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ANALYSIS & DESIGN OF MULTISTOREY BUILDING G+4

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ABSTRACT

Bridges 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. Bridges 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. These can be constructed with different material such as masonry (brick, stone etc) or reinforced cement concrete. Since bridge 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. Culverts are required to be provided under earth embankment for crossing of water course like streams,. This Paper deals with box culverts made of RCC, with andwithout 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, coefficient 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. Proper design covering these aspects has also been given in the Annexure. To our knowledge, these matters have neither been covered in any text book nor in any special publication at one place. This project deals with box minor bridges made of RCC. The size, invert level, layout etc. are decided by hydraulic considerations and site conditions. The cushion depends on road profile at the bridge 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 referred. The structural elements are designed to withstand maximum bending moment and shear force.

Key words: Minor Bridge, RCC Box Culvert, Single & Double Cell box Culvert, IRC Codes

I. INTRODUCTION

It is well known that roads are generally constructed in embankment which comes in the way of natural flow of storm water (from existing drainage channels). As, such flow cannot be obstructed and some kind of cross drainage works are required to be provided to allow water to pass across the embankment. The structures to accomplish such flow across the road are called culverts, small and major bridges depending on their span which in turn depends on the discharge. The culvert cover upto waterways of 6 m (IRC:5-19981) 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

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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.

A box can also be placed within the embankment where top slab is few meters below the road surface and such boxes are termed with cushion. The size of box and the invert level depend on the hydraulic requirements governed by hydraulic designs. The height of cushion is governed by the road profile at the location of the culvert.

II. NEED FOR RESEARCH

This Paper is devoted to box culverts constructed in reinforced concrete having one, two or three cells and varying cushion including no cushion. The main emphasis is on the methodology of design which naturally covers the type of loading as per relevant IRC Codes and their combination to produce the worst effect for a safe structure. The IS: 1893-1984[2] (Clause 6.1.3) provide that box culverts need not be designed for earthquake forces, hence no earthquake forces are considered. Although box of maximum three cells has been discussed but in practice a box culvert can have more cells depending on the requirements at site.

Culverts are provided to allow water to pass through the embankment and follow natural course of flow but these are also provided to balance the water level on both sides of embankment during floods, such culverts are termed as balancers (IRC:78-2000[3]), although there is no
difference in the design.

Fig. 1: Double cell Box Culvert acting as a Minor Bridge

Sometimes the road alignment may cross a stream at an angle other than right angle, in such situation a skew culvert may be provided. For a smaller span there would be no difference in the design of culvert but it may require an edge beam and the layout of wing walls will have to be planned as per skew angle. For a box culvert, the top slab is required to withstand dead loads, live loads from moving traffic, earth pressure on sidewalls, water pressure from inside, and pressure on the bottom slab besides self-weight of the slab. 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.

III. CO-EFFICIENT OF EARTH PRESSURE

The earth can exert pressure, minimum as active and maximum as passive, or in between called pressure at rest. It depends on the condition obtained at site (Terzaghi4 and Gulati5). For example in case of a retaining wall where the wall is free to yield and can move away from the earth fill the pressure exerted by the earth shall tend to reach active state and thus be minimum

