Analysis and Design of Single Vent Box Curvet for different Loading condition by Using STAAD Pro Software

Naveen Kumar S M 1, Dr Amarnath Shetty ,Manu Vijay 3 , Shashank P4and Sagar

1Adichunchanagiri Institute of Technology, Chikkamagalur, VTU, Chikkamgalur, India

2 AJIET, Department of Civil engineering VTU, Mangalore, India

3 ATME College of Engineering, Department of Civil engineering VTU, Mysuru, India 4ATME College of Engineering, Department of Civil engineering VTU, Mysuru, India 5JNNCE College of Engineering, Department of Civil engineering VTU, Shivamogga , India

Email: [smnaveen75@gmail.com.](mailto:smnaveen75@gmail.com. ) [amarnathshetty2003@gmail.com,](mailto:amarnathshetty2003@gmail.com) [hlmanuvijay@gmail.com ,](mailto:hlmanuvijay@gmail.com) [Shashank.psha@gmail.com](mailto:Shashank.psha@gmail.com) and [sagarhalappa@jnnce.ac.in](mailto:sagarhalappa@jnnce.ac.in)

*Abstract*— Box culverts are the optimum monolithic construction to balance the flood water on both sides of a highway or railway embankment. This paper presents a comprehensive examination of box culverts using the manual approach. Live load surcharge, dead load, soil pressure on the side walls, longitudinal force/braking force, impact load 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)**

# 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 designWhen compared to slab or arch culverts, box culvert offers many benefits. The structure of the box is sturdy, stable, safe, and simple to assemble. The key benefit is that, unlike other types of culverts, it may be positioned at any

elevation within the embankment with adjustable cushion. A multi-cell box may accommodate a big discharge and fit within an embankment with a reduced height. It can be erected on soft soil without the need for a separate elaborate foundation by projecting an appropriate base slab that will lower base pressure within the foundation soil's safe bearing capacity. No bearings are required. In the event that the roadway needs to be widened in the future, it is easy to expand the current culvert without encountering any design or construction issues. The culvert can be either a box or slab and can span up to 6 metres of waterways (IRC: 5-2016). The box is one whose top and bottom slabs are joined to the vertical walls in a single piece. Although the top slab in a slab culvert is supported over the vertical walls (abutments/piers), there is no monolithic link between them. The placement of a box culvert [1, 3&6] can be such that it has more than one cell and that the top slab is virtually level with the road.

1. **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.

2.1 **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: There is no water pressure from the inside (no flow in the drain), live load, dead load, and earth pressure are all present.

Case 2: Internal water pressure operating against external live load, dead load, ground

pressure, and other forces.

Case 3: There is no lateral pressure because of the live load, but there are dead and live loads acting on the top slab, and there is internal water pressure.

# 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 loadingand 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**: Idealizing slabs into comparable grilling

