Design Considerations For Seismic Foot Bridge A Case Study

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Abstract- *A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley. In other words, bridge is a structure for carrying the road traffic or other moving loads over a depression or obstruction such as channel, road or railway. Also a footbridge or a pedestrian bridge is a bridge designed for pedestrians and in some cases cyclist, animal traffic and horse riders, rather than vehicular traffic. Footbridges can also be built in the same ways as road or rail bridges. Footbridges are small, but important, because they are usually presented in townscape. The appearance of footbridges, and indeed of any other bridges, in a town, is a major concern for designers. Increasing strength of new structural materials and longer spans of new footbridges, accompanied with aesthetic requirements for greater slenderness, are resulting in livelier footbridge structures. In the past few years this issue attracted great public attention.*

Keywords- Seismic, Foot Bridge

I. INTRODUCTION

a) Aim & Objective:

Footbridges are smaller lighter structures. They are narrow (about 2m wide) and are usually single span structures that rarely span more than 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.

b) Need

In recent years, there has been a growing trend towards the construction of lightweight footbridges. Due to its reduced mass of such structures, the dynamic forces can cause larger amplitudes of the vibration. The more slender structures become, the more attention must be paid to vibration phenomena.

The increase of vibration problems in modern footbridges shows that footbridges should no longer be designed for static loads only. But fulfilling the natural frequency requirements that are given in many codes restricts footbridge design: very slender, lightweight structures, such as stress ribbon bridges and suspension bridges may not satisfy these requirements. Moreover not only natural frequencies but also damping properties, bridge mass and pedestrian loading altogether determine the dynamic response. Design tools should consider all of these factors. Provided that the vibration behavior due to expected pedestrian traffic is checked with dynamic calculations and satisfies the required comfort, any type of footbridge can be designed and constructed. If the vibration behavior does not satisfy some comfort criteria, changes in the design or damping devices could be considered. The need for construction of Foot Bridges is:

Structural steel has been the natural solution for long span bridges since 1890; Steel is indeed suitable for most span ranges, but particularly for longer spans. So, to overcome all these problems Seismic Resistant Foot Bridges need to be constructed.

c) Research Methodology

The research methodology consist of the following points

d) To Determine Resource And Consumption

As due to rapid development of construction industry, first of all findings for various types of resources and their consumptions present impact of the resource will be analyzed.

As the seminar is dealing with the analysis and Design of Foot Bridge.

Steel plays a very important role in the construction of Foot Bridges as Steel has good tensile as well as compressive properties. So, for that I am selecting steel as a construction material for analysis and design of Foot Bridge.

As steel is being used for the construction of Foot Bridge we have to know their properties whether it is liable for the construction or not. If so, why?

e) Advantages of Steel over Concrete Bridges:

The following are some of the advantages of steel bridges that have contributed to their popularity in many developed countries:

f) They could carry heavier loads over longer spans with minimum dead weight, leading to smaller foundations.

g) Steel has the advantage where speed of construction is vital, as many elements can be prefabricated and erected at site. In urban environment with traffic congestion and limited working space, steel

Bridges can be constructed with minimum disruption to the community.

- Greater efficiency than concrete structures is invariably achieved in resisting Seismic forces and blast loading.
- The life of steel bridges is longer than that of concrete bridges.
- Due to shallow construction depth, steel bridges offer slender appearance, which make them aesthetically attractive. All this frequently leads to low life cycle costs in steel bridgesThere are various types of steels available in market but out of them some steels have the good quality they are as follows:
- Materials Used:

Conventional Steel Used In Bridges:

Steel used for bridges may be grouped into the following three categories:

(i) Carbon steel:

This is the cheapest steel available for structural users Where stiffness is more important than the strength. Indian steels have Yield stress values up to 250 N/mm² and can be easily welded. The steel conforming to IS: 2062 - 1969, the American ASTM A36, the British grades 40 and Euronorm 25 grades 235 and 275 steels belong to this category.

(ii) High strength steels:

They derive their higher strength and other required properties from the addition of alloying elements. The steel conforming to IS: 961 - 1975, British grade 50, American ASTM A572 and Euro norm 155 grade 360 steels belong to this category. Another variety of steel in this category is produced with enhanced resistance to atmospheric corrosion. These are called 'weathering' steels in Europe, in America they conform to ASTM A588 and have various
Trade names like ' cor-ten'.

