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Comparison of Foot-Over Bridge with Different Configuration of Members

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Abstract

Foot over bridge is an important civil engineering structure designed for the free movement of pedestrians in heavy vehicle traffic regions across roads, railway line etc.

There is a critical comparison between foot over bridges having different configurations based on Strength, Safety, Economy and Sustainability using the concept of Influence Line Diagram (ILD). The comparison between compression and tension members having equal forces has been highlighted by designing and cost comparing of both.

Keywords

IS 800-2007, Influence Line Diagram (ILD), Configuration of Trusses, Tension & Compression

Introduction

Foot-over bridge is a walkway bridge designed for the free movement of pedestrian across railway line canals and marshy land etc. Foot over bridge are also located across roads for free movements of pedestrians in high Vehicular traffic region. [8]

Methodology

Foot-over Bridge is a civil engineering structure, consisting of different structural members in which truss members carries the major stresses. [6] For analysing the structure we have selected four different configurations of trusses. A standard load (constant Live Load & Dead Load) is applied on all the foot-over bridges by keeping all the parameters constant (span, walk-way, height of truss etc) for determining the stresses in the members and hence selecting the most suitable configuration based on safety and sustainability. [3,7]

Problem Statement

Comparison of different configurations of foot-over bridge as shown in fig A, B, C & D, by analysing & designing Bottom Chord, Top Chord, Vertical & Inclined members using IS 800-2007. The different configurations of truss members are as shown in the figure A, B, C, D

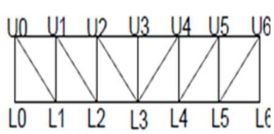

Figure A
Mirrored N-Type Foot-over Bridge

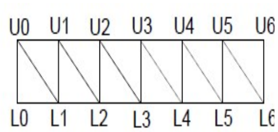

Figure B
N-Type Foot-over Bridge

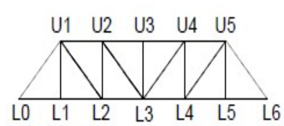

Figure C
Mirrored N-Type Triangular Foot-over Bridge

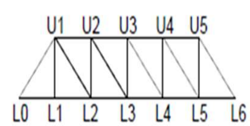

Figure D
N-Type Triangular Foot-over Bridge

Standardised Data [2,5]

Span length = 2m, No of Panels = 6, Walkway = 2.4m, Height of Truss = 2m

Cross girder: Bearing= 0.1m, Effective length=2.5m, Self-weight= 0.1KN/m, Thickness of flooring = 0.1m, TRUSS: Self weight= 0.1KN/m, Live load intensity=4KN/m^2,

fu=410N/mm^2, fy=250N/mm^2, bolt diameter= 18mm, pitch=2.5d=50mm, edge distance=1.5d0=30mm, gm0=1.1, gmb=1.25: As per IS 800-2007 and Indian steel table

Table 1: Loading Calculation

DEAD LOAD		LIVE LOAD	
Flooring	3KN/m	Live load= live load intensity X walkway =4 x 2.4/2 = 4.8KN/m	
Cross girder	0.0625KN/m		
Self-weight of truss	0.1KN/m		
Total load	3.1625KN/m		
Factored Load	4.75KN/m	Factored load	7.2KN/m

Above Table 1 showing Dead load and Live load calculation of foot-over bridge.

Table 2: Influence Line Diagram [1,8]

