Parametric Study on Single Cell Box Culvert Design Considerations-A Review

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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 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. They are normally cheaper than bridges, which make them the natural stream passes through channels. 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. Analysis of box culvert is done by stiffness matrix method. Box culvert is assumed as externally determinate assuming discrete boundary conditions. Single cell box structure is assumed as rigid frame structure consisting of top slab, bottom slab and two vertical side walls which forms a closed rigid box frame It is assumed that structure is externally determinate. In this work, the review of various authors and their views in the design and analysis of box culvert with software approach and comparison between software and manual approach has shown. The IS standard requirements in the design manual for roads and bridges (IRC-6-2000, IS 21-2000) is used in the structural designing of concrete box culverts. The Paper provides full discussions on the provisions in the Codes, considerations and justification of all the above aspects on design.**

Keywords: Box culvert, loading types, Single cell, IRC codes.

I. INTRODUCTION

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. 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. Box culverts are low rise bridge or structure which is used to discharge water in the proper channel in crossing of railway, flyover, roads etc. and is used where the bearing capacity of soil is low. Culverts are always economical than bridge where the discharge in the opening is 18 Cu.m. It depends on the number of cells which is generally used where roadway crosses the high embankment. RCC rigid frame box culvert with square or rectangular openings is used up to spans of 4m. The height of the vent generally does not exceed 3m. Box culverts are economical due to their rigidity and monolithic action and separate foundation are not required since the bottom slab resting directly on the soil, serves as raft slab. For small discharges, single celled box culvert is used and for large discharges, multicell box culverts can be employed. The barrel of the box culverts should be sufficient length to accommodate the carriageway and the kerb.

II. LITERATURE REVIEW

NEHA KOLATE, MOLLY MATHEW, SNEHAL MALI: studied the analysis and design of box bridge and they have found that Box culvert is easy to add length in the event of widening of the road and Box is structurally very strong, rigid & safe. Box 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.

DALGOBINDMAHTO & ANJANI KUMAR: described the details about the bridge construction technology. This paper also reviewed the existing various types of bridges with the history of worldwide bridges and their classification based on materials used in the performance.

Y. VINOD KUMAR AND Dr. CHAVA SRINIVAS: have presented a complete study of box culvert by using computational methods such as Grillage analysis and Finite element method. Grillage analysis is versatile in nature and can be applied to verify of bridge decks having both simple and complex configurations with ease and confidence. Grillage analysis has done by most commonly using software STAAD Pro. Their main objective was to know the behavior of box culvert and variation of stresses in terms of shear force and bending moment values.

SANDEEP KUMAR AHIRWAR, MOHD. AFAQUE KHAN, ABHISHEK KUMAR: tried to explain the various methods to understand the behavior of Box Girder Bridges. The study states that, the main beam of Box Girder Bridge is comprises of girders in the shape of hollow box which is economical and long-lasting solution as well. These are

widely constructed for medium and short spans. They are built to carry load in Shear and Flexural bending. Design and analysis of box-girder bridges are very complex because of its three-dimensional behavior which consists of torsion, distortion and bending in transverse and longitudinal directions. The need of this study is to understand the behavior of box girder bridges with the help of various analytical works.

A.D PATIL, A. A GALATAGE: had done analysis manually. The design and analysis factors of box were done with cushioning and without cushioning. The maximum bending moment in each and every loading were determined. The result is the load combination to be found very critical for all aspect ratio bending moments for different ratio or aspect is varying or constant for with and without cushion.

ABHIJEET AND VIDYA: had done analysis of box culvert using STAAD Pro software and found out B.M. and S.F. at support and mid span. They had presented analysis of a Reinforced concrete box culvert using finite element method. Three-dimensional configuration of the space has been considered and computer code has been developed for finding the bending moments, member forces and support reactions due to equivalent traffic load, lateral soil pressures.

M.G. KALYANSHETTI AND S.A. GOSAVI: prepared model of single, double, triple cell box culvert in STAAD Pro and developed C language program which gave the quantity of steel and total cost of culvert. IRC class AA tracked live loads were considered. The analysis was done by using stiffness matrix method and a computer program in C language was developed for the cost evaluation. Variation in bending moment; subsequently cost comparison was made for different aspect ratios. 12m was fixed as channel length and 2 to 6m height variation was considered. They concluded that for different cells and different heights the optimized thickness of box culverts was to be obtained by the different formulas which will a cost-effective design of the box.

AJAY R. POLRA, PRO. P. CHANDRESHA, DR. K.B Parikh: had done the analysis and comparison by using design consideration in mind of box coefficient of earth pressure, cushion, width or angle of dispersion and load case for design. The result is without cushion or with cushion and angle of dispersion is zero there will be maximum live load greater stresses are created without cushion.

SUJATA AND R. SHREEDHAR: had carried out the work to evaluate the design coefficients for shear force, bending moment and normal thrust for single cell, two celled and three celled box culverts subject to various loading cases. The study showed that the maximum positive moment develops at the Centre of top and bottom slab for the condition that the sides of the culvert not carrying the live load and the culvert is running full of water and the maximum negative moments develop at the support sections of the bottom slab for the condition that the culvert is empty and the top slab carries the dead load and live load.

B.N. SINHA, R.P. SHARMA: This Paper deals with box culverts made of RCC, with and without cushion. 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 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.

III. INFERENCE

From the above literature it can be conclude that size of box culvert has to be adopted based on hydraulic conditions. Culverts have to be analysed for critical load combinations and designed for maximum shear force and bending moment. IRC standards and IS Codes have to be followed for the analysis and Design of Box culvert.

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