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Pedestrian Steel Truss Over Bridge Analysis and Design at Saharsa Railway Station, Bihar

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Abstract

The current research focuses on "Analysis and design of steel truss foot over bride using STAAD.Pro and AutoCAD." In India, steel truss foot over bridges are the most cost-effective and widely used kind of foot over bridges. The Warren truss is utilised to design the construction because it evenly distributes the load. Foot over bridges are mostly utilised in railway stations because they facilitate crowd flow between the tracks. Steel foot over bridges are less expensive and easier to build because they do not require expert labour. The loads on the bridge are analysed using STAAD.Pro software, and the relevant IS codes are used to construct the various sections of the structure. The load values produced from STAAD are used to design all of the structure's sections. The pieces and pro are tested to ensure that they can be utilised in the construction.

1. INTRODUCTION

Railway foot over bridges is constructed to connect two or more platforms in the railway station, the foot over bridge is increasingly popular since it allows people to change lanes without constantly worrying about high-speed traffic and it really is a highly safe choice that does not disrupt automobiles.

Steel bridges are one of the important sources of building. Steel bridges have the greatest and most advantageous strength and durability features from all other types of bridges, making them ideal for the most creative bridges. Steel foot over bridges are frequently used by railways nowadays since they are simple to construct and cost much less than other materials. These bridges are very easily constructed within a short period of time. The position of foot over bridge is provides so that maximum number of people can pass though it during peak time. It should also be convenient for individuals over both sides of the railway bridge.

The increase in pedestrian traffic on railway station due to arrival of two or three trains at the same time cause rushing between the passengers to catch other trains which leads to many accidents and missing of train of many passengers as well as missing of passengers. The present over bridge in Saharsa station is constructed years ago and there is a risk of breakdown of bridge during peak hours. Also, the number of over bridges in Saharsa station is not sufficient for transportation of crowd in peak hour because of that many people prefer rail line to go to other platform. The objective of the present study includes the planning, analysis and designing of a steel truss foot over bridge at Saharsa railway Station, Bihar. The study helps to reduce the Pedestrian traffic cause due to arrival of multiple trains in different tracks at Saharsa railway station. It will reduce the accident cause while trespassing the rail lines or due to heavy pedestrian traffic. This may be used as a basis for future design of the other bridge in railway station so that the whole bridge could be designed easily. This design did not consider disabled pedestrians.

The planning of the structure is used with AutoCAD Software, analysed using STAAD.Pro software and designed manually. The Truss member used in over bridge will be light in weight and also having maximum durability and bearing strength. The design procedure is taken from the present design procedure used by industries to make it simple and effective.

2. LITERATURE SURVEY

Gupta and Gupta (2011) have used a span and height of 30 m and 75 m respectively for the design of foot over bridge. The High strength Light weight tubular steel was used in the right design of the foot over bridge. Moreover, the foot over bridge was completely supported by a 30 m steel beam, demanding the usage of a significant cantilever beam to ensure the stability of the construction.

Kumar (2014) had developed a transportable pedestrian bridge which might assist a passenger carrying a load in traversing a creek. The major goal was to reduce overall structural system distortion by optimising cross sections, material characteristics, and mass.

Aniket and Sumit (2015) conducted a survey and investigation on the evaluation of conventional foot over bridge facilities, identifying people's aversion to using foot over bridges owing to inconvenience, lack of knowledge, crowded traffic, long travel times, inadequate accessibility, and poor conditions. Considering the inherent problems, authors provided enough service to the site, and which could satisfy the increasing demands.

Patil (2016) used stability analysis to assess, inspect, and examine the structural response of a hybrid bridge. The study also examined the findings quantitatively to determine whether they were appropriate. Gajghate and Rewatkaral (2017) had done seismic analysis of bridge for different varieties of soil. The authors used reaction spectrum analysis to emphasize the impact of varied soil conditions in different zones, as well as checking the bridge's ability to sustain bending moment and shear for various span columns.

3. METHODOLOGY

The selection of a place is the first step in the approach. For the construction of the overbridge, a suitable site was chosen taking into account all parameters**.** AutoCAD is used to create the plan drawing for the Overbridge. STAAD.Pro is used to model and load analysis of the Overbridge. The load values produced from STAAD.Pro are used to design the top and bottom chord members, vertical, diagonal members, columns, bracings, footing, and flexural reinforcements.

4. ANALYSIS OF OVERBRIDGE

4.1 DATA FOR DESIGN OF OVERBRIDGE:

1. Location: Saharsa Railway Station
2. Total Span : 86 m
3. Width of Gangway: 4 m
4. Length of vertical member: 3 m
5. Height from the Rail line to Base:6.5m
6. Live Load: 5 kN
7. Depth of RCC Slab: 150 mm
8. Truss Used: Warren truss.