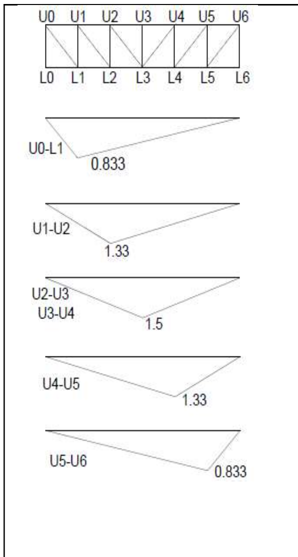

Fig. E: TOP CHORD MEMBER

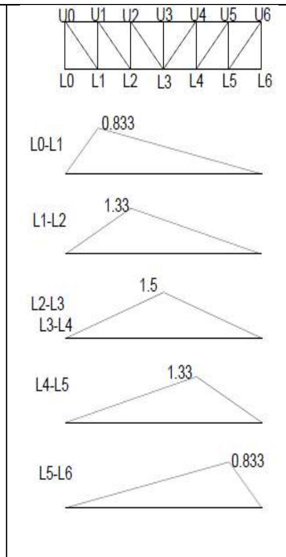

Fig F: BOTTOM CHORD MEMBER

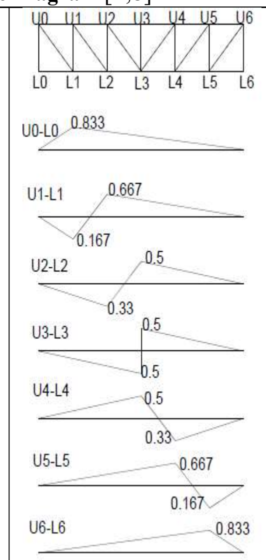

Fig.G: VERTICAL MEMBER Fig: A

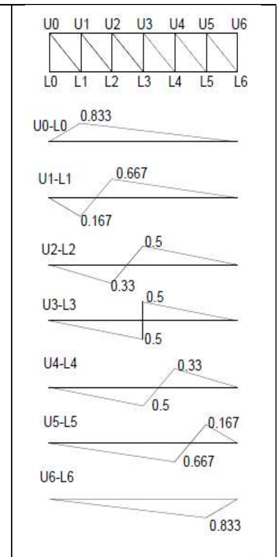

Fig.H: VERTICAL MEMBER Fig: B

ILD of Top chord (Fig:1) and Bottom Chord (Fig:2) will be same for all the figures A,B,C,D

Table 3: Influence Line Diagram [4,6]

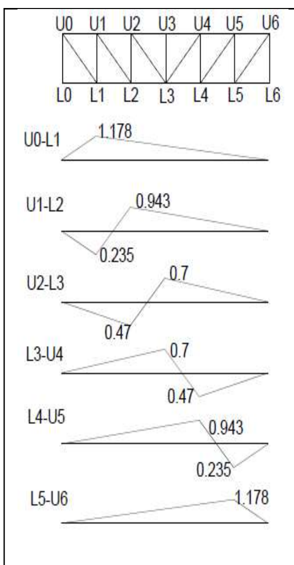

Fig.I: INCLINED MEMBER of Fig A

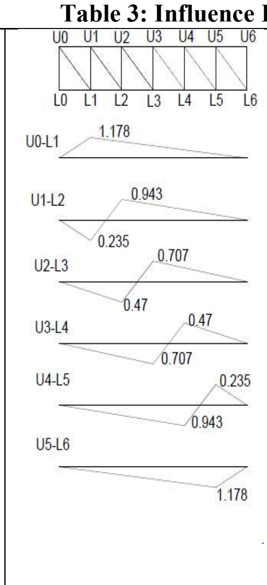

Fig.J: INCLINED MEMBER of Fig B

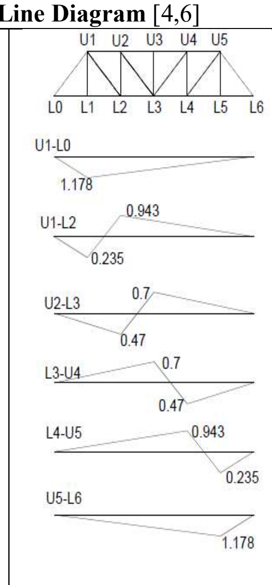

Fig.K: INCLINED MEMBER of Fig C

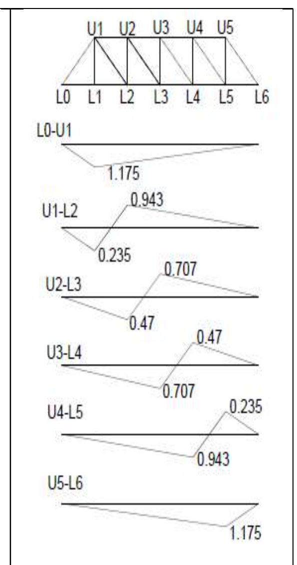

Fig.L: INCLINED MEMBER of Fig D

Above table 2 & table 3, shows INFLUENCE LINE DIGRAM of Foot-over Bridge for figure A, B, C, D.

