>0.85\ell = 4250 \text{ mm}</math></p> <p>Try the section shown.</p> <p><math>A = 25786 \text{ mm}^2</math></p> <p><math>r_x = 165.4 \text{ mm}</math></p> <p><math>r_y = 210 \text{ mm}</math></p> <p><math>I_x = 4250/165.4 = 25.7</math></p> <p>Then, <math>s_c = 239 \text{ N/mm}^2</math></p> <p>[See chapter on axially compressed columns using column curve c]</p> <p>Axial capacity = <math>(239/1.15) * 25786/1000 = 5359 \text{ kN} &gt; 4798.5 \text{ kN}</math></p> <p><u>Hence, section is safe against axial compression</u></p>		<p>2 plates of size 550 mm X 12 mm</p>
<p><b>(ii) Bottom chord design(L<sub>4</sub>L<sub>5</sub>):</b></p> <p>Maximum compressive force = 478 kN</p> <p>Maximum tensile force = 5092 kN</p> <p>Try the box section shown.</p> <p><math>A = 25386 \text{ mm}^2</math></p> <p><math>r_x = 144 \text{ mm}</math></p> <p><math>r_y = 210 \text{ mm}</math></p> <p>Axial tension capacity of the selected section = <math>25386 * 250/1.15 = 5518 \text{ kN} &gt; 5092 \text{ kN}</math></p> <p>Hence, section is safe in tension.</p>		
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<p>Maximum unrestrained length = <math>\ell = 5000 \text{ mm}</math></p> <p><math>\lambda_x = 5000/144 = 34.7</math></p> <p>Then, <math>\sigma_c = 225 \text{ N/mm}^2</math></p> <p>Axial capacity = <math>(225/1.15) * 25386/1000 = 4967 \text{ kN} &gt; 478 \text{ kN}</math></p> <p><u>Hence, section is safe against axial compression also.</u></p> <p>The example is only an illustration. The following have to be taken into consideration:</p> <ul style="list-style-type: none"> <li>• Design of lacings/batten</li> <li>• Design of connections and effect of bolt holes on member strength</li> <li>• Secondary bending effects</li> <li>• Design for fatigue</li> </ul>			