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Comparative Analysis of Box Culvert with Cushion and without Cushion Using Staad Pro

Puneet Kumar Pandey[1], Dr. A. K. Jha[2], Dr. R. S. Parihar[2]

[1]M. Tech Scholar, [2]Professor,
[1,2]Department of Civil Engineering, LNCT University, Bhopal, Madhya Pradesh, India

ABSTRACT

Bridges are essential for the efficient movement of trains and locomotives, as well as for crossing water courses such as streams across embankments as roads are not allowed to obstruct the natural flow of water. Culverts provide balance to the water flow on both sides of the road, as well as protecting and balancing the embankment in order to reduce flooding. Different types of bridges exist, such as arch, slab, and box. Masonry (brick, stone, etc.) or reinforced cement concrete can be used to build them. The bridges pass through the embankment and are therefore subject to the same traffic loads that the road carries, so they must be designed accordingly. Depending on where the bridge is located, the cushion will vary. Structures must be designed to take into account the loads (empty, full, surcharge, etc.) along with factors such as live loads, width, force of braking, load dispersion within the fill, impact factor, and earth pressure. Referrals are required for relevant IRCs. It is necessary to design structural elements that can withstand maximum bending moment and shear force. The culvert crosses over the earthen embankment, so it is subject to the same traffic load as the roads; as a result, it has to be designed for such loads acting on the culvert surface. The present study focuses on reinforced concrete box culverts with different aspect ratios. The box culverts are analysed for varying cushion and no cushion loading. A large emphasis is placed on determining how well a structure will behave under various types of loading as recommended by IRC codes, and the combinations that will cause the most harmful effects on the structure. Comparative analysis and conclusions are based on maximum bending moments for different loading conditions.

Part 1 The study deals with the planning and analysis of Box Culvert using Staad-Pro software. In this study Box Culvert clear span is 5m and clear height is 3m and the slab is fixed supported. The drafting and detailing work was completed using AutoCAD software and thereafter the entire analysis work was completed using “Staad-Pro v8i ss6.

Part 2 Comparison of Box Culvert with cushion or without cushion also the analysis results in term of shear, bending moment, axial force and deflection were checked by STAAD-Pro which is passes through many different load combinations. The maximum design moments resulting from the combinations of various loading cases.

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KEYWORDS: *Bridges, Staad-Pro., Box Culvert, cushion or without cushion, design moments, Axial force and deflection*

I. INTRODUCTION

Culverts are structures built below roads and railroads for the purpose of allowing natural drainage to cross underneath. Sometimes they are built to provide access to the animals across the road as well. The culvert opening should be determined according to the maximum amount of water it will have to handle during the design flood, and the culvert section should be thick the structures must be capable of carrying those loads. The purpose of culverts and bridges is often the same, although the size of each differs. The type of material, how they carry weight, and how closely a culvert is bound to the soil surrounding them determine whether culverts are flexible, semi-rigid, or rigid. When it comes to carrying imposed loads, culverts depend on many factors, including the type of material they are made of, the age of the material, and the surrounding materials. In a box culvert, more than one cell can be present and the top slab may be situated so that it almost touches the road and there is no cushion. After repetitive loading of heavy trucks, material aging and degradation has a tendency to decrease capacity gradually.The report discusses reinforced concrete box culverts with varying aspect ratios. In addition to culverts placed within embankments, slab-top culverts can also be installed along roadway embankments. This type of box is a cushion. The box culverts are analysed for different cushion loadings and no cushion loadings. According to IRC codes, this paper explores how variations of loads can negatively impact structures and what combinations can trigger significant impacts. Structures must be loaded safely.

