Analysis and Design of Single Vent Box Curvet for different Loading condition

by Using STAAD Pro Software

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*Abstract*— To balance the flood water on both sides of a highway or railway embankment, box culverts are the ideal monolithic structure. This paper presents a comprehensive examination of box culverts using the manual approach. Live load surcharge, dead load, impact load, longitudinal force/braking force, soil pressure on the side walls, utilizing computational techniques like the Staad pro analysis method, the Limit state approach of IRC class AA loading and box culvert design should take into account both internal and external water pressure. The structure under consideration in this research experiences stresses such as bending moments and shear forces. These stresses were calculated using computational methods and were compared.

***Index Terms*—Bending Moment (BM), Shear forces (SF), Area of reinforcement (AST)**

**1. INTRODUCTION**

The need for a bridge is felt by people and it is communicated to Government through Public representatives or the importance of bridge is felt by Govt. due to the increased traffic demand that may be due to various reasons viz. important road, tourist place, pilgrimage center, industries, etc. The government thus decides to construct a bridge at a particular location. Road Project Division is required to carry out a survey for the bridge location and collect the requisite preliminary survey data that is required for bridge planning and design. 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 (IRC: 5-2016) 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 [1, 3&6].\

2. **ANALYSIS AND DESIGN OF BOX CULVERT**:- Design of a box culvert must take into account a variety of loads, including Dead load, Live load, Impact load, Longitudinal force/braking force, Soil pressure on the side walls, Surcharge due to Living load, and Water pressure from both inside and outside. Design must be completed using the Limit State Method of IRC Class AA Loading [13&14] and analysis by STAAD Pro Software, with the results of both being finalized. The Indian Road Congress Standards are used as a basis for computing design parameters. In this essay, we also examine the box culvert design and compare various reinforcement features. The culvert's vent size is fixed in accordance with the flood discharge from an upstream side. The box culvert's open size is 3m by 3m. The slab is 300 millimetres thick. M35 is the concrete grade, Fe415 is the steel grade, and 300 is the angle of repose.

* 1. **Different Analysis conditions for box culvert:-**A single box culvert is designed by thinking of it as a sturdy frame. The moment distribution method is typically used to calculate final moments at the frame's joints. Critical loading conditions are examined in the culvert. The following three loading conditions are regarded as critical:

**Case 1.** Live load, dead load, and earth pressure are present and no water pressure from the inside (no flow in the drain).

**Case 2**. Live load, dead load, and earth pressure acting from outside and water pressure from inside.

**Case 3.** Live load and dead load act on the top slab and water pressure acts from inside and no lateral pressure due to living load.

1. **ANALYSIS AND DESIGN OF BOX CULVERT** 
   1. **MANUAL DESIGN CONSIDERATIONS:** *- The* loads considered for the analysis of box culverts are Dead load, Live load, Soil pressure on side walls, Surcharge due to living load, and Water pressure from inside, Design BM and SF for top, Bottom slab, and Sidewalls. In a study, we have to consider IRC class AA loading and Use the limit state method of design is conforming to IRC 112-2011.
   2. **SOFTWARE DESIGN: -** The greatest bending and thus the Box Culvert's overall economics depend on the longitudinal girders' optimal spacing. With the advent of computers, many of these issues have been readily resolved by adopting pertinent software. Manual analysis of various Box Culverts with various longitudinal girder spacing is a time-consuming operation that also encourages human mistake. The same data was used to redesign the Box Culvert in STAAD Pro, and the outcomes are compared. The box culvert modelling process is as follows:

**Step 1**: Idealization of slabs into equivalent grillage

**Step 2**: Assigning Properties

**Step 3**: Assigning Subgrade modulus for elastic Mat

**Step 4**: Assigning Loads on Grillage beams

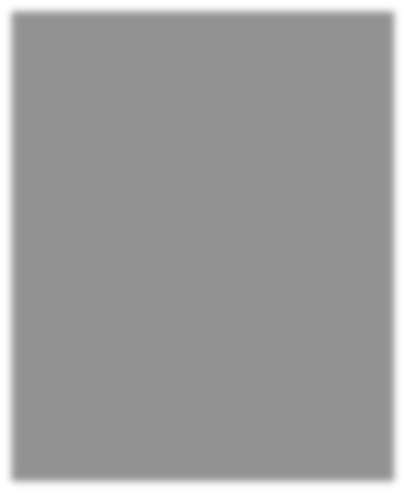
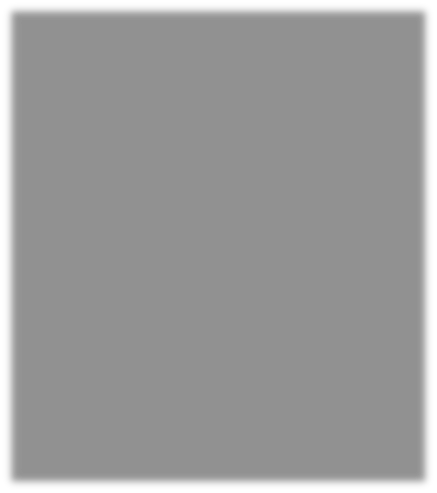
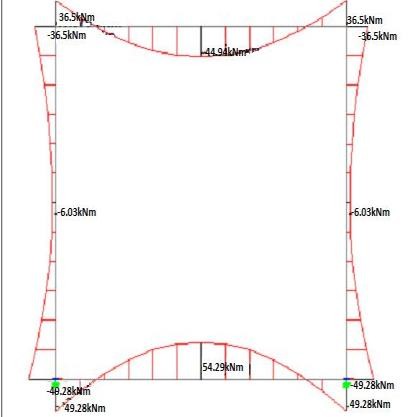
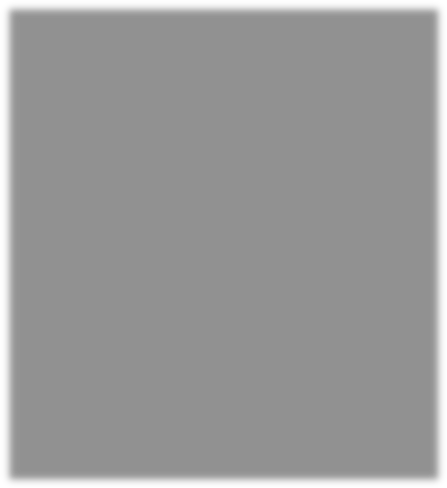
**Step 5:** Results of Bending Moment and Shear forces

**3.3 Comparison between Manual and Software Method: -** Now that both techniques are used regularly in civil engineering work, we choose which to use depending on factors like cost, strength, and time to finish the assignment. These are the main criteria we use to decide which method to use when designing or analyzing a beam. Therefore, a basic understanding of manual computation is needed, and software must be chosen for design and analysis reasons. In the present era, software is the most useful instrument for creating and analysing.In terms of economy, the structure is more economical if we choose the software for analysis and designate amount of interest provided by the software is much more compared to the manual.he time it takes to design many beams and many columns or other structure component can be done within minutes while it takes huge time for a manual to design the whole structure.

**4.0 RESULTS AND DISCUSSION**: - For researchers in this subject, study and design of RCC box culverts have been approached using a variety of methodologies. The quantities and form of the bending moment and shear force diagrams are identical when comparing this condensed method to the earlier methods. Installing the spacing between the springs involves trial and error until a logical space is found. In particular for inverted members, closer spacing results in output values that are more precise. Joint displacement, support reactions, bending moment, and shear force [2, 4&5] diagrams are symmetrical because to the symmetry of section characteristics and stresses applied to the culvert barrel. The outcomes of the following case studies using the manual approach and software method are contrasted in the form of tables I, II, and III, respectively.

Table I: Compression of Bending Moment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Load Case** | **Bending Moment (kN-m)** | | | | | |
| **Top Slab** | | **Bottom Slab** | | **Side Wall** | |
|  | Manual | Staad Pro | Manual | Staad Pro | Manual | Staad Pro |
| 1 | 43.93 | 44.94 | 53.25 | 54.29 | 5.726 | -6.03 |
| 2 | 50.54 | 51.56 | 61.32 | 62.5 | 20.40 | -20.88 |
| 3 | 56.31 | 57.34 | 67.1 | 68.4 | 31.96 | 32.63 |