4.2 GEOMETRY OF GIRDER

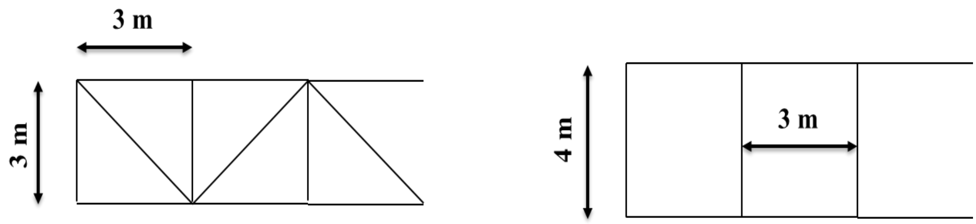

Figure 1: Elevation and Plan of section

1. Vertical member : 3m
2. Diagonal Member : 3.61m

3. Horizontal member: 3m
4. Cross Beam : 4m

4.3 LOAD CALCULATIONS

As per IS 875-2 (1987): Code of Practice for Design Load

1. Live Load : 5.00 kN
2. Weight of RCC Slab : 3.75 kN/m^2
3. Floor Finish : 0.75 kN
4. Total load : $10KN/m^2$
5. Factor of Safety : 1.5
6. Final Load : 11.5 kN/m^2

4.4 MATERIAL PROPERTIES:

STEEL:

1. The structural steel utilized in this design has the following characteristics:

   Steel Yield stress : 250 M pa

   Steel Ultimate stress : 410 M pa

1. HYSD Fe 415 reinforcements according to IS 808 is applied everywhere.

CONCRETE:

M20 grade

f_{ck} : 20 N/mm^2

4.5 DATA OBTAINED FROM STAAD.PRO:

After putting the load data in the STAAD.Pro model the forces in the members were determined and maximum values in members where consider for the design of bridge are follows:

1. Top Chord member : 664.07 kN (Compression)
2. Bottom Chord member : 252.35 kN (Tension)
3. End Diagonal : 308.44 kN (Compression)
4. Other Diagonal : 295.57 kN (tension)

   269.38 N (Compression)

5. Vertical member : 100.00 kN (Tension)

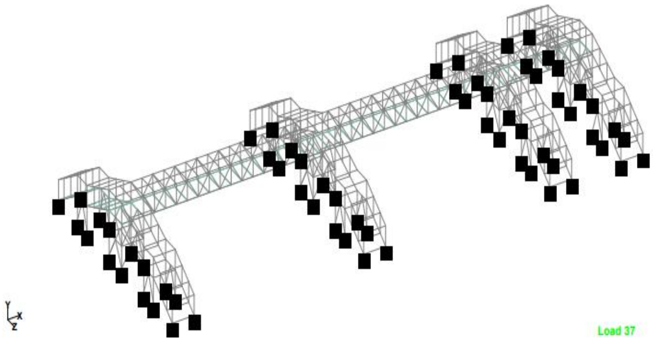

Figure 2: STAAD.Pro Model of over bridge

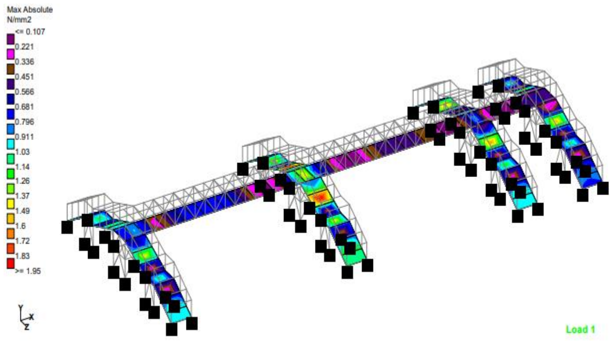

Figure 3: Plate load analysis

5 DESIGN OF OVERBRIDGE

Table 1: Designed section for main truss

Structure	**Force**	**Section**
Top chord	Compression	ISA 150×150×12 (double)
Bottom chord	Tension	ISA 150×150×12 (double)
Diagonals	Compression	ISA 100×100×10 (double)
	Tension	ISA 100×100×10 (double)
End diagonals	Compression	ISA 150×150×12 (double)
Vertical	Tension	ISA 90×90×8 (single)

Table 2: Designed Section for Gangway

Structure	**Section**
Parallel Girder (Primary)	ISMB 200
Perpendicular girder (Secondary)	ISMB 200

