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A Review Paper on Analysis and Design of Precast Box Culvert Bridge

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Abstract - *Box culverts are monolithic structures used to bridge roads, railway lines, and other structures. Culverts must be installed beneath the earth embankment for the crossing of watercourses such as streams, Nallas, and other bodies of water, as the road embankment cannot be allowed to block the natural waterway. Culverts are also needed to balance flood water on both sides of the earth embankment, lowering the flood level on one side of the road and lowering the water head, lowering the flood threat. Water, traffic, cushion, soil, and other forms of loads are absorbed by the box. This work examines the many types of IRC loadings as well as design considerations such as the effect of ground pressure and the depth of cushion at the base.*

The structural elements have been developed to withstand maximal bending moments and shear stresses. This article gives a comprehensive examination of the requirements in the codes, as well as considerations and arguments for all of the above design characteristics.

Key Words: Box Culvert, Design Coefficients, Loadings Types, Moment, Shear, Pressure Cases, Cushioning, Loading class, Moment calculations, Percent reinforcement, Pressure cases, Side walls, Top slab, cushion, coefficient of earth pressure, lateral earth pressure etc.

1. INTRODUCTION

Box culverts with four corners are joined monolithically. In other circumstances, the box will be three-sided, meaning it will have a bottom slab (Raft) as well as vertical walls. If we don't make the top slab, which is also available in the market, we won't be able to join it monolithically. Every box culvert requires cushioning, which is determined by the road profile and bearing capability of the soil on site.

Box culverts are simple to design and inexpensive to build. It is meant to handle all of the loads that come from the top slab and are carried to the bottom slab via vertical walls, which rests in areas where the soil is having low bearing capacity. The box culverts' barrels should be long enough to accommodate the highway and kerb. Because of their stiffness and monolithic action, box culverts are cost-effective because no separate foundation is required when the bottom slab is resting on hard soil. On the basis of the vertical walls and slabs, the structure is constructed as a rigid frame using the moment distribution method to achieve final distributed moments.

1.1 TYPES OF IRC LIVE LOADING CONSIDERED

a. IRC-CLASS-70R - This is a municipal loading that includes industrial areas, important highways, bridges, and culverts, among other things. The bridge, as well as culverts intended for Class-A and Class-B military heavy-load trucks. It should be examined for Class-A loading since Class-A loading will result in high strains. According to IRC 6, the value for a tracked vehicle in Class 70 R is 350 KN.

b. IRC-CLASS-A: - This loading is preferable on all highways with permanent structures such as bridges, culverts, and other similar structures. According to IRC 6, the figure for Class A for a wheeled vehicle is 114 KN.

c. IRC-CLASS-B: This loading is preferable on all roads where temporary constructions are present.

Figure:1 Box culvert with cushion

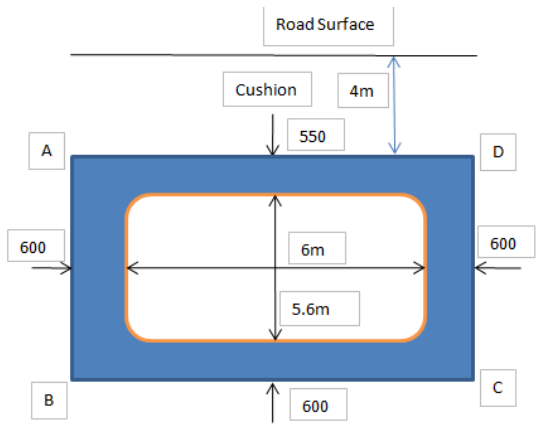
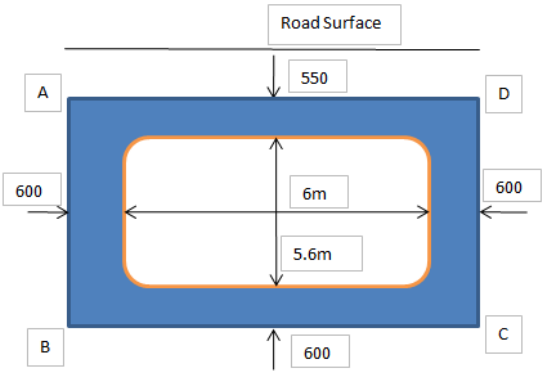