(iii) Heat-treated carbon steels:

These are steels with the highest Strength. They derive their enhanced strength from some form of heat-Treatment after rolling namely normalization or quenching and Tempering. The physical properties of structural steel such as strength, ductility, brittle fracture, weld ability, weather resistance etc., are important factors for its use in bridge construction.

- Advanced Hollow Steel sections Used for the construction of Steel Foot Bridges:

Tata Structural Steel Hollow sections command several techno-economic advantages over conventional steel sections. Manufactured from world class Hot Rolled Coils of Tata Steel, it is noted for better compressive strength and enhanced shear capacity among several other advantages. Structures made of Tata Structural Hollow Sections are lightweight and therefore more resistant to seismic forces. Thus it ensures high durability for the structures it supports and is preferred by architects & structural engineers.

- Different Product Categories
  - Rectangular Hollow Sections
  - Square Hollow Sections
  - Circular Hollow Sections
  - Galvanized Hollow Sections

- Brand Benefits
  - Conforming to IS:4923 and IS:1161 standards
  - Better compressive strength due to lower slenderness ratio and higher yield strength
  - Full strength under bending moment, regardless of lateral restraints due to superior torsional rigidity
  - Lower drag coefficients of closed structurals help to bypass the fluid currents more effectively than conventional sections
  - shear capacity due to more effective area under shear
  - Due to YST 310 grade, sections can take more tensile loads as compared to ordinary lower grade structural and hollow sections

- The concentric connections of symmetrical hollow sections are extremely efficient in resisting secondary moments
- Because of light weight, the seismic forces on the structure will be less, thereby reducing the weight of the structure
- Manufactured from world class Hot Rolled Coils of Tata Steel

• Design Concept

Earthquakes cause the ground to shake violently thereby triggering landslides, creating floods, causing the ground to heave and crack and causing large-scale destruction to life and property. The study of why and where earthquakes occur comes under Geology. The study of the characteristics of the earthquake ground motion and its effects on engineered structures are the subjects of earthquake engineering. In particular, the effect of earthquakes on structures and the design of structures to withstand earthquakes with no or minimum damage is the subject of earthquake resistant structural design.

To resist this seismic ways there are some provisions made in Indian Standard Code of Practices for Bridges. By using those methods of analysis and Designing we can minimize the effect of seismic ways over Foot Bridges. They are

• Design Philosophy And Methodology

Severe earthquakes have an extremely low probability of occurrence during the life of a structure. If a structure has to resist such earthquakes without any failure, it would require an expensive lateral load resisting system, which is unwarranted. On the other hand, if the structure loses its aesthetics or functionality quite often due to minor tremors and needs repairs, it will be a very unfavorable design. Therefore, a dual strategy, akin to the limit state design, is adopted. The usual strategy is:

'To ensure elastic behavior under a moderate earthquake which has a return period equal to the life of the structure and prevent collapse under the extreme probable earthquake'.example, if the expected life of the structure is fifty years, then it is designed to remain elastic under an earthquake, which is likely to occur at least once in fifty years. Thus, no major repair will be necessary as a consequence of such earthquakes during the life of the structure. However, structures are designed to prevent collapse and loss of life under the most severe earthquake. The reason for adopting such a strategy is that it is extremely expensive to design structures to respond elastically under severe earthquakes, which may not occur during their expected life.

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:

a) Dead load = (Thickness × Density)
b) Floor finish = (given)
c) Live load = (given)
d) Total load =
e) Load per unit Length = Total load × Length of panel.

Assume self weight of cross beam 0.5 kN/m^2

Total load = Load per unit Length + 0.5.

Factored load = 1.5 × Total load.

f) Maximum Bending moment = $Wl^2/8$
g) Factored Bending Moment = 1.5 × Maximum Bending moment.
h) Max Shear force = Wl/2
i) Factored Shear force = 1.5 × Max Shear force.

Considering compression flange of beam fully laterally restrained

Plastic section modulus required:-

Zp(req) = M × ϒmo/fy.
Shape factor = Zp (req)/ Ze
Now by using Steel Table:

Select the ISLB Section Whatever the answers comes Therefore,

Zp (provided) = Ze × 1.14

3. Section Classification according to IS 800-2007

$\epsilon = (250/fy)^{1/2} = 1$

a) Flange Criteria = b/2tf
b) Web criteria = α/tw

If it satisfies then the section is Plastic.