Sample Calculations [1,6]

Forces in Inclined Member: U1-L2 for figure A, B, C, D

Fdead = 4.75 X (-0.5 X 2.4 X 0.235 + 0.5 X 9.6 X 0.943) = 20.16 KN

Flive 1 = (-0.5 X 2.4 X 0.235 X 7.2) = -2.0304 KN

Flive2 = 0.5 X 9.6 X 0.943 X 7.2 = 32.59 KN

Net Forces = Dead Load + Live Load;

F1 = 20.106 – 2.304 = **18.07 KN(T)** & F2 = 20.106 + 32.59 = **52.7 KN(T)**

Table 4: Vertical Members

MEMBE R	FIGURE A		FIGURE B		FIGURE C		FIGURE D	
U0 –L0	**59.5(T)**	-	59.5(T)	-	-	-	-	-
U1 –L1	12.8(T)	37.3(T)	12.81(T)	37.30(T)	12.8(T)	37.30(T)	12.81(T)	37.3(T)
U2 –L2	0.88(C)	17.7(T)	0.89(C)	17.77(T)	0.88(C)	17.78(T)	0.89(C)	17.7(T)
U3 –L3	10.8(C)	10.8(T)	10.8(C)	10.8(T)	10.8(C)	10.8(T)	10.8(C)	10.8(T)
U4 –L4	17.7(T)	0.89(C)	17.78(C)	0.899(T)	17.7(T)	0.89(C)	17.7(C)	0.89(T)
U5 –L5	37.3(T)	12.1(T)	37.30(C)	12.81(C)	37.3(T)	12.81(T)	37.3(C)	12.8(C
U6 –L6	59.5(T)	-	**59.5(C)**	-	-	-	-	-

Above Table: 4 shows compressive & tensile forces of Vertical Member for figure A, B, C, D

Table 5: Top Chord Member

MEMBER	FIGURE A		FIGURE B		FIGURE C		FIGURE D	
U0-U1	59.5 (C)		59.5 (C)					
U1-U2	95.36 (C)		95.36 (C)		95.36 (C)		95.36 (C)	
U2-U3	107.55 (C)		107.55 (C)		107.55 (C)		107.55 (C)	
U3-U4	107.55 (C)		107.55 (C)		107.55 (C)		107.55 (C)	
U4-U5	95.36 (C)		95.36 (C)		95.36 (C)		95.36 (C)	
U5-U6	59.5 (C)		59.5 (C)		-		-	

Above Table: 5 shows compressive & tensile forces of Top Chord Member for figure A, B, C, D

Table 6: Bottom Chord Member

MEMBER	FIGURE A		FIGURE B		FIGURE C		FIGURE D	
L0-L1	59.5 (T)		59.5 (T)		59.5 (T)		59.5 (T)	
L1-L2	95.36 (T)		95.36 (T)		95.36 (T)		95.36 (T)	
L2-L3	107.55 (T)		107.55 (T)		107.55 (T)		107.55 (T)	
L3-L4	107.55 (T)		107.55 (T)		107.55 (T)		107.55 (T)	
L4-L5	95.36 (T)		95.36 (T)		95.36 (T)		95.36 (T)	
L5-L6	59.5 (T)		59.5 (T)		59.5 (T)		59.5 (T)	

Above Table: 6 shows compressive & tensile forces of Bottom Chord Member for figure A, B, C, D

Table 7: Inclined Members

MEMB-ER	FIGURE A		FIGURE B		FIGURE C		FIGURE D	
	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
U0-L1	84.46 T	0	84.46 T	0				
U1-L0					84.46 C		84.46 C	
U1-L2	18.07 T	52.7 T	18.07 T	52.7 T	18.07 T	52.7 T	18.07 T	52.7 T
U2-L3	1.5 C	24.75 T	1.5 C	24.75 T	1.5 C	24.75 T	1.5 C	24.75 T
U4-L3	24.75 T	1.5 C			24.75 T	1.5 C		
U3-L4			24.76 C	1.5 T			24.76 C	1.5 T
U5-L4	52.7 T	18.07 T			52.7 T	18.07 T	-	-
U4-L5			52.7 C	18.07 C			52.7 C	18.07 C
U6-L5	0	84.46 T						
U5-L6			0	84.46 C	0	84.46 C	0	84.46 C

Above Table: 7 shows compressive & tensile forces of Inclined Member for figure A, B, C, D

Design of Truss Members

a) **Compression Member**

Initially member of size 60 x 60 x 10 for Top Chord Member, 70 x 70 x 8 for Inclined Member were taken for design, which eventually failed to sustain the loads, in the similar manner we increased the member sizes to check the safety of the member.

The minimum safe sizes for calculated forces in Top Chord Member & Inclined Member are: 65 x 65 x 8 & 75 x 75 x 8 respectively.