There are some types of culverts generally used in construction:

a. Pipe culvert

b. Pipe Arch

c. Box culvert

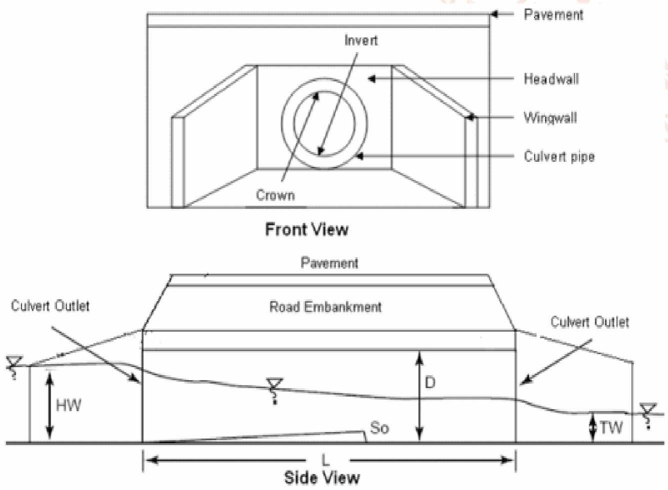


Fig-1.1 Pipe Culvert

II LITRATURE REVIEW:

Raza and Khedikar (2019) Researched and designed a variety of slab culverts for different mix designs and spans. This paper compares culvert designs that are designed with different mix designs and spans.

Patel and Jamle (2019) developed a manual approach for the analysis and design of box culverts. In this paper, we study complete box culvert design manually and analyse parameters such as earth pressure effect, the depth of cushions above the culvert, braking force, load impact, live load, load dispersal from tracked and wheeled vehicles, and effective width. Study of culverts with and without cushions was carried out for different IRC loading classes and conclusions drawn based on bending moments and shear forces under different cushioning situations. As part of the discussion of Indian Standards, their justifications and considerations are taken into account for design purposes.

Bangari et al. (2019) researched the parametric behaviour of rcc box culverts under dynamic loading. As a main source of human life, bridges allow human beings to travel from place to place. This research examines the analysis and design of bridges. Bridges are modelled and analysed with the help of the software Staad-pro. A box culvert bridge is the design we came up with. According to IRC 6, design loads are taken into account. Staad-pro is used to design the box culvert and the results are compared manually.

Hussien (2020) He studied the effect of the haunch on the stresses in box culverts. The paper analyses the effects of the haunch on the stresses in box culverts by studying the thickness of the haunch, the coefficient of earth pressure, the thickness of the box culvert, and the fill depth on the top slab. Comparing different widths of culverts in terms of stress and cost was examined by the researchers. The cost of culverts is reduced by a specific percentage when a haunch is present.

Bhujade and Gaikwad (2020) worked on Design of RCC box culvert with cushion and without cushion.Box culverts are structures that are built beneath highways and railways to allow natural drainage to pass through, with the opening determined based on the waterway needed to pass a design flood. Box culvert is suitable CD structurewhere hydraulic head is limited. This paper deals with study of box culvert constructed in reinforced concrete without cushion and withcushion as per limit state method. According to IRC, the thickness of the culvert section should be calculated based on the vehicular loading in order to create the strongest load for a safe structure. Using STAAD Pro, structural engineers must analyze bending moments and shear forces to determine how the steel should be designed to withstand maximum bending moments and shear forces.

