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A Review Paper on Analysis and Design of Box Culvert using staad pro

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ABSTRACT

Box culverts are very important part of a transportation network as they provide a cost-effective alternate to substantial bridges. A culvert is a structure that allows water to flow under a road ways, railways, or similar obstruction from one side to the other side. A culvert may be made from a pipe, reinforced concrete or other material. Culverts are commonly used both as cross drains for channel release and to pass water under a road at natural drainage and river crossings. A culvert may be a bridge like structure designed to allow vehicle or pedestrian traffic to cross over the watercourse while permitting suitable opening for the water. Culverts can be of different shapes such as arch, slab and box. These can be constructed with different material such as masonry (brick, stone etc.) or reinforced cement concrete. Since culvert pass through the earthen embankment, these are subjected to same traffic loads as the road carries and therefore, required to be designed for such loads. This Paper deals with box culverts made of RCC, without cushion. The size, invert level, layout etc. are decided by hydraulic considerations and site conditions. The scope of this Paper has been further restricted to the structural design of box. The structural design involves consideration of load cases (box empty, full, surcharge loads etc.) and factors like live load, effective width, braking force, dispersal of load through fill, impact factor, co-efficient of earth pressure etc. Relevant IRC Codes are required to be referred. The structural elements are required to be designed to withstand maximum bending moment and shear force. The Paper provides full discussions on the provisions in the Codes, considerations and justification of all the above aspects on design. Box Culverts are required to be provided under earth embankment for crossing of water course like streams, Nallas across the embankment as road embankment cannot be allowed to obstruct the natural water way. The culverts are also required to balance the flood water on both sides of earth embankment to reduce flood level on one side of road thereby decreasing the water head consequently reducing the flood menace. Culverts can be of different shapes such as arch, slab and box. These can be constructed with different material such as masonry (brick, stone etc) or reinforced cement concrete. Since culvert pass through the earthen embankment, these are subjected to same traffic loads as the road carries and therefore, required to be designed for such loads. The size, invert level, layout etc. are decided by hydraulic considerations and site conditions. The cushion depends on road profile at the culvert location. The structural design involves consideration of load cases (box empty, full, surcharge loads etc.) and factors like live load, effective width, braking force, dispersal of load through fill, impact factor, co-efficient of earth pressure etc. Relevant IRC Codes are required to be referred in the analysis and design of box culverts. The aim of this project is to analyse the box culvert using STAAD PRO software. The structural elements of box culvert are designed to withstand maximum bending moment and shear force. The results obtained from STAAD are almost similar to manual calculations.

Keywords: *Reinforced cement concrete box culvert, structural design, theoretical calculation, staad pro*

I. INTRODUCTION

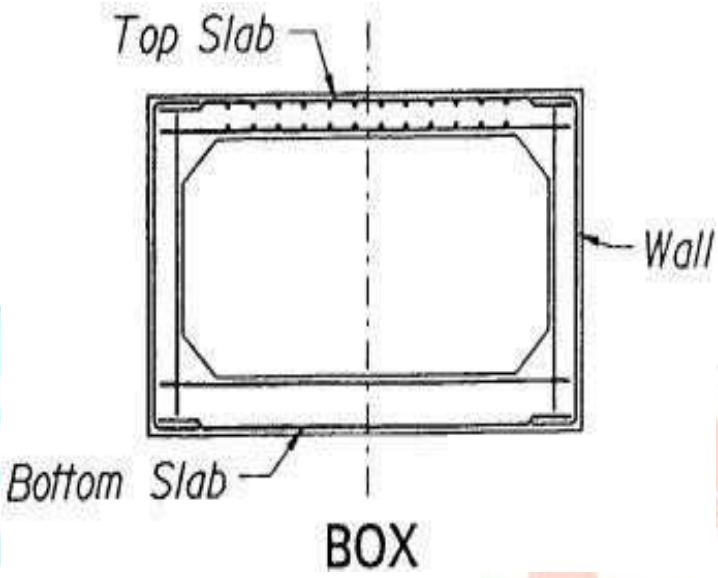
The box culvert are the structure constructed below highways and railways to provide acess to the natural drainage across them. The opening of culvert is determined based on the waterway required to pass the design flood whereas thickness is designed based on the loads applied. Culvert are provided to allow to traffic one side to other side. Culvert are also provided to balance the water level on both side of embankment during flood..

Box culvert has many advantages compared to slab culvert or arch culvert. The box is structurally strong, stable and safe and easy to construct. The main advantage is, it can be placed at any elevation within the embankment with varying cushion which is not possible for other type of culverts. A multi-cell box can cater for large discharge and can be accommodated within smaller height of embankment. It does not require separate elaborate foundation and can be placed on soft soil by providing suitable base slab projection to reduce base pressure within the safe bearing capacity of foundation soil. Bearings are not needed. It is convenient to extend the existing culvert in the event of widening of the carriageway at a later date as per future requirement, without any problem of design and/or construction. The culvert cover up to waterways of 6 m and can mainly be of two types, namely, box or slab. The box is one which has its top and bottom slabs monolithically connected to the vertical walls. In case of a slab culvert the top slab is supported over the vertical walls (abutments/ piers) but has no monolithic connection between them. A box culvert can have more than single cell and can be placed such that the top slab is almost at road level and there is no cushion.

