RCC Box Culvert – Design and Analysis by STAAD Pro

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Abstract – 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. This work 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 work has been further restricted to the structural design of box.

Keywords: Shear stress, Cushion, Box Culvert

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I. INTRODUCTION

Culverts are the structures constructed below highways and railways to provide access to the natural drainage across them. They are also constructed sometimes to provide the access to the animals across the road. The opening of the culvert is determined based on the waterway required to pass the design flood, whereas the thickness of the culvert section is designed based on the loads applied on the culvert. Culverts and bridges often serve the same purpose; however, they differ on the size of the structure.

It is monolithic structure having parts are top slab, bottom slab and vertical walls and wing walls. Culverts are provided to allow water to pass through the embankment and follow natural course of flow and road passes and culverts are also provided to balance the water level on both sides of embankment during floods, such culverts are termed as balancers.

II. NECESSITY OF WORK

A few things like coefficient of earth pressure for lateral pressure on walls, effective width (run of culvert) for live loads and applicability of braking force on box without cushion (or little cushion) for structural deformation are important items where need to be dealt in much detail. These affect the design significantly and therefore, required to be assessed correctly for designing a safe structure. It is customary to consider box a rigid frame and unit length of box is taken for design by considering the effect of all forces acting on this unit length (generally 1.0 m of box), Since very few literature is available for design of box culvert It is necessarty to study the design of Box culvert.

III. METHODOLOGY

Analysis of box culvert –

1) Considering traffic load using IRC codes.

2) Earth pressure on walls.

3) Base pressure on base slab.

By considering all loads, FEM method is used for analysis. This FEM analysis is validated by manual analysis.

Design of box culvert –

Design of box culvert using results from analysis (FEM).

FORCES TO BE CONSIDERED:

To analyze the box culvert it is very necessary to apply proper forces with different load combinations on Box culvert. In addition of Dead Load, Temperature and Shrinkage load, following loads are to be considered in Analysis.

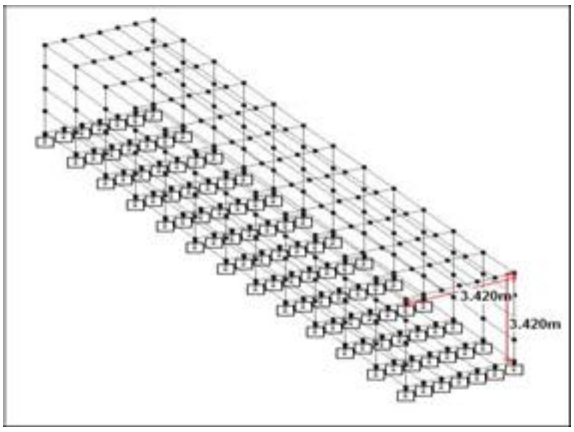
a) Earth Pressure

b) Braking Force

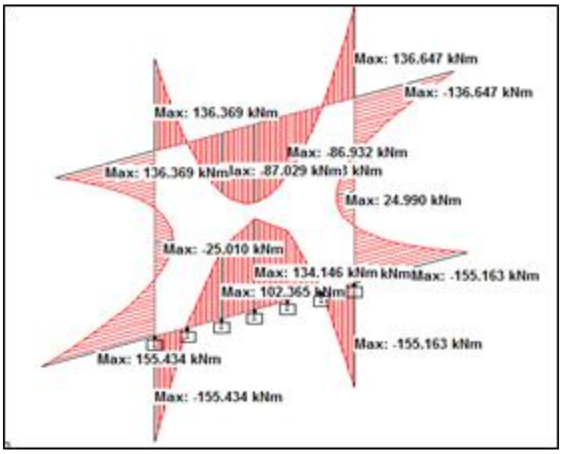
c) Impact Live Load

d) Shear Stress

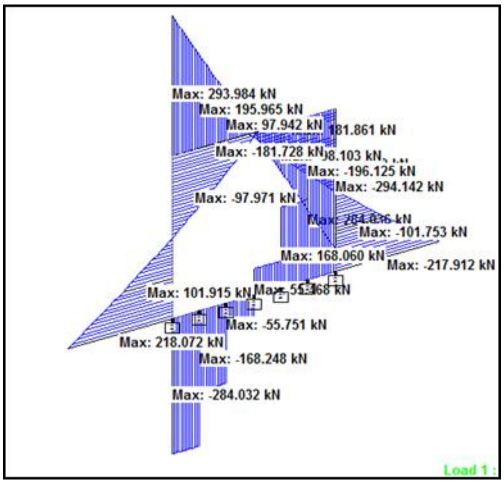
IV. STAAD MODLE AND B.M. AND S.F. DIAGRAM



STAAD MODLE



BENDING MOMENT DIAGRAM



SHEAR FORCE DIAGRAM

V. RESULTS AND DISCUSSION

Results of B.M. for STAAD pro and manual calculation for with cushion

Sr. No	B.M. AT	STAAD pro	Manual Calculations
1	Corners of top slab	83.05 KNm	83.0 KNm
2	Corners of bottom slab	94.66 KNm	96.0 KNm
3	Midpoint of top slab	69.99 KNm	70.0 KNm
4	Midpoint of bottom slab	81.70 KNm	80.0 KNm
5	Midpoint of side slab	15.22 KNm	15.0 KNm

From above table we can say that results obtained from analysis of box culvert in STAAD Pro are almost same as results obtained from manual analysis.

Results of reinforcement required for with and without cushion for top slab

Sr. No	Reinforcement required for	Cushion	Without cushion
1	Top Slab	1271.07 mm^2	1848.6 mm^2
2	Bottom Slab	1579.4 mm^2	1304.9 mm^2

For Top Slab -

Reinforcement requirement for top slab in without cushion case is greater than reinforcement requirement of top slab of With cushion case i.e.

1848.6/1271.07 =1.45.That means top slab required 45% more steel for with cushion case.

For Bottom Slab –

Reinforcement requirement for bottom slab in without cushion case is less than reinforcement requirement of bottom slab of With cushion case i.e. 1304.9/1579.4= .83.That means bottom slab require 17 % lass steel for cushion case.

VI. CONCLUSIONS

1) Results obtained from analysis of box culvert in STAAD Pro are almost same as results obtained from manual analysis.

2) 3D modeling of Box culvert with beam element in STAAD Pro proves a good option for analysis.

3) For Without cushion case, braking force causes considerable moments. Hence It is very necessary to consider braking force separately in the analysis

4) For Without cushion case, vehicle load is directly coming on top slab, hence Reinforcement requirement for top slab is greater than reinforcement requirement of top slab of with cushion case.

5) For With cushion case, earth fill load on box culvert causes more downward pressure. Which is transferred to the base slab, Hence Base slab requires more bending reinforcement than reinforcement required for without cushion case

6) Thickness of members assumed initially proves that thinner member can be used in short span box culvert. Hence it is economical.

VII. REFERANCES

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