Table 3: Designed section for column

Structure	**Section**
Primary Column	ISMB 500
Bracing (Horizontal)	ISA 75×75×8 (double)
Inclined bracing	ISA 75×75×8 (double)

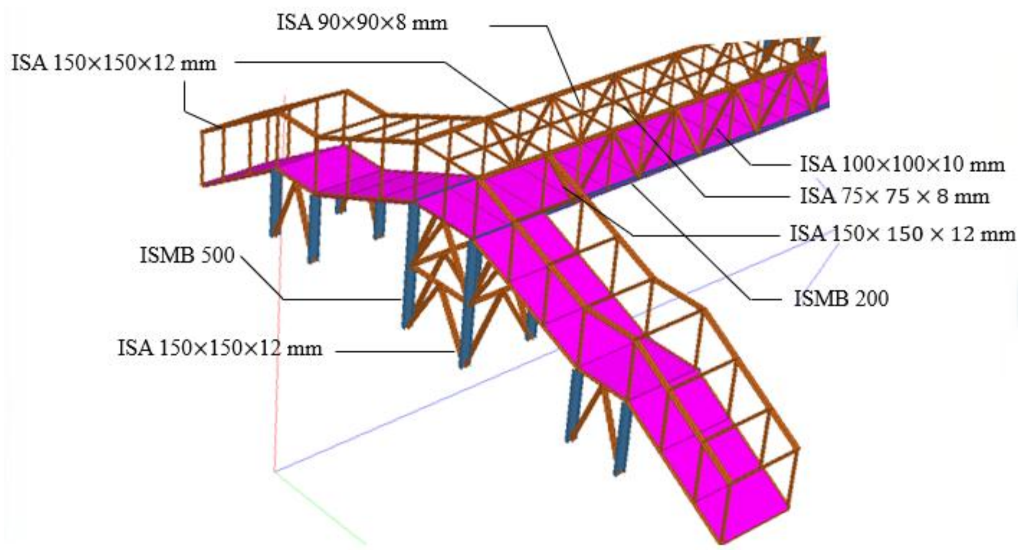

Figure 4: Labelled diagram of over bridge

5.1 DESIGN OF FOOTING

Square column as pedestal = 900 × 900 mm (Assume)

P = 452 kN

SBC = 190 kN/m^2

Using M20 grade of concrete and Fe415 grade of steel.

Size of footing

Load = 452 kN

Q_u = 190 kN/m^2

Depth (h) = 1.8 m

Ultimate load (P_u) = 452/190 = 2.3789 m^2

Size of square footing = $\sqrt{2.3789}$

= 1.542m (Minimum)

Assume a size of 1.8 m × 1.8 m

Footing Slab thickness based on shear

Ultimate force (Q_U) = $452/0.25$ = 1.80 N/m^2

One way shear,

V_{U1} = $1.80 \times 1800 \times (250 - D)$

= 810000 – 3240 D

Assuming τ_c = 0.359 N/m^2 and p_t = 0.25

V_{C1} = 0.359 × 1800 × D = 648 D

810000 – 3240D = 648 D

D = 198.33 mm

Therefore, assume a thickness of 20 cm

Two-way shear,

The critical section is at $d/2$

V_{u2} = $1.80 \times (18002 - (900 + d)^2)$

Substitute d = 200 mm

V_{u2} = $1.80 \times (18002 - (900 + 200)^2)$ = 960 kN

Shear resistance (Two way) V_{c2} = $Ks\tau c \times (4 \times (900.00 + d)d)$

τ_c = $0.25\sqrt{19.98}$= 1.119 MPa

V_{c2} = $1 \times 1.12 \times 4d \times (900 + d)$ = $4032d + 4.48d^2$

V_{u2} = V_{c2}

960×103 = $4032d + 4.8d^2$

d = 196 mm

Assume clear cover of 75 mm and 16 mm ϕ bars

D = 196 + 75 + 8 = 279 mm

Over depth given is 300 mm

d_{avg} = 300.0 – 75 – 8 = 217 mm

220 mm depth is provided

Assuming,

Unit weight of concrete: 25 kN/m^2

Unit weight of soil : 18 kN/m^2

q = $\frac{320}{1.8\times1.8} + (25\times0.3) + (18\times0.3)$

= 111.86 kN/m^2 <190 kN/m^2

5.2 DESIGN OF FLEXURAL REINFORCEMENT:

Factor moment:

Mu = $Q_{UD}\left(\frac{D-d}{2}\right)^2 = 1.80\times1800\times\left(\frac{1800-900}{2}\right)^2$

