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ANALYSIS AND DESIGN OF RAILWAY BOX BRIDGES USING STAAD SOFTWARE

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ABSTRACT

Bridges are the structural components necessary for the efficient movement of trains and locomotives, as well as the crossing of water courses, such as streams, across earth embankments, as road embankments cannot obstruct the natural waterway. Bridges can take various forms, including arch, slab, and box. These can be made from a variety of materials, including masonry (brick, stone, etc.) or reinforced cement concrete. Since the bridge passes through the earthen embankment, it is subjected to the same traffic loads as the road and must therefore be designed to withstand these loads. The buffer depends on the rail profile at the location of the bridge.

The structural design requires consideration of load cases (box vacant, full, surcharge loads, etc.) and factors such as live load, effective width, deceleration force, load dispersion through fill, impact factor, and earth pressure coefficient, among others. Referring to relevant IRCs is required. The structural elements must be designed for optimum bending moment and shear force resistance. This paper examines the Codes' provisions, considerations, and justifications for the aforementioned design aspects. Software or Computational methodologies can be utilised to analyse the box bridge. Therefore, it is essential to evaluate the efficacy of results obtained from both methods.

Keywords: Railway minor Bridge, Box Bridge, Analysis and design of Box Bridge

1. INTRODUCTION

A bridge is a building that allows traffic to cross over an obstruction without blocking the path below. The necessary passageway might be for a pipeline, a canal, a road, a railway, or people. It may be necessary to cross a river, road, railway, or valley. In other terms, a bridge is a building used to transport vehicles or other moving cargo across an impediment like a canal, road, or railway. A bridge is a structure designed to over an obstruction like low land, a stream, or a river without blocking the path below. A railway system's critical connection is made up of bridges. As of March 31, 2002, the Indian Railways system has 127154 bridges. Many of these bridges, which date back 80 to 100 years, were built to withstand the lesser loading standards that were then in use. Since the building of these bridges, both freight and passenger traffic on Indian Railways have increased significantly. From 93 million tonnes in the early 1950s, originating traffic increased to 522 million tonnes in 2001–2002.

The amount of passenger traffic has also grown, going from 67 billion to nearly 493 billion passenger kilometres. In order to guarantee the safety of rail traffic, bridges require particular attention and care, including renovation when necessary. This is due to the introduction of bigger axle loads and faster speeds as well as ageing and strain. Any bridge damage may need extensive time for repairs, and the financial effects may also be fairly severe due to the high cost of repairs and traffic disruptions. Therefore, increased focus on maintenance and adequate, consistent care is essential for the long-term health of these bridges. Any structure, whether single or multiple-span, with an internal width of 6.096 m (20 ft) or less when the measurement is taken horizontally along the centre line of the highway from face-to-face of abutments or sidewalls is referred to as a culvert in the Standard Specifications.

2. OBJECTIVES OF THE STUDY

1. Creation of the project's overall concept.

2. Assessment of different bridge parameters in accordance with IRS rules and RDSO (Research Designs and Standards Organisation) designs.

3. To use STAAD Pro software and MDM to analyse the R.C.C box bridge.

4. Analysis from STAAD Pro and MDM were compared to determine whether approach is more effective.

5. To design all of the box bridge's structural components.

6. To assess the bridge's safety

3. METHODOLOGY

- Analysis and design by STAAD pro.
- Analysis method adopted for RCC box is MDM (Moment Distribution Method).
- Designing Box Bridge considering LSM.

Various cases those are to be generally adopted for designing:

Case 1: Dead load and live load acting from outside as well as earth pressure, while no water pressure from inside (i.e., Design of Box Bridge by considering the box as in empty conditions, no water will flow from it)

Case 2: Dead load and live load acting from outside as well as earth pressure, while water pressure acting from inside (i.e., designing the by considering that it is half full)

Case 3: Dead load and live load acting from outside as well as earth pressure, while water pressure acting from inside (i.e., designing the box by considering that it is full.

Considering case one, as it is the worst possible case for designing bridge.

Serviceability Limit State– For the limitations given in 10.2.1. load combination only shall be considered. For the stress limitations given in 10.2.2, load combinations 1 to 5 shall be considered. The value of YfL for creep and shrinkage of concrete and prestressed (including secondary effects in statically indeterminate structures) shall be taken as 1.0.

Ultimate Limit State– To check the provisions of 10.3 load combinations 1 to 4 shall be considered. The value of YfL for the effects of shrinkage and, where relevant, of creep shall be taken as 1.2. In calculating the resistance of members to vertical shear and torsion YfL for the prestressing force shall be taken as 1.15 where it adversely affects the resistance and 0.87 in other cases. In calculating secondary effects in statically indeterminate structures YfL for prestressing force may be taken as 1.0.