Components of Box culvert:

The main parts of a box culvert are as below:

1) Leveling course
2) Bottom slab
3) Side walls
4) Top slab
5) Wing walls & apron



BOX CULVERT COMPONENTS

1.2 Advantages of Box Culverts

- ✓ Prevent Erosion
- ✓ Prevent Flooding
- ✓ Allow Water to Flow Unobstructed
- ✓ Divert Water for Farming/Engineering Purposes

1.3 Objective of the Project

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

1) To design and analyze box culvert using STAAD PRO software.
2) To design elements of the box culvert as per IS specifications.
3) Structural designing of RCC culvert considering various load cases including factor like effective live load, dead load,effective width and coefficient of earth pressure.
4) Saving time.
5) Saving money(alternate to bridge).

II LITERATURE REVIEW

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

Had study by using Staad Pro software the culvert are subjected to certain cases and providing the values in the form of graph and tables in which reduction in displacement and reduction in bending moment are shown. The result is by using software result came to know about bending moment and displacements are declined to minimum value taken in percentage. For flared portion structure change gets a positive response.

This paper analysis the stress value increases in the flared portion and shear values decreased on increment of flared portion. Principle stresses declined and give a positive response for structural change. The result is the paper gives the graph and their variations in values with respect to stress by using the flared portion the stress value are dropped for different cases.

2. Afzal Hamif Sharif (2016)

Had done study by using moment distribution method and Staad pro software. Compared them and check out all the structural elements for safety of bridge.

The results are the advantage of box culvert and their design critical and span length according by ratio of cell and number of cell.

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

The analysis is done by using stiffness matrix method and a computer program in C language is developed for the cost evaluation. Study is carried out related to variation in bending moment; subsequently cost comparison is made for different aspect ratios.

The percentage reduction in cost of single cell, double cell and triple cell based on optimum thicknesses are presented. The optimum thicknesses presented over here are used to achieve the economical design of box culvert. Based on these optimum thicknesses optimum cost per meter width of single cell, double cell and triple cell is evaluated. The study reveals that the cost of box culvert reduces if the optimum thicknesses which are presented in this study are considered.

4. Lande Abhijeet Chandrakant, Patil Vidya Malgonda (2014)

Analysed the box culvert by finite element method. In the paper they presented about the structural elements are required to be designed to withstand maximum bending moment and shear force. So excel program is developed for analysis and it is compared with software results. So analysis of box culvert is carried out for it for various box conditions and structural design is suggested for critical cases. In skew box culvert various angles are considered and analysis of box culvert is carried out for various conditions NehaKolate, Molly Mathew, Snehal Mali presented paper on analysis and design of RCC box culvert.

This paper deals with study of some of the design parameters of box culverts like angle of dispersion or effective width of live load, effect of earth pressure and depth of cushion provided on top slab of box culverts.

Depth of cushion, coefficient of earth pressure for lateral pressures on walls, width or angle of dispersion for live loads on box without cushion and with cushion for structural deformations are important items.

5.Sujata Shreedhar and R.Shreedhar (2013)

Presented the paper on Design coefficients for single and two cell box culverts. The box culvert has to be analyzed for moments, shear forces and thrusts developed due to the various loading conditions by any classical methods such as moment distribution method, slope deflection method etc. It becomes very tedious for the designer to arrive at design forces for various loading conditions. Hence a study is made to arrive at the coefficients for moments, shear forces and axial thrusts for different loading cases and for different ratios of length to height.

6. H. Chanson (2000)

Analyse the hydraulic design of culvert. The paper presents a new way to teach hydraulic design to civil and environmental engineering students in an undergraduate curriculum. The hydraulic design of a culvert is introduced as part of a complete design approach. The paper describes engineering design techniques in which individual originality and innovation is required.

III METHODOLOGY

1. Analysis and design by STAAD pro.

2. Analysis method adopted for RCC box is MDM (Moment Distribution Method).

3. 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).

IV RESULTS AND DISCUSSION

The above literature analysis and design of box culvert is under the influence of different kinds of loading conditions.It can be noted that effect of depth of cushion, impact load,braking forces, coefficient of earth pressure and the angle of load dispersion due live load are important factors. Box culverts are analyzed for different cases of pressure and their variations. It is seen that maximum bending moment occur for dynamic load case. The analysis and design of box can be done by using the Indian Standard Codes IS456-2000, Indian Road Congress, IRC 6-2000 & IRC 21-2000.The result will be analyzed by variations in shear force,bending moment, impact load, braking force etc.

V CONCLUSION

Box bridge is structurally very strong, rigid & safe. Box bridge does not need any elaborate foundation and can easily be placed over soft foundation by increasing base slab projection to retain base pressure within safe bearing capacity of ground soil. Box Bridge is easy to construct, practically no maintenance. It can have multi cell to match discharge within smaller height of embankment. The designer has option to select the number of cells with desired span to depth ratio suiting to hydraulic conditions at site.

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