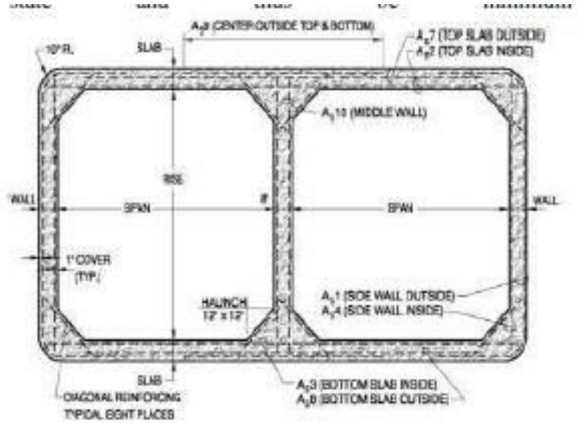

Fig. 2: Double cell Box Culvert Middle Cross Section

IV. IMPACT OF LIVE LOAD

Moving loads create impact when these move over the deck slab (top slab). The impact depends on the class and type of load. The IRC:6-2000 Code gives formula to obtain impact factor for different kind of loads by which the live load is to be increased to account for impact. The box without cushion where the top slab will be subjected to impact is required to be designed for live loads including such impact loads. Any such impact is not supposed to act on box with cushion. Hence no such impact factor shall be considered for box with cushion. The impact by its very nature is not supposed to act at lower depth and no impact is considered for the bottom slab of the box. It does not affect the vertical walls of the box and not considered in the design.

V. DESIGN OF TYPICAL BOX

Based on the above discussions and clarifications design of a typical box covering all above mentioned points are presented as Annexure. The box of 3 m x 3 m without cushion and with 5 m cushion has been given. Various load cases have been given for the maximum design moments. The box has also been checked in shear and shear reinforcement provided as required. The relevant parameters are mentioned in the design. It is seen that they compare well. The design of box can, therefore, be carried out by STAAD. Pro as well. Input data sheet, bending moment diagram and shear force diagram as obtained by STAAD. Pro are given in the Paper at Annex C. The analysis part to get these design moment and shear values for relevant members which runs in number of pages, is not given in the Paper as it will add to the length without serving much purpose. The STAAD. Pro is well known computer software commonly used.

A. General Codes

The design of various components of the bridge, in general are based on provisions of IRC/IS Codes. Wherever IRC code is silent, reference is made to other Indian/International codes and standards. The list of IRC Codes (latest revisions) given below will serve as a guide for the design of structures.

 IRC: 5-1998 Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design.

 IRC: 6-2000 Standard Specifications and Code of Practice for Road Bridges, Section-II – Loads and Stresses.

 IRC: 21-2011 Standard Specifications and Code of Practice for Road Bridges B. Design of Elements

 The live load intensities obtained are applied on the top slab and analysed to obtain the forces at various required locations in top slab and side walls.

 Combination factors according to IRC:6-2010 Annexure B Table 3.2 are multiplied to the forces to obtain the design forces.

 The maximum & minimum base pressures are applied onto the bottom slab and analysed to obtain the forces and these forces are multiplied with the combination factors to obtain the design forces.

 For the serviceability limit state, rare combination is adopted to check the stresses in various components and Quasi-permanent combinations to check cracking

VI. CONCLUSIONS

1) Box for cross drainage works across high embankments has many advantages compared to a slab culvert.
2) It is easy to add length in the event of widening of the road.
3) Box is structurally very strong, rigid and safe.
4) 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.
5) Box of required size can be placed within the embankment at any elevation by varying cushion. This is not possible in case of slab culvert.
6) Right box can be used for flow of water in skew direction by increasing length or providing edge beam around the box and it is not necessary to design skew box.
7) Easy to construct, practically no maintenance, can have multi-cell to match discharge within smaller height of embankment.
8) Small variation in co-efficient of earth pressure has little influence on the design of box particularly without cushion.
10) For culverts without cushion (or little cushion) taking effective width as per provision in IRC:21-2000 corresponding to α for continuous slab shall not be correct. It is likely to provide design moments and shear on lower side hence not safe.
11) For box without cushion braking force is required to be considered particularly for smaller span culverts. Further for distribution of braking force effects the same effective width as applicable for vertical application of live load shall be considered. If braking force is not considered or distributed over the whole length of box (not restricted within the effective width) the design shall be unsafe.
12) It may be seen that α affects effective width, mainly applicable for the top slab (particularly for box without cushion) and braking force. As regards bottom slab and top and bottom slabs of box with cushion due to dispersal of loads either through walls or through fills effective width loses its applicability.
13) The design of box is covered by three load cases dealt in this paper. The forth situation when whole box is submerged under water, provide design moments etc less than given by the three load cases hence need not be considered.
14) The design of box with cushion done by STAAD. Pro computer software compares very close to manual design.

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