4. GEOMETRY AS PER GENERAL ARRANGEMENT DRAWING (GAD)

All the dimensions that have been decided for the designing of a bridge are as follows:

1.R.C.C. twin box Where

- No. of Boxes= 2
- Barrel length= 6m for both boxes

2.Internal height is of 6m.

3.Ballast Retainer height is 1.2m.

4.Ballast cushion height will be 0.4m for Broad gauge as per Bridge Manual.

5.Soil fill will be of 1m.

6.Bottom and Top slab thickness= 1m

7.Side wall thickness= 0.9m

8.Concrete grade= M35

9.Steel grade= Fe500

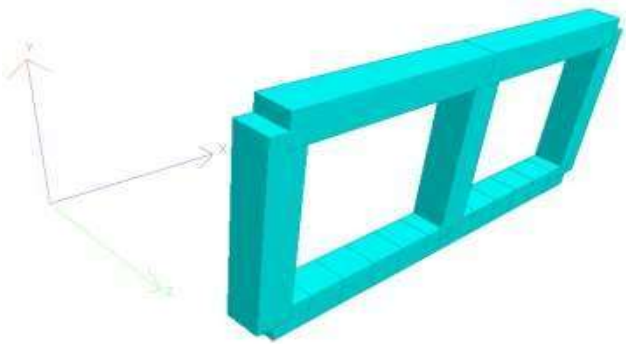

Fig.1: 3D Rendering View

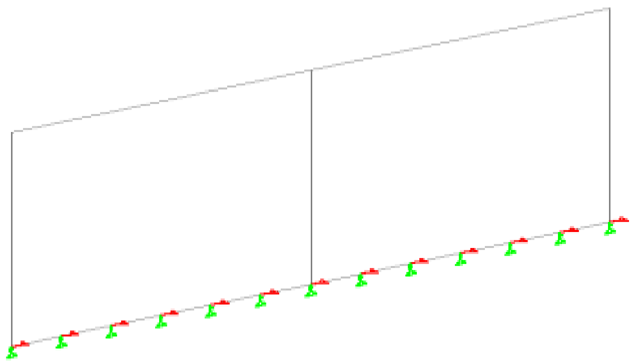

Figure 2: STAAD pro Model

5. LOAD CALCULATION FOR STAAD PRO ANALYSIS

Size of RCC Box Bridge =3m (Formation width) x14.7m (Length) x 8m (Height) (Outer to outer dimension)

Design span of Bridge = 14.7 m (clear)

Thickness of Raft Assumed =1m Thickness of Side walls =0.9m

Thickness of Deck slab =1m

Span c/c = 6.9m (Outer span)

Height of Box c/c = 7m

Width of load dispersion B = 3m (For Live load due train)

Width of load dispersion B1 =3m (For SIDL due self-weight of rails) Live load consider =25 t loading ballast)

LOAD 1:- Dead Load

For Top and bottom Slab: b x d x γ =25KN/m

For Side walls and Intermediate Walls = b x d x γ=150KN/m

Total Dead load of a structure = (2x75) + (3x450) = 500 KN/m

LOAD 2:- Super Imposed Dead Load (SIDL)

Load of Rails, ballast = 60kN/m

SIDL / m =20 KN/m2

UDL = 20kN/m

LOAD 3:- Live Load (as per IRS, BR, Appendix XII(a))

CDA factor = 0.15 + 8 / (6+L) = 0.7702

EUDL for Bending Moment

Cushion =400 mm

L	EUDL
6	839
6.9	920.09
7	929.1

EUDL (B M) =920.09kN

Load / m2 =44.449 KN/m2

Consider 1 m width load = 44.449 KN/m

UDL with CDA factor = 78.681 KN/m EUDL for Shear Force

Cushion = 400mm

L	EUDL
6	937.6
6.9	1006.27
7	1013.9

EUDL (SF) =1006.27kN

Load / m2 = 48.612kN/m2

Consider 1 m width load =48.612kN/m

UDL with CDA factor =86.051kN/m

LOAD 4:-Earth Pressure EP (As per IRS, BS&FC, and clause no 5.7)

Density of soil =18kN/m3

Design height =7m

Φ =	30	deg	0.524	rad
δ =	10	deg	0.175	rad
α =	0	deg	0.000	rad
i =	0	deg	0.000	rad

Ka = 0.472

Triangular Earth pressure =59.524kN/m on side wall @ Base

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LOAD 5:- Surcharge Load Due to Earth Filling (Formation)

This Load is Under EP

Height of Surcharge load =1m

Load on Deck slab =18kN/m2

Load / m =18kN/m

(1 m width)

Load Combinations

CASE I) For Live Load Due to Moving Train Load Combination 1 (Ultimate Limit State, ULS)

1.4 DL + 2 SIDL + 1.7 EP+1.7SURCH + 2 LL

Load Combination 1 (Serviceability of Limit State, SLS) 1DL + 1.2 SIDL + 1 EP+1SURCH + 1.1 LL