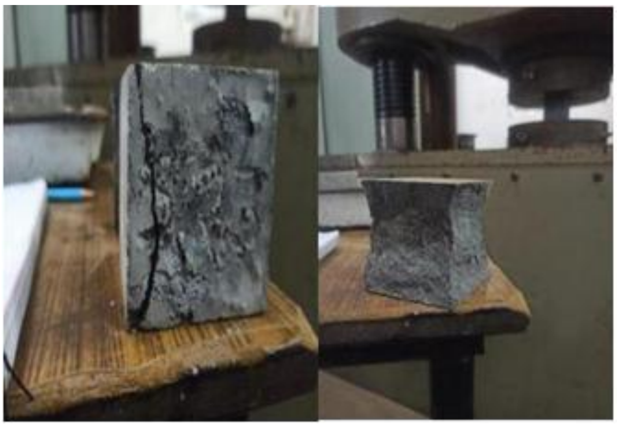
Chaithra et al. (2021) worked on Parametric Study on Single Cell Box Culvert Design Considerations-A Review. The use of box culverts in transportation networks is vital since they are a cost-effective alternative to bridges that require substantial amounts of funding. Basically, a culvert is a structure that provides a way for vehicles and pedestrians to cross over a waterway while allowing water to pass through. The natural stream passes through channels since they are normally cheaper than bridges. A culvert can be constructed from a pipe, reinforced concrete or another material. It is common to use culverts both for drainage under roads and to pass water under channels at natural drainage and river crossings. A stiffness matrix method is used to analyze box culverts. Suppose that the boundary conditions of a box culvert are discrete and externally determined. A single cell box consists of a top slab, a bottom slab, and two vertical walls, forming a rigid frame enclosed in a rigid box. It is assumed that the structure is externally determined. A review of various authors, including their views on the design and analysis of box culverts with software approach, has been done in this study, and a comparison between manual and software approaches has been made. IS standards are used in the structural designs of concrete box culverts (IRC-6-2000, IS 21-2000) in design manuals for roads and bridges. A full discussion is provided of the provisions in the Codes, as well as the considerations and justifications for all the things listed above.

III EXPERIMENTAL PROGRAM:

Box structures typically have clear spans of 5m and slab thicknesses of 0.5m, and the slab is fixed supported. Various loads are simulated by STAAD-Pro. Furthermore, the results were analysed by STAAD-Pro which passes through different loads conditions in terms of shear, bending moments, axial forces, and deflection. This resulted in the maximum design moment.

S.no	Type of Member	Dimensions or nos.
1.	Top Slab	6000 mm x 16000 mm x 500 mm
2.	Bottom Slab	6000 mm x 16000 mm x 500 mm
3.	Outer Wall	450 mm x 16000 mm x 3000 mm

Table 3.1 Dimensions of structure



a. Examine historic and contemporary documents related box culvert bridge structures.
b. Modeling and analysis of culvert by STAAD pro.
c. It is important to choose the geometrical box and the size of the elements so as to ensure the highest degree of accuracy.
d. Specifying the thickness (top slab, side walls, bottom slab) and material properties.
e. Now installed spring support under the bottom sla b.
f. Various load cases for the structural design of RC C culverts, such as effective live loads, effective width, and coefficient of earth pressure should be considered
g. Axial forces on the Deck slab, Axial forces on the Side Walls, Shear forces on the Deck slab, Shear forces on the Side Walls, Deck slab bending moments are all considered as part of the Ultimate Bearing Capacity.

IV METHODOLOGY:

a. Examine historic and contemporary documents related box culvert bridge structures.
b. Modeling and analysis of culvert by STAAD pro.
c. It is important to choose the geometrical box and the size of the elements so as to ensure the highest degree of accuracy.
d. Specifying the thickness (top slab, side walls, bottom slab) and material properties.
e. Now installed spring support under the bottom sla b.
f. Various load cases for the structural design of RC C culverts, such as effective live loads, effective width, and coefficient of earth pressure should be considered
g. Calculations are output for the Maximum bending moment, Maximum shear force, and Maximum axial force.

Material	Grade	Density	Modulus E	Posion ratio (v)
		(kg/m^3)	kN/mm^2	
Conrete	M-25	2500	30	0.20
Steel	Fe-500	7850	200	0.30

Table 4.1 Material properties

Fig-4.1 Setup in STAAD Pro

Selection of Model

It has been considered to analyse the position of vehicles under the basic load according to the Indian Road Congress and analyse it with Staad professional programming for the investigation of a 7m clear span RCC Bridge. The proposed steps are as follows:

Step 1: Choose the type of structure you would like to make in staad before you map it

2. Modeling

Geometry of the structure can be selected by using the coordinate system in Staad Pro or by Plotting over the AUTO CAD, which can be imported into Staad-Pro according to the box Dimensions, such as the span, height, wall thickness, and number of boxes. Below you will find a sketch of the box structure.