**Step 2**: Adding Properties

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

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

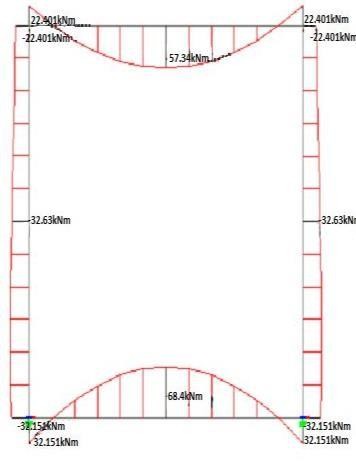
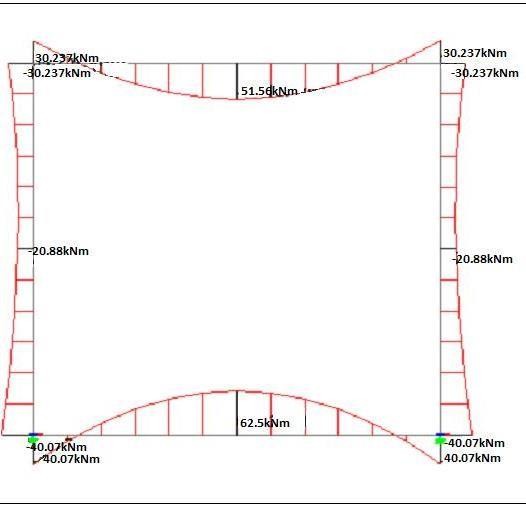
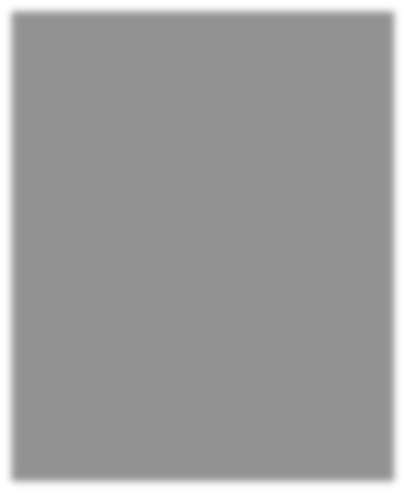
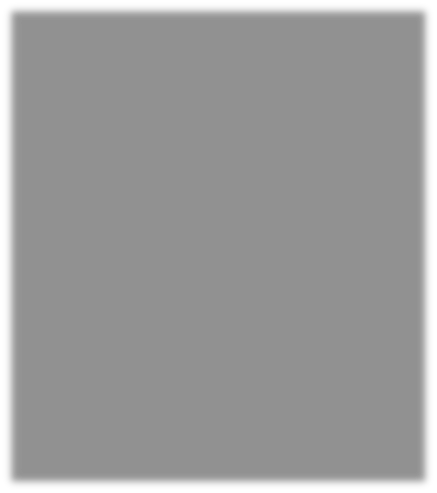
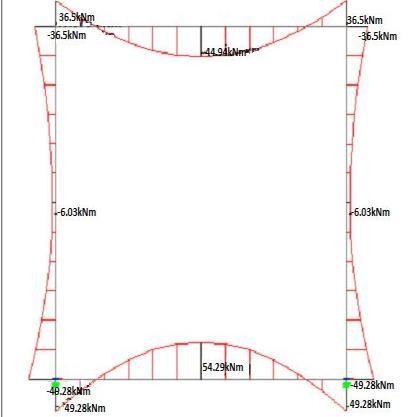
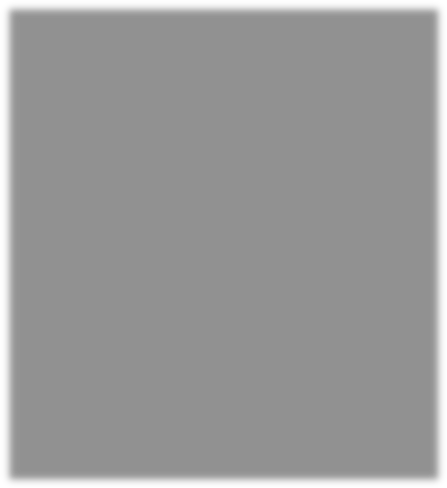
**Step 5:** Results of Bending Moment and Shear forces

* 1. **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 bedone within minutes while it takes huge time for a manual to design the whole structure.

**4.0 RESULTS AND DISCUSSION**: Researchers in this field have used a number of approaches to study and design RCC box culverts. When comparing this condensed method to the earlier ways, the bending moment and shear force diagrams' values and shapes are the same. Trial and error are used to install the spring spacing until a sensible gap is discovered. The output values are more accurate when the spacing is closer, especially for inverted members. Due to the symmetry of the sectional features and pressures placed on the culvert barrel, the diagrams for joint displacement, support responses, bending moment, and shear force [2, 4&5] are symmetrical. Tables I, II, and III, which compare the results of the following case studies utilizing the manual methodology and software method, 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 |



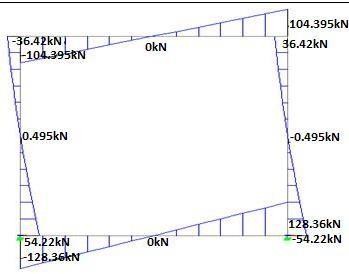
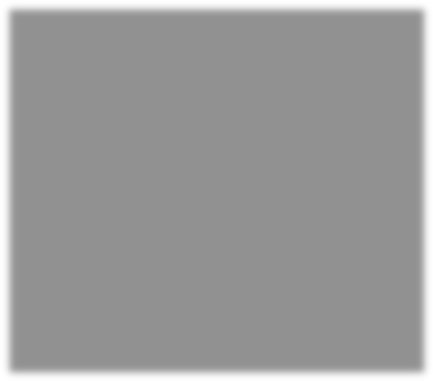
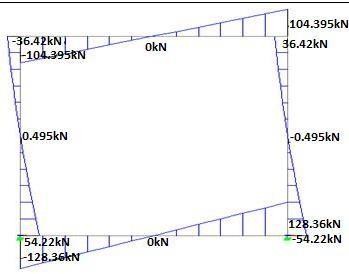
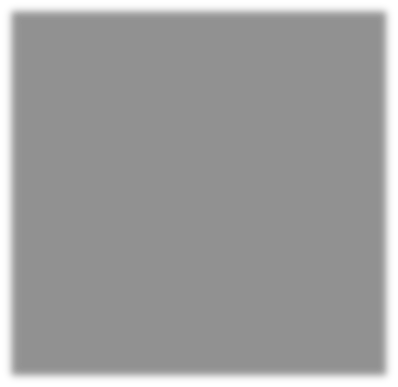
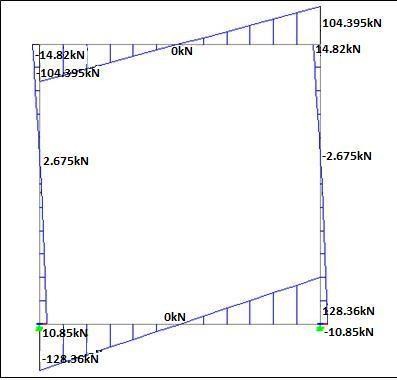
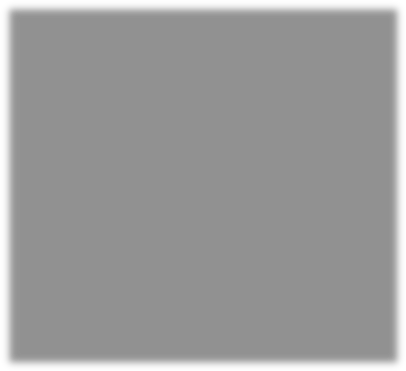
**Graph 1:- Different Bending Moment Case 1,2&3**