6. RESULTS

- **For Deck Slab:**

Position	STAAD Values (KN-m)	MDM values (KN-m)
At Support	670.703	166.165
At Mid Span	796.48	554.46

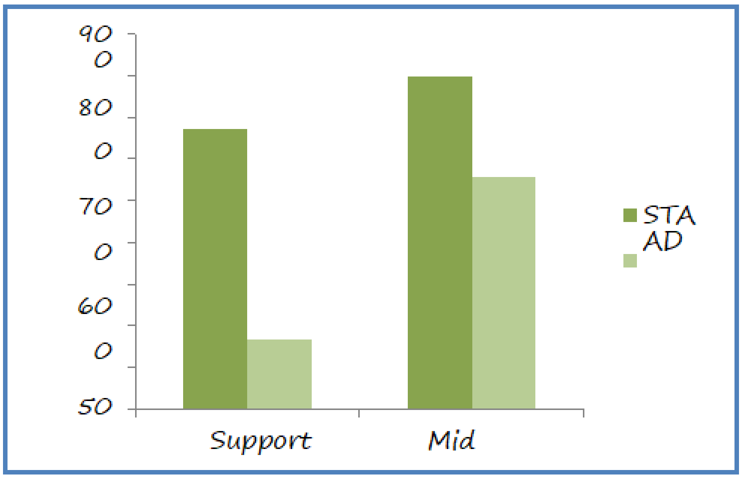

Figure 3: Comparison of STAAD and MDM results for Deck Slab

For Side walls:

Position	STAAD Values (KN-m)	MDM values (KN-m)
At Top	346.389	166.165
At Base	471.968	308.074
At Mid	35.199	-

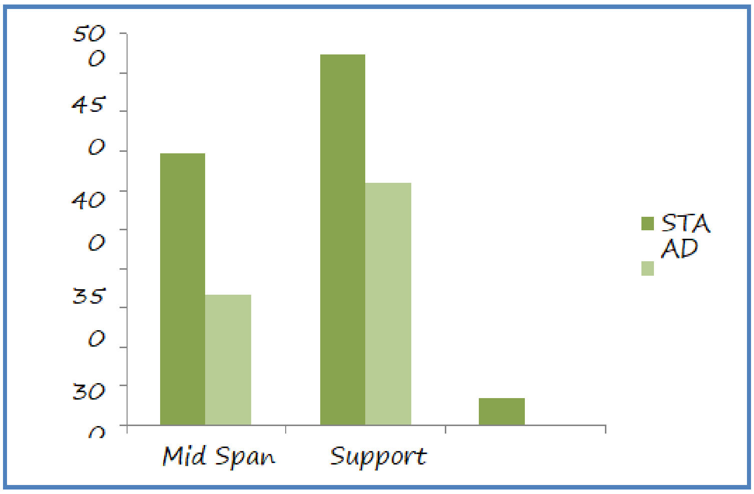

Figure 4: Comparison of STAAD and MDM results for Side Walls

For Base Raft:

Position	STAAD Values (KN-m)	MDM values (KN-m)
At mid span	121.741	-
At support	828.751	308.074
At Intermediate	770.687	802.278

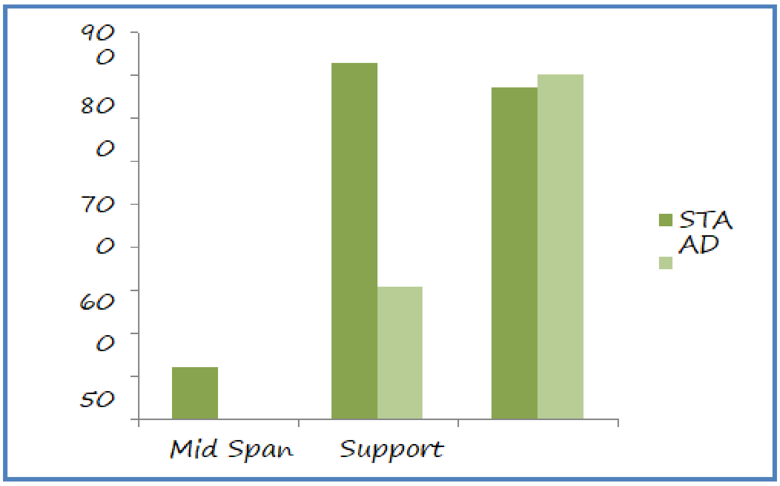

Figure 5: Comparison of STAAD and MDM results for Base Raft

7. CONCLUSION

- STAAD Pro software is used to analyse every structural component.
- The MDM approach is used to manually analyse the structure.
- The Ultimate Limit State approach and the Serviceability Limit State method are used to finish the design.
- From the aforementioned, it is clear that STAAD Pro software is far more capable than MDM.
- When different weights are involved and there are circumstances for designing purposes, a bridge's size is a determining factor.
- It has been discovered that the relevant IRS rules must be followed with extreme care while constructing any railway bridge.

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