Comparative Cost Evaluation of RCC Box and Solid Slab

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Abstract— This study involves Cost evaluation of two Bridge forms RCC Box and Solid slab. A range in which these culverts are usually used. The bridge forms are designed in prepared Excel sheet and thereafter analyzed in STAAD.Pro and this process is repeated for all the span length considered in the comparison. The detailed cost estimation of all these structures have been prepared and presented and thus suitability of the better bridge type have been scrutinized on the ground of economy.

Key words: Solid Slab, RCC Box

I. INTRODUCTION

A. *Reinforced Concrete Box*

Reinforced concrete box, either precast or cast-in-place, are primarily used for a road or a railway bridge crossing with high embankments crossing a stream with a limited flow. As shown in the figure 1. Box culverts consisting of two horizontal and two vertical slabs built monolithically are economical due to their rigidity and monolithic action and separate foundations 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, multi-cell box culverts can be employed. The barrel of the box culverts should be sufficient length to accommodate the carriageway and the kerb. 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.

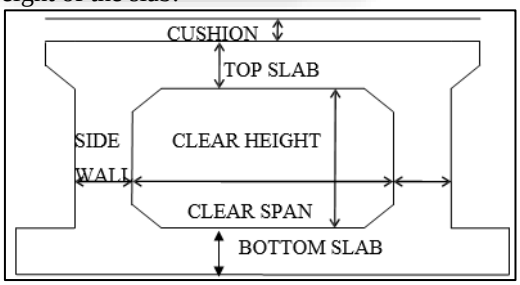

Fig. 1: Typical view of RCC BOX structure

B. *Solid slab bridges*

This is the simplest type of bridge deck slab used for short span bridges. Solid slab bridges are efficient in distributing the concentrated loads. These are one way or two way spanning slabs. Mostly solid slab bridge is simply supported. The solid slab cast-in-situ reinforced concrete structure and the same is resting on two abutments. It gives good results when the span of the bridge is less than 25 m. However, for the bridges having longer span, the dead weight becomes larger. The bridge deck slab can be constructed monolithic or non-monolithic with the abutment Non-monolithic section shows a lower resistance to deterioration due to leakage of drainage water and wear and tear in the expansion joints which affects the pier and sub-structure abruptly. Maintenance and repair cost is much higher as it is cumbersome to work on the sub-structure. Therefore, monolithic structures are commonly preferred for short and normal span bridges to avoid the problem of deterioration of sub-structure. Furthermore, integration of the bridge deck slab with the abutments reduces the sagging moments in the mid-span of the slab. A detailed drawing of the solid slab bridge has been shown below in plan and section which shows us the general arrangement of parts of bridge.

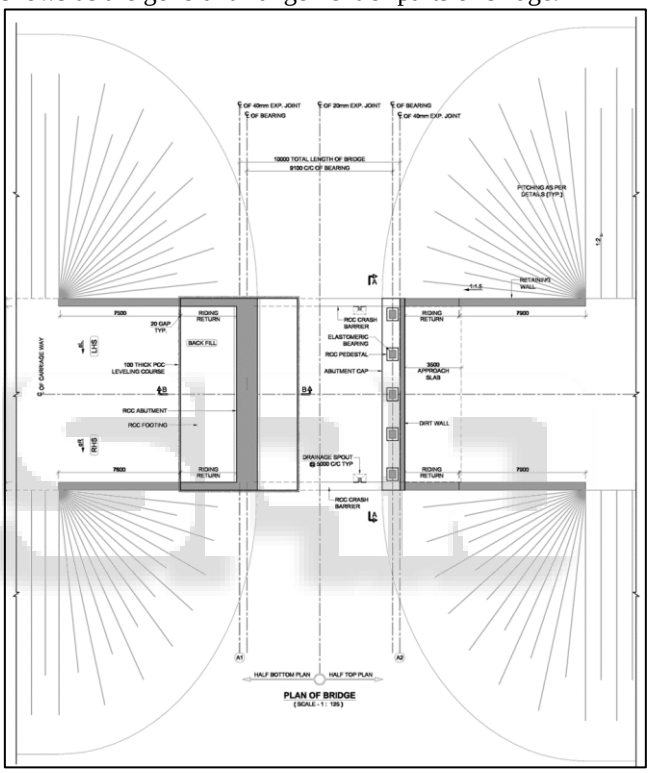

Fig. 2: Plan of slab culvert

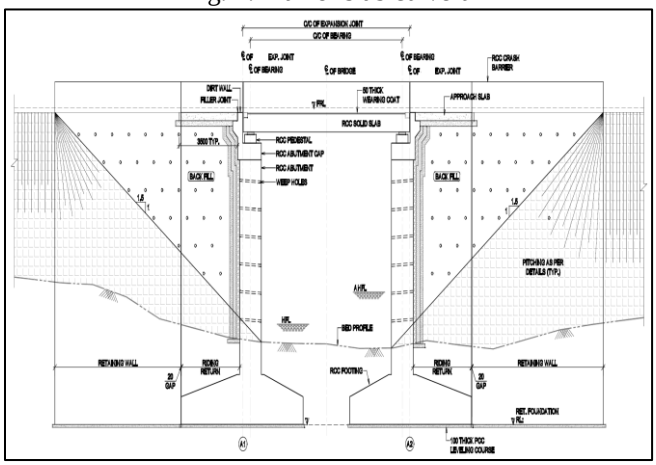

Fig. 3: Typical view of slab culvert

Different spans have been taken to analysis the two bridge forms for their suitability 5 meter, 7.5 meter, 10 meter & 12 meter. The Detailed design for RCC Box type Bridge and Solid slab type Bridge have been carried out.