Figure:2 Box culvert without cushion



1.2 AIM OF THE PROJECT

The purpose of this study is to achieve the following goals: -

1) To design and analyze the precast box culvert with top slab and bottom U separately using STAAD PRO software.
2) To design bottom slab, walls and top slab of the box culvert as per IS specifications.
3) Structural designing of box culvert considering various IRC live loading including factor like effective live load, dead load, effective width and coefficient of earth pressure.
4) Compare results of cast in situ and precast top slab construction with all types of live loadings.
5) Checking effect of cushion on top of box culvert.

2. LITERATURE REVIEW

1. Neha Kolate, Molly Mathew & Snehal Mali

   Had done study in Analyses and design of box culvert considering coefficient of earth pressure, longitudinal/breaking force, effective width and impact factor in design and analyses of single and multi cell culverts. Had taken load cases with empty and full filled box culvert along with different types of laodings. Concluded with design of main and distribution reinforcement and shear design.

2. Afzal Hamif Sharif (2016)

   Used the moment distribution method and Staad pro software to conduct the research. In order to ensure the safety of the bridge, they were compared and all structural aspects were examined. The advantages of box culverts, as well as their crucial design and span length, are determined by the cell ratio and number of cells.

3. Vasu Shekhar Tanwar, Dr. M. P Verma, Sagar Jamle (2018)

   The culvert was submitted to various situations using Staad Pro software, and the results were presented in the form of graphs and tables, showing the reduction in displacement and bending moment. As a result of applying software, the bending moment was discovered, and displacements were reduced to the smallest percentage value possible. A favourable response is received when the flared part structure is changed. The stress value increases in the flared portion, but shear values decrease as the flared portion is increased. Principle stressors have decreased, and structural modification has received a favourable response. As a result, the study presents the graph and their variations in values as a function of stress, utilising the flared section as the stress value.

4. M.G. Kalyanshetti and S.A. Gosavi (2014)

   The study is carried out using the stiffness matrix approach, and the cost evaluation is carried out using a computer programme written in C. A study of bending moment variation is carried out, followed by a cost comparison for various aspect ratios. Based on ideal thicknesses, the percentage reduction in cost of single cell, double cell, and triple cell is shown. The optimum thicknesses described here are used to construct a cost-effective box culvert design. The ideal cost per metre width of single cell, double cell, and triple cell is calculated using these optimum thicknesses. When the optimum thicknesses described in this study are taken into account, the cost of a box culvert is reduced.

3. METHODOLOGY AND PROBLEM SOLVING APPROACH STEPS

a. Modelling of 2-D line box model in Staad Pro software with required end conditions as per the design requirement.
b. Application of loading with IRC live loading, earth pressure, impact factor and longitudinal force over it.
c. Calculation of difference load cases as per IRC 6 and generation of critical load in shaer and moment.
d. With critical load design of different elements of box culvert for depth and reinforcement.

e. Compare of the results for top slab monolithically casted with wall and separately casted on maximum moment, shear and deflection.

f. Compare the results with manual calculation for design of elements with moment distribution method.

4. DISCUSSION

Different types of loading circumstances have an impact on the above literature study and box culvert design. The depth of the cushion, the impact load, the braking forces, the coefficient of earth pressure, and the angle of load dispersion owing to the live load are all significant aspects to consider. Different pressure scenarios and their variations are investigated in box culverts. The highest bending moment is seen in the dynamic load condition. The Indian Standard Codes IS-456-2000, Indian Road Congress, IRC 6-2000, IRC 112-2020, and RC 122-2017 can be used to analyse and build a box. Variations in shear force, bending moment, impact load, braking force, and other factors will be examined.

5. CONCLUSION

The structure of a box bridge is exceptionally robust, rigid, and safe. The base of a box bridge does not need to be intricate, and it can be simply erected over a soft foundation by increasing the base slab projection to keep the base pressure within the ground soil's safe bearing capacity. Box Bridges are simple to build and require little upkeep. It can contain multiple cells to meet discharge within a lower embankment height. The designer can choose the number of cells with the desired span-to-depth ratio based on the site's hydraulic characteristics.

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