4. Plastic section:-Bb = 1

Check for moment Resistant Capacity
Md = Bb × Zp(provided) × fy/ ϒmo

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

8. 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)

9. Forces in Diagonal member:-

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

10. Design Forces calcuations as discussed earlier :-
11. Design of Chord Member.
Max Force =
Assume the design stress = 90 Mpa
Provide the necessary sections of angles (Single or Double angle section)
12. Now From Steel table Choose ISA For the final Calculations.
13. Seismic Design Calculations were done by using IS Codes specifications.
14. Sample Design Detailing :- (Source from net)

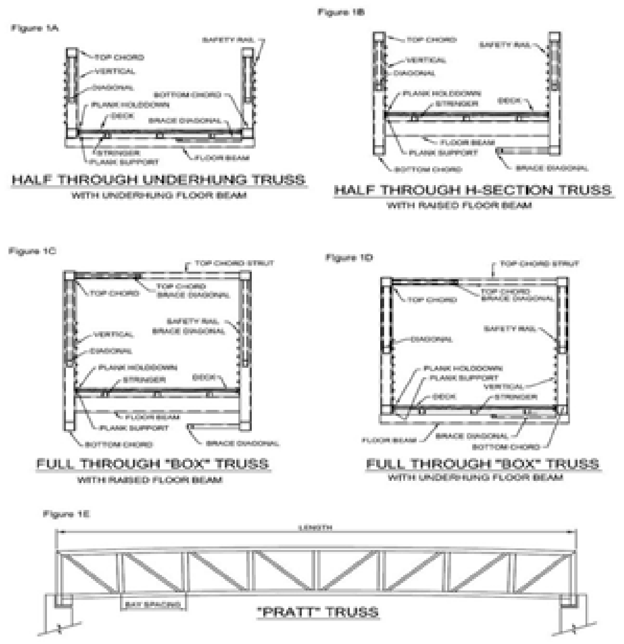

Fig. 1 : Picture taken from NET source

Criteria & Check:

Seismic loads: - The calculation of seismic forces in areas subject to earthquakes should be as set forth in the applicable design code or specification (typically IBC/ASCE 7 or AASHTO). For states with high seismic activity, such as California, it is common to be required to meet the seismic requirements of local or state agencies (i.e., CALTRANS or the California Building Code). A geotechnical investigation to determine relevant site conditions is recommended for all bridges that may encounter high seismic forces so that an appropriate seismic evaluation can be accomplished.

Design code: - two main design codes are used to govern prefabricated steel truss pedestrian bridge types:

- "AASHTO Guide Specification for the Design of Pedestrian Bridges," published by the American Association of State Highway and Transportation Officials (AASHTO);
- "International Building Code" (IBC) for design loads in conjunction with the specification for structural steel buildings published by the American Institute of Steel Construction (AISC) for member and connection design.
- In general, AASHTO Guide Specifications for the Design of Pedestrian Bridges is referenced most commonly on projects where state and/or federal funds are allocated to the bridge construction.
- Indian Standard Practice Code For Steel Structures (IS 800-2007)
- Indian Steel Table By. S. Ramamrutham
- Indian Standard Code Practice Criteria For Earthquake Resistant Design Of Structures Fourth Revision (IS 1893-1984)

III. 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.

REFERENCES

[1] E.T.Ingolfsson , C.T..Georgakis & J.Jonsson [1], a comprehensive review of studies related to pedestrian-induced lateral vibrations of footbridges
[2] P.Kumar and A.Kumar [2] studied the effect of human vibaration induced in the foot bridge.
[3] Vibration serviceability of footbridges under human-induced excitation: a literature review Zivanovic, Stana, Pavic, Aleksandar and Reynolds, Paul.
[4] AASHTO Guide Specifications for Design of Pedestrian Bridges, American Association of State Highway and Transportation Officials.
[5] Guide for the Development of Bicycle Facilities, American Association of State Highway and Transportation Officials.
[6] Standard Specifications for Highway Bridges, 16th edition, American Association of State Highway and Transportation Officials.
[7] ASCE Standard 7-95, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.
[8] 2006 International Building Code.
[9] Indian Standard Practice Code For Steel Structures [IS 800-2007]
[10] Indian Steel Table By. S. Ramamrutham.