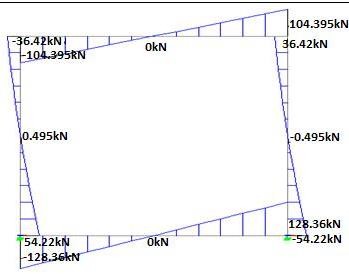
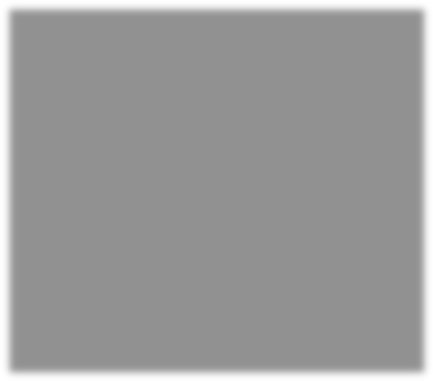
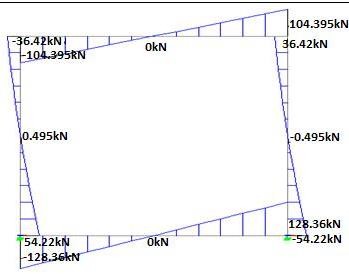
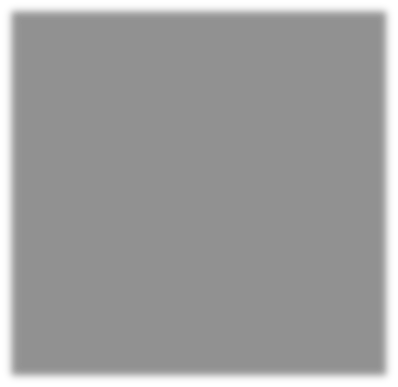
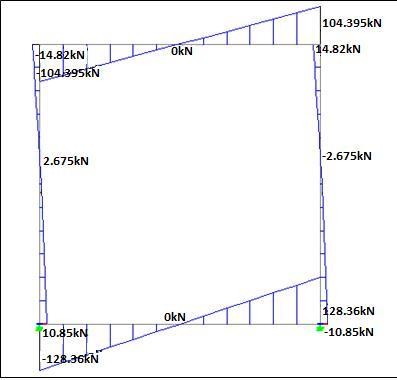
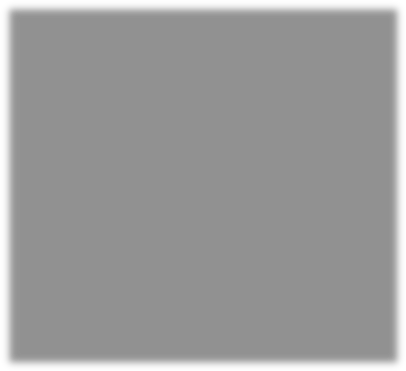
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| --- | --- | --- | --- |
|  |  |  |  |

**Graph 1:- Different Bending Moment Case 1,2&3**

Discussion: - The above graph shows the bending moment for different Cases compared with manual and Staad pro results of top slab, bottom slab, and side wall the maximum bending moment will be acting in Case 3.The study shows that the maximum positive moment develops at the center of the 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 which is case 1 condition. 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 [2, 4&5].

Table II: Compression of Shear Force

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Load Case** | **Shear Force (kN)** | | | |
| **Top Slab** | | **Bottom Slab** | |
|  | **Manual** | **Staad Pro** | **Manual** | **Staad Pro** |
| 01 | 36.24 | 36.42 | 53.86 | 54.22 |
| 2 | 14.71 | 14.82 | 10.71 | -10.75 |
| 3 | 21.17 | -21.34 | 31.73 | 32.02 |