= 112 × 10^6 N mm

R = $\frac{M_u}{bd^2} = \frac{112\times106}{1400\times220^2}$ = 1.65 N/mm^2

P_t/100 = $\frac{fck}{2f_y}(1-\sqrt{1-4.598R/fck})$

= $\frac{20}{2\times415}(1-\sqrt{1-4.598\times1.65/20})$ = 0.018

$S_{at\ min}$ = 0.0012 bd^2

= 0.0012 × 1800 × 300 = 648 mm^2

Pt = $\frac{100\times648}{1800\times220}$ = 0.16 <0.25

From table 19 IS 456: 2000

$A_{st\ req}$ = $0.248\times1800\times220/100$ = 990 mm^2

Using 12 mm ф bars, number of bars required is

n = $\frac{990}{\pi/4\times122}$ = 8.75 = 9 Nos (approx.)

To determine the spacing

S_v = 113.04/990 × 1000 = 114.18 mm

Provide 9 numbers of 12 mm ф bars at 120 mm center to center spacing in 2 ways)

Check for shear

$Vu = 198.96 \times (1000.0 - 900.0) = 20.645$ kN

Table 4: Footing dimensions

Structure	Length	Breadth	Depth	Reinforcement
Main Footing	1800 mm	1800 mm	300 mm	12 mm diameter @ 120 mm center to center both ways

$100\frac{A_{st}}{Bd} = \frac{100 \times 771}{1000 \times 220.0} = 0.35$

From IS 456: 2000 Table 19 and from the clause 40.2.1.1

$K_S\tau_C = 1 \times 0.459 = 0.459$ N/mm^2

$\tau_v = 20.639 \times 103/\ 1000 \times 220 = 0.092$ N/mm2

$\tau_v < K_S\ \tau_C$

Size of footing provided: 1.8 m × 1.8 m

Depth of footing provided: 1.8m, below ground level

Footing depth: 300 mm

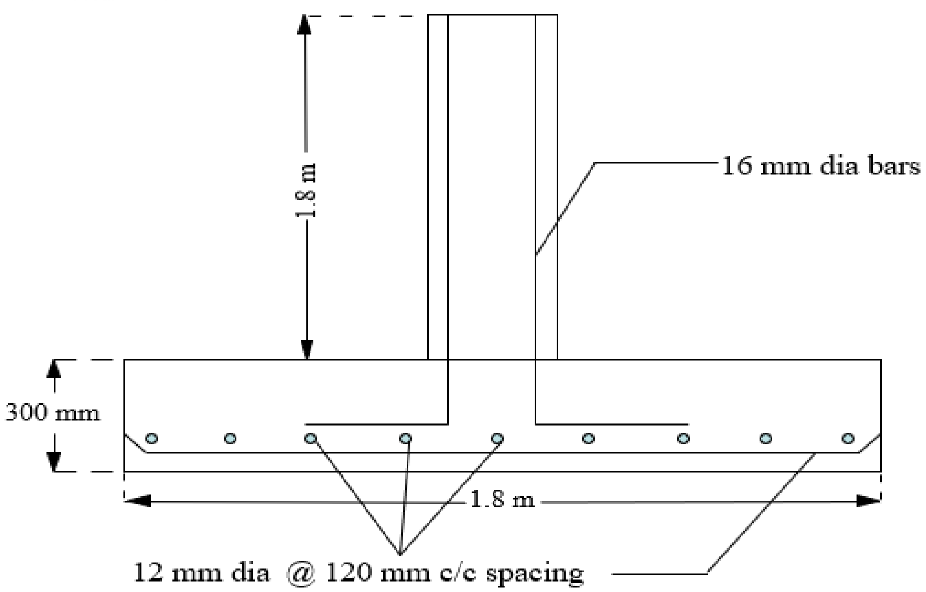

Figure 5: Reinforcements in footing

6. RESULT AND CONSLUSION:

The Foot Over Bridge was Planned in AutoCAD, and STAAD.Pro was used to examine several structures of the foot over bridge, including truss, footing and column. Manual design yields professional software as well as the most cost-effective and secure sections. When compared to Reinforced Concrete Structures, steel structure is more economical in terms of construction, since steels are easy to assemble and also have high strength.

After analyzing it with the STAAD.Pro software and manually designing the bridge, it can be finally concluded that the bridge is safe and will reduce the pedestrian traffic efficiently.

REFERENCES

[1] A. Das. S. Barua, "A Survey Study for User Attributes on Foot Over Bridge in Perspective of Dhaka City, "International Conference on Recent Innovation in Civil Engineering for Sustainable Development, vol. 1, no. 1, p. 7, 2015.

[2] Design of Steel Structures’, B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain Lakshmi Publications, New Delhi, 2008.

[3] Design of Steel Structures’, S.K. Duggal, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2009.