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Comparative Analysis and Design of Steel Footbridge using Conventional and Hollow Section

Anushka M. Pachpute[1], Nikita J. Patil[2], Vrushali M. Muraskar[3], Prajkta V. Patil[4], Prof. Dushyant A. Zamre[5]
[1, 2, 3, 4] *Civil Engineering Department, Savitribai Phule Pune University*
[5] *Assistant Professor, Civil Engineering Department, Savitribai Phule Pune University*

Abstract: a bridge is a structure providing passage over an obstacle without closing the way beneath. with the rapid development in urban sector in our country, construction of roadway and railway network is very fast now a days as six lining, four lining of highways and railway track increment. this trend is likely to continue for next ten years thus due to increased traffic and development there is great need for construction of foot over bridge to safely pass the fast moving traffic. foot over bridges offer a wide range of opportunities for imaginative and innovative architectural design. design should be as attractive as possible. the structure should be in harmony with surrounding environment. the proportion of different elements of bridge should be proportionate. The external finish and painting should be such as enhance the elegance of bridge.

a proper design of foot over bridge is very important since the clear span is 20m. the design and analysis carried out by using conventional steel sections and hollow steel sections is done by using staad.pro software, and the comparative analysis is carried out on the economy of the steel sections.

I. INTRODUCTION

A Bridge is a structure which provides a passage over an obstacle without closing the way beneath. The required passage may be for road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a road, a river, a railway or a valley. Footbridges are smaller lighter structures. They are narrow (about 4m wide) and are usually single span structures that rarely span up to 40m. There are a number of forms of steel footbridge. They provide easy and safe passage for the pedestrians to across the road without obstructing the traffic. Advantage of footbridges is that they provide safer crossing over the rivers, highways, railways and other obstacles. Disadvantage of footbridges can be high cost if elevators or long ramps for wheelchair users have to be built into the bridge. Some of the characteristics of steel that make it an attractive option for bridge builders include its versatility, cost effectiveness, longevity, and sustainability. These qualities allow designers to develop structures that would be impossible to build without steel components. Steel can carry loads in tension, compression, and shear. That makes it the perfect material to use in many types of bridges.Steel has a remarkably high strength-to-weight ratio.

This minimizes the weight of bridge superstructures, which reduces the cost of building the substructures that support them. This is particularly beneficial when constructing bridges in places where the ground is unstable, such as river beds and canyons. Compared to heavier materials, the lower weight of steel lowers the cost of transporting and handling it.In addition to all this, environmentalists are more likely to support the construction of steel bridges compared to other types because they're generally more sustainable and earth-friendly. There are some key benefits of steel foot over bridge. Such as Economic benefits, Environmental benefits, Benefits to society.

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II. DESIGN CONSIDERATION

A. *Design*

The design of steel truss pedestrian bridges is based on the siting and functionality factors, the loading conditions — wind, dead, live, fatigue, snow, seismic, and stream force — required for the bridge. Seismic and stream load forces are key determinations that should be addressed by the specifying engineer during the specification phase

Design Steps

1) *Given Data:* Span of Bridge = Width of walkway = N-type Lattice Girder = Thickness of RCC Slab = Loadings:-
2) *Geometry of Lattice Girder*
a) Assuming depth of girder = Span/No of panels {Span/5 ≤ Span/8}
b) Length of panel = Span/no of panels
c) Length of Vertical member.
d) Length of Diagonal member = $\sqrt{(\text{Length of Vertical member})^2 + (\text{Length of panel})^2}$ Design of Cross Beam:
e) Dead load = (Thickness × Density)
f) Floor finish = (given)
g) Live load = (given)
h) Total load =
i) Load per unit Length = Total load × Length of panel. Assume self weight of cross beam 0.5 kN/m² Total load = Load per unit Length + 0.5. Factored load = 1.5 × Total load.
j) Maximum Bending moment = $Wl^2/8$
k) Factored Bending Moment = 1.5 × Maximum Bending moment.
l) Max Shear force = $Wl/2$
m) Factored Shear force = 1.5 × Max Shear force.

Considering compression flange of
beam fully laterally restrained
Plastic section modulus required:-
$Z_p(req) = M \times \Upsilon_{mo}/f_y$.
Shape factor = $Z_p(req)/Z_e$
Now by using Steel Table:
Select the ISLB Section Whatever the answers comes
Therefore,
$Z_p(provided) = Z_e \times 1.14$

3) *Section Classification according to IS 800-2007* $\epsilon = (250/f_y)^{1/2} = 1$
a) Flange Criteria = $b/2t_f$
b) Web criteria = α/t_w

If it satisfies then the section is Plastic.

4) *Plastic section:-Bb = 1*

Check for moment Resistant Capacity
$M_d = B_b \times Z_p(provided) \times f_y/\Upsilon_{mo}$

5) *Design of N-Type Lattice girder*
a) Dead load intensity = D.L due to selfweight × width of walkway/2
b) Self weight of truss in meters = Dead load intensity/10
c) Total D.L = Dead load intensity + Self weight of truss in meters.
d) Factored D.L= Total D.L × 1.5
e) Live load =L.L × width of walkway/2
f) Factored L.L = 1.5 × L.L × width of walkway/2
g) Total factored load = D.L +L.L
h) Load on each node = Total factored load/no. of panels

6) Forces in Chord Members

In This step ILD Diagrams should be drawn and the answers should be entered in the tables