Step 2: Whenever you start a project, the first step is to set up model data, such as name, storage, place, units, etc

Step 3: Once the units are set, we can create a model using the node/beam courser, or we canprovide co-ordinates to allow for generation of the model.

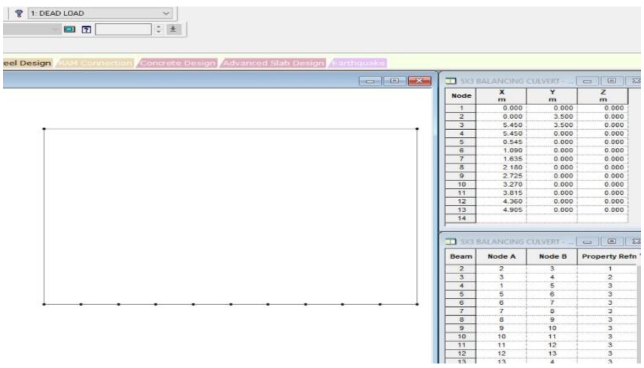


Fig-4.2 Provide coordinates in STAAD Pro

V RESULT AND DISCUSSION

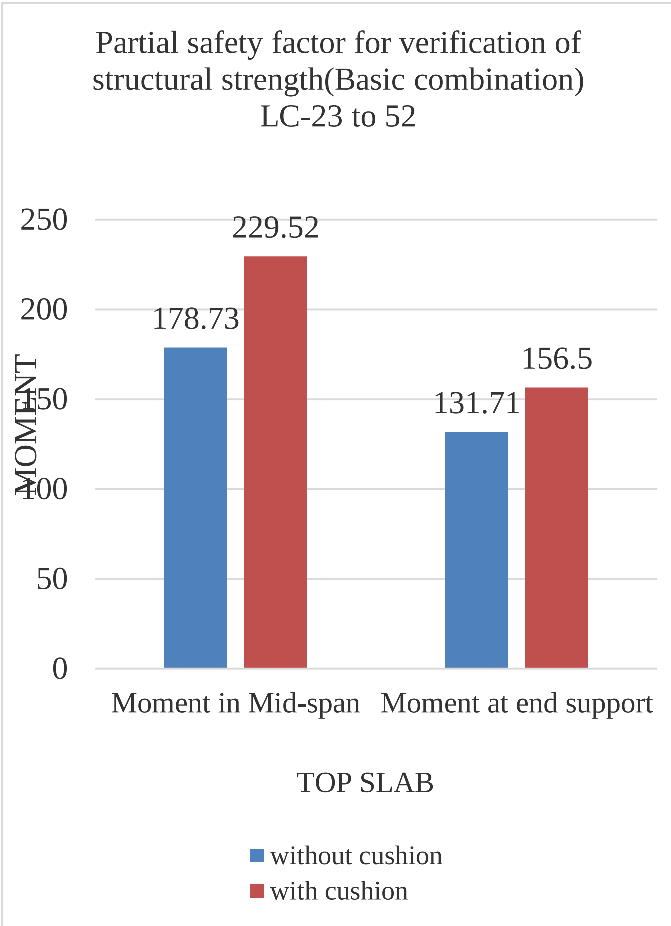
In this study Box bridge analyzes by STAAD-Pro under different loading conditions. And also the analysis results in term of shear, bending moment, axial force and deflection were checked by STAAD-Pro which is passes through many different load combinations. The maximum design moments resulting from the combinations of various loading cases.