Table 8: Compression Member [2,10]

	TOP CHORD MEMBER U0-L1 of Fig. A	INCLINED MEMBER U1-L0 of Fig. C	REFERENCES
ANGLE SIZE	65 x 65 x 8	75 x 75 x 8	Indian Steel Table
Properties of Angle	Ag=976mm^2, rmin=11.5mm	Ag=1138mm^2, rmin=14.5mm	
Effective Lentgth	0.85 x 2000= 1700mm	0.85 x 2000= 1700mm	Clause.7.2.2, Page :35, IS 800-2007
Slenderness Ratio	λ= lmin/rmin=136	λ= lmin/rmin=117.25	Clause.7.1.2.1, Page :34, IS 800-2007
Design Compressive Stress	Fcd=69.44N/mm^2	Fcd=90.708N/mm^2	Table:9C, Page :42, IS 800-2007
Load Carrying Capacity	Pu=69.44 x 977=67.84KN > 59.5KN	Pu=90.708 x 1138= 103.2KN >84.46KN	

Above Table: 8 shows calculations for design of compression member i.e. **U0-L1 & U1-L0**

B) Tension Member

On construction site the minimum size of angle used is 50x50x6mm, hence considering this section and checking for the maximum tensile load. Here this section is safe in sustaining the maximum tensile force. Therefore, all members with tensile forces lesser than the Maximum tensile force (84.46KN) is designed for minimum size of 50 x50 x6mm

Table 9: Tension Member [2,9,10]

	TENSION MEMBER	REFERENCES
Angle size	50 x 50 x 6mm (minimum size)	Indian Steel Table
Gross Area	568mm^2	
Design Strength due to Yielding of gross section $T_{dg} = A_g f_y/\gamma_{mo}$	129.1KN >84.46KN	Clause.6.2, page:32 IS 800-2007
Design Strength due to Rupture of critical section $T_{dn} = 0.9A_{nc}f_u/\gamma_{m1} + \beta A_{go}f_y/\gamma_{mo}$ $\beta = 1.4-0.076(w/t)(f_y/f_u)(b_s/L_c) \leq (f_u\gamma_{mo}/f_y\gamma_{m1}) \geq (0.7)$	Anc=162mm^2, Ago=282mm^2, β=1.114, Tdn=119.22>84.46KN	Clause.6.3.3, page:33 IS 800-2007
Design Strength due to block shear $T_{db}=(0.9A_{vn}f_u/(\sqrt{3}\gamma_{m1})+A_{tg}f_y/\gamma_{m0})$	Avn=480mm^2, Atg=180mm^2 Tdb=122.7>84.46KN	Clause.6.4.1, page:33 IS 800-2007
or $T_{db}=(A_{vg}f_y/(\sqrt{3}\gamma_{m0})+0.9A_{tn}f_u/\gamma_{m1})$	Avg=780mm^2, Atn=120mm^2 Tdb=137.77KN>84.46KN	

Above Table: 9 shows calculations for design of Tension member of size 50x50x6mm

Result & Discussion

a. In configurations of figure A & C there are more tensile stresses than the compressive stresses.
b. In configurations of figure B & D there are more compressive stresses than the tensile stresses.
c. Major Tensile & Compressive Stresses in Inclined members are 84.46KN & 84.46KN respectively, for all four configurations.

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d. For the same load in tension(84.46KN) and comparison (84.6KN) the size of the member in tension (table 9) is comparatively smaller than that in compression (table 8)

Table 10: Cost Comparison [2,10]

1	Inclined member for tension force 84.46 KN (50x50x6mm) Standard weight =4.5 kg/m Weight = 12.727 Kg	Percentage Reduction in Steel 1) for Inclined Member = (25.173-12.727)/25.173 =0.4934=49.34%
2	Inclined member for compression force 84.46 KN Size of member =75x75x8 mm Weight =25.173 Kg	
3	Vertical member for Tension Force 59.72KN (50 x 50x 6) Standard Weight= 4.5Kg/m Weight=12.727Kg	2) for Fig A and Fig C end spans = (40.5279-25.1730)/40.5279 =0.37=37%
4	Top Chord Member for Compression force 59.51KN (65 x65 x100) Standard weight=9.4Kg Weight =18.8Kg	

Above Table: 10 shows results of cost variation of different configuration of foot-over Bridge

Conclusion

1. In foot-over bridge tensile force should always be preferred over compressive force.
2. For two members carrying same forces of tension and compression respectively, steel required for tension member is nearly 50% that of steel required for compression member.
3. As per Configurations of Figure A & Figure B, there are more compressive forces in figure B compared to that of in figure A, hence Figure A is Preferred.
4. As per Configurations of Figure C & Figure D, there are more compressive forces in figure D compared to that of in figure C, hence Figure C is Preferred.
5. On Comparing, the steel required in Figure C it is nearly 60% of steel required in Figure A for the end spans.
6. On comparing all the configurations, Figure C is most economical and sustainable.

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