II. CONCEPT OF BRIDGE DESIGN

Design standards and loading to be considered are generally based on the requirements laid down in the latest editions of IRC and IS Codes of practices & standards specifications, and guidelines of Ministry of Road Transport & Highways. Additional technical references has been used wherever the provisions of IRC/IS codes are found inadequate. All the bridge forms have been designed and after which analyzed on Staadpro. A simplified understanding of the design concept and a broader overview of all forms a stepwise approach has been described.

A. Geometry and specification

A suitable section is taken including slab thickness, Girder depth and other size and cross sections is initially considered. The clear cover as for all the reinforcement the clear covers to be adopted as per clause. 14.3.2.1 of IRC: 112-2011. Back fill properties Density and other such specification taken as per standards.

B. Material

Material used basically includes the Reinforcement and Concrete grade. HYSD (TMT) bar of Grade Fe-500 is used in all RCC components as reinforcing steel. grade of concrete in different elements are listed below

- RCC Solid Slab M30
- RCC Pedestal M35, M40
- RCC Approach Slab M30
- RCC Box M30
- PCC Leveling Course M15
- PCC Curtain wall M20
- PCC substructure & foundation M25
- RCC substructure & Open foundation M30, M35
- RCC Abutment cap/Pier cap M30, M35
- RCC Crash Barrier M40
- PCC Toe wall M20
- Retaining Wall M30

C. Loading

There are various loads acting on the structure and they have to be taken into account while designing, all such loads and stresses which have an impact on the structure are stated as codal provision to us in IRC 6-2014. The loads and stresses which are to be considered for design of Bridges are as follows:

- Dead Load
- Live Load
- Impact factor due to vehicular live load
- Vehicle Collision Load
- Wind Load
- Longitudinal forces due to braking
- Earth Pressure (including live load surcharge)
- Temperature Effect
- Seismic Forces

D. Design check

For stability and safety of structure the checks have to applied i.e.., Check for Moment capacity, Check for stresses, Check for crack width, Deflection check, Distribution reinforcement, Check for Reinforcement percentage. For a section failing in any of the stated check either extra reinforcement has been provided else the section i.e... The slab thickness have to be revised.

E. Staad pro analysis

The structure designed is then been analyzed in the software (Staadpro) for its structural behavior and to check failed members if any. On the basis of these the design the drawing are pre-paired and further the cost estimation has been done.

III. COST ANALYSIS

In the cost analysis part of the study we work out the detailed cost analysis of both bridge forms for span lengths taken into considerations to come to a conclusion as of which bridge forum would be most economically efficient for the span ranges. The following considerations have been taken into account for the estimation purpose:

- The Dimensions are taken in meter and millimetre for the structures.
- The quantities of the Structures have been worked out.
- The rates have been taken in accordance with Government of Madhya Pradesh Public Works Department Sor for Road & Bridge work (2016).
- The product of quantities and rates gives us the cost estimation.
- All other specification and details like SBC, Seismic zone, wind considerations etc. have been taken same for both the bridge forms which are compared so as to compare the quantity and therefore the final cost for the both bridge forms.
- The Concrete grade and steel grade have been mentioned in the format for each bridge forum and have been taken as per specifications of codal provision and that used in the construction practices.

IV. RESULT & INFERENCES

As per the cost analysis which has been represented in the Graph –I it is very clear that the Box culvert are more economical than the other Bridge form upto the span length of nearly 8 to 9meters. After this span length the Solid slab type structure is found to be cheaper than Box type upto 15 meters. There are also other advantages of Box culvert structurally found to be better than Solid slab type like the Raft foundation which is to be used in the Box type bridges gives it more stability and allows it to be used in the soils with even worse bearing capacity. Moreover the structure is easy to be constructed as the same is casted monolithically and lesser amount of formwork is required.

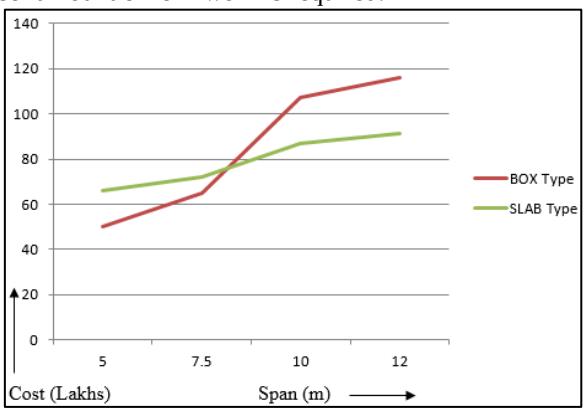

Fig. 4: Graph–I

SPAN(in m)	5	7.5	10	12
Cost of BOX Type	50	65	107	116
Cost of SLAB Type	66	72	87	91

Table 1: Results

V. CONCLUSIONS

Hence for the span range upto 9 meter RCC Box Type bridges should be implemented after which the Solid slab should be the preference for the span range upto 15m.

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