Live Load

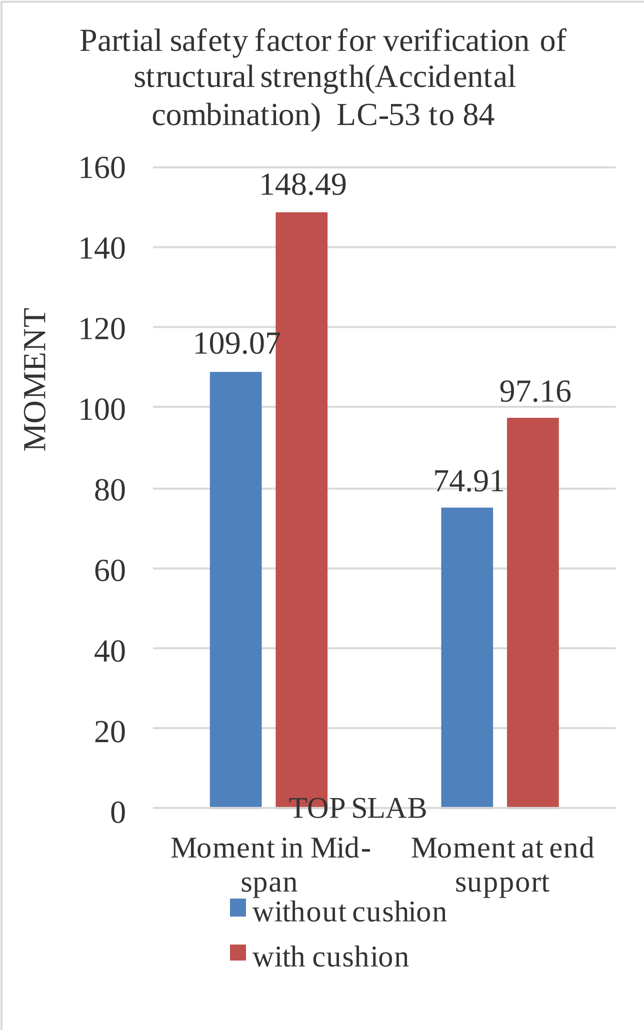
As specified in IRC: 6-2016, the load analysis has been carried out using class A, class 70R tracked cars, 70R wheeled cars, Special vehicle and 70R bogie cars. The various combinations of the RCC box type structure that are capable of producing worst shear force and bending moment. A maximum bending moment is identified at different sections for each of the various combinations.

Impact of Live Load

Whenever loads move off the top slab, they create an impact. This impact is dependent upon the type and class of the weight. According to IRC: 6-2017 Code, an impact factor formula is provided to calculate impact factor for different kinds of loads. For each load, the live load should be increased to account for the impact. If the top slab is subject to heavy impact, the box, without a cushion, must be designed to withstand those types of loads including impacts. The impact percentage for bridge structures whose filling is not less than 0.6 m plus the road crust shall be a half of what is specified in Clauses 208.2 and 208.03. The impact on the vertical walls of the box is considered.



Graph 5.1: Variation of Max. Bending Moment for Basic combination



Graph 5.2: Variation of Max. Bending Moment for Accidental combination

VI CONCLUSION:

After analyzing the results obtained for various loading variations and creating graphs, the following conclusions can be drawn:

1. Staad Pro will show the entire study and behavior of bridge structure under different IRC loading conditions.
2. A bridge structure can be constructed economically with the help of the software.
3. The basic combination of loading vehicles is the most critical instance of maximum BM, since this is the loading that results in maximum BM
4. Load positions along a longitudinal edge affect shear stress at a reference point.
5. As the distance between edge and 2.7 m from RHS is varied, the absolute maximum total deformation (moment) first increases, and then decreases while the distance from RHS to edge is changed.
6. As the size of the box structure is reduced, the total deformation, and the shear stress at a reference point decreases.
7. Bending moment reaches its highest value at the center, and shear force reaches its highest value at the support.

VII SCOPE FOR FURTHER STUDY

Using the STAAD Pro software or the MIDAS civil software, you can conduct further research on the Skew Box culvert, such as:

1. It is possible to have a longer span.
2. The STAAD Pro software can be used to analyze shear behavior of box structures.
3. STAAD Pro software can be used to analyze box structures using seismic loading.
4. Bending behavior of box structure can be done.

Here, 4 lanes are considered, but in the future 6 lanes could be considered.

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