Top Chord	Bottom Chord	ILD (Area in m²)	Load in kN	Moment in kN/m (Area × load)	Force = Moment/Depth of panel
(1)	(2)	(3)	(4)	(5)	(6)
				(3)×(4)	(5)/Depth of panel

7) Forces in Vertical member

Member	Area		Net Area (N.A)	D.L (N.A ×10.98)	Total force (L.L(N.A ×11.8))			
	+ Ve	-Ve						
					+ve	-ve	Max	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			(4)=(2)-(3)				(8)=(5)+(6)	(9)=(5)-(7)

8) Forces In Diagonal Member

Member	Maximum	Minimum
(1)	(2)	(3)
	√2 × (8)	√2 × (9)

9) Design Forces calcuations as discussed earlier :- Design of Chord Member. Max Force =Assume the design stress = 90 Mpa Provide the necessary sections of angles (Single or Double angle section)

10) Now From Steel table Choose ISA For the final Calculations.

11) Seismic Design Calculations were done by using IS Codes specifications.

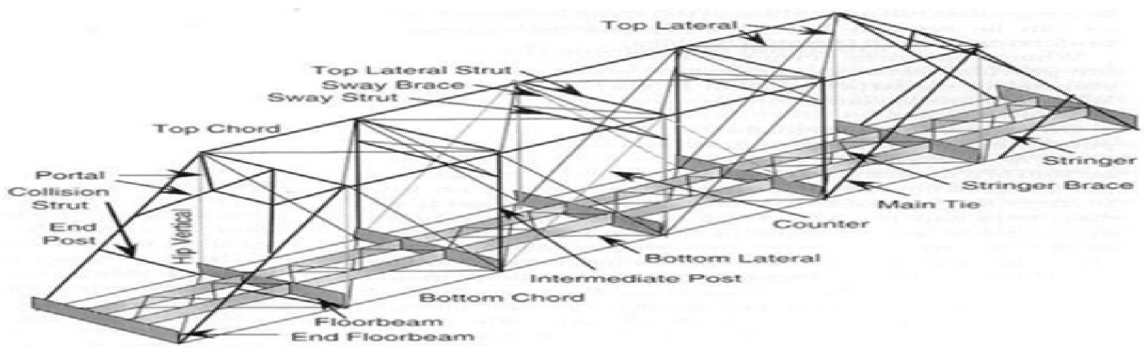


Fig. - Component Parts OF Foot Bridge

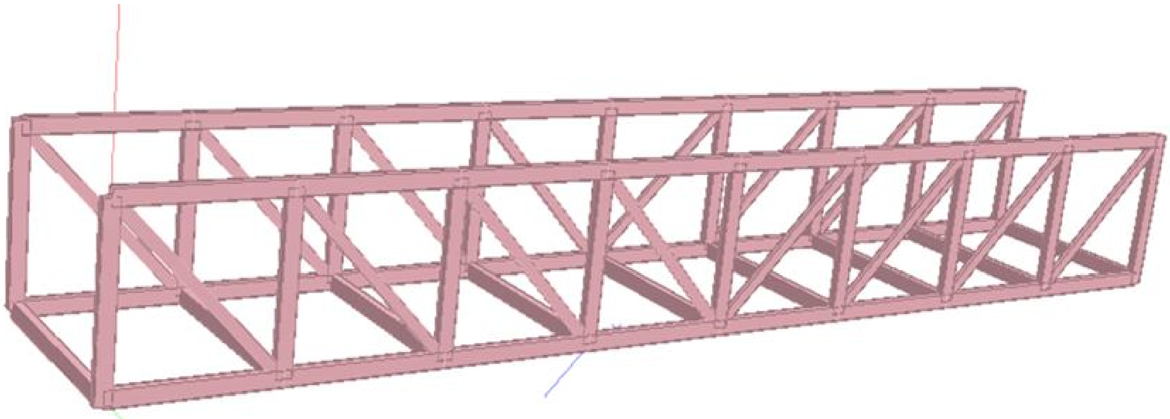
III.RESULT ANALYSIS

After comparing the result of conventional and hollow steel section on the basis of total weight, total cost inculding fabrication cost, total expenses and % of saving with reference to seismic design etc. we get results as follow :

Cases	Sections (in mm)	Total Length (m)	Total Weight (Kg)	Cost Rs/kg	Fabrication Cost (Rs)	Total Amount (Rs/Kg)	Total Expenses (Rs)	% Savings with reference to seismic design
Case 1	ISMB400	157.50	9497.8	45	14	59	560370.2	30
Case 2	ISMB500	157.50	13430	45	14	59	792370	0
Case3	TUB E 200X200X8	157.50	11543.1	58	18	76	877275.6	0
Case 4	OD=356 ID=348	157.50	16420.4	40	16	56	919542.4	0
Case 5	TUB E 240X140X8	157.50	7024.8	56	16	72	505785.6	36.16

1) *Case 1:* design of foot bridge subjected to gravity loads only.
2) *Case 2:* seismic load design with conventional sections.
3) *Case 3:* seismic load design using square tube hollow steel section.
4) *Case 4:* seismic load design using circular pipe hollow steel section.
5) *Case 5:* seismic load design using rectangular tube hollow steel section.

Here we get hollow rectangle section most economical than other section.



Design of Rectangular tube hollow steel section subjected to Seismic loads

IV. CONCLUSIONS

construction industry being one of the important sector concerns more about human and living beings safety and thus the strength and durability of structures matter. one such important structure that is foot bridge is studied over here in this paper, force consideration, factor affecting them and its design parameters related to natural hazard like earthquake so as to make it stable and earthquake resistive.

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