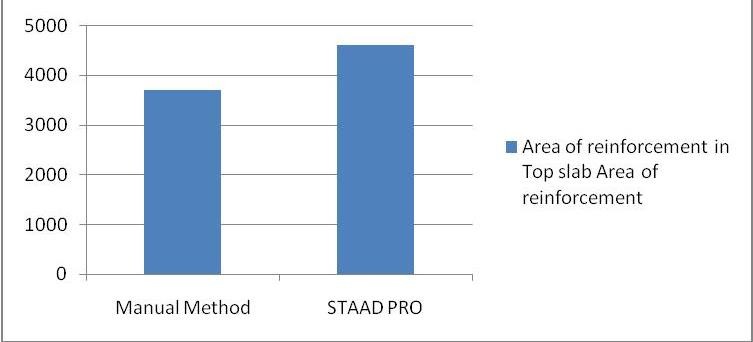
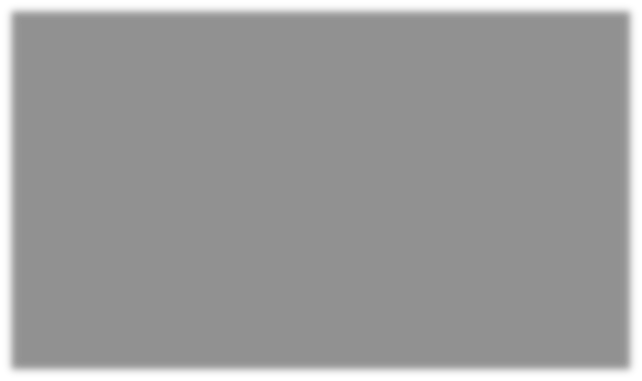
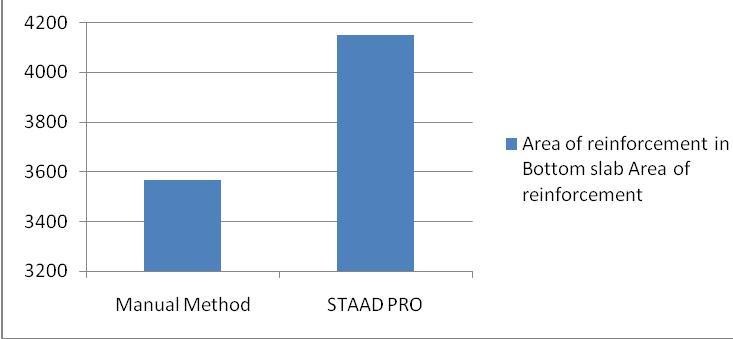
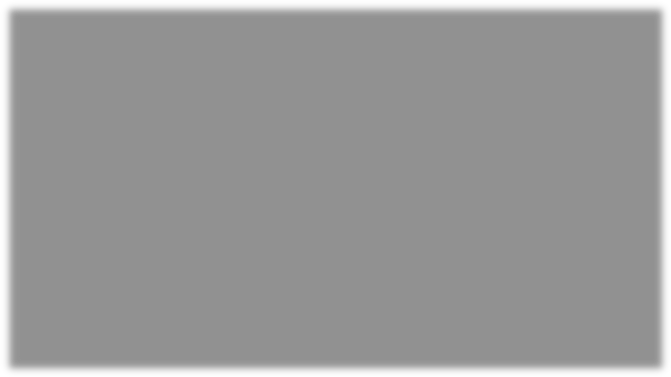


GRAPH 2: DIFFERENT SHEAR FORCE DIAGRAMS FOR CASE1, 2&3

**Discussion: -** The above graphs and table shows that the Shear force for different Case compared with manual and Staad pro results of top slab and bottom slab the maximum bending moment will be activated at Case The maximum shear forces develop at the corners of the top and bottom slab when the culvert is running full and the top slab carries the dead and live load [2, 4&5].

Table III: Compression Area of Reinforcement

|  |  |  |
| --- | --- | --- |
| **Method of Analysis** | **Area of Reinforcement** | |
| **Top Slab** | **Bottom Slab** |
| Manual | 3703.00 | 3565.00 |
| Staad Pro | 4608.00 | 4148.00 |



3

Graph III:- Reinforcement details for Top and bottom Slab

**Discussion: -** From, Table III, it has been seen that area of reinforcement for the top slab of the Ast is maximum for staad pro. Compare to the manual method and bottom slab the as also increased in the software method compare to the conventional method, [2, 4&5].

1. **CONCLUSION**

The main objective of the study was to identify manual and computerized methods for box culvert analysis and design. Three load cases are used to cover the box culvert design. The design moments, shear forces, and other values are slightly higher than (or almost the same as) the values provided by hand calculations for the three load situations. The analysis demonstrates that when the culvert is operating at full capacity and when uniform lateral pressure caused by a superimposed dead load operates alone, the maximum positive moment moments arise at the centre of the top and bottom slab, whereas the largest negative moment moments develop at the centre of the vertical wall. The study demonstrates that multi-celled box culverts are more cost-effective for longer spans than single-celled box culverts because they require thinner sections and have lower maximum bending moment and shear force values.

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