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 |

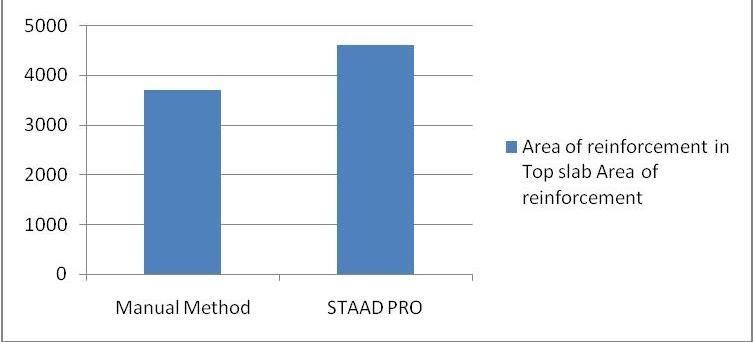
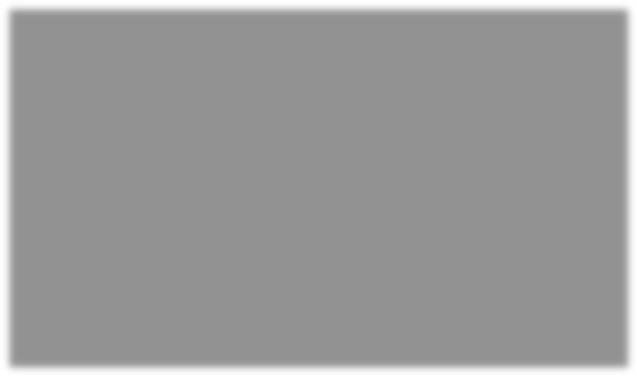
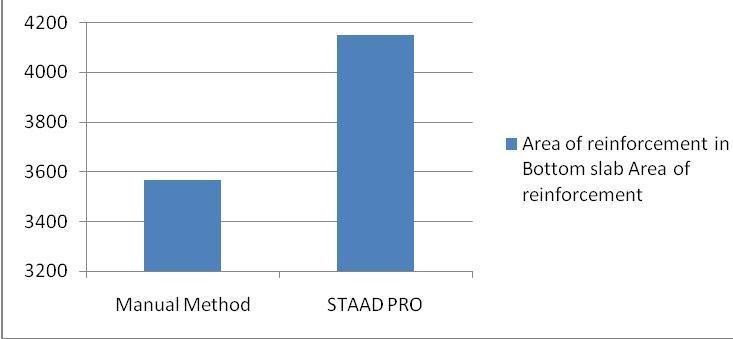
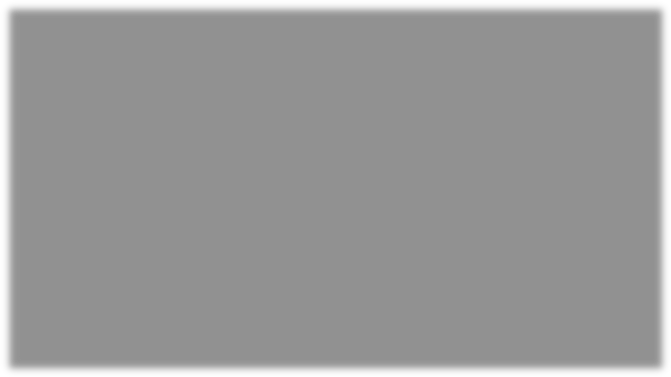


GRAPH 2: DIFFERENT SHEAR FORCE DIAGRAMS FOR CASE1, 2&3

**Discussion: -** The above graphs and table shows that the Shear force for different Case compared with manualand Staad pro results of top slab and bottom slab the maximum bending moment will be activated at Case Themaximum 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].

# 5.0 CONCLUSION

Finding manual and automated methods for box culvert analysis and design was the study's main goal. The box culvert design is covered by three load cases. For the three load conditions, the design moments, shear forces, and other values are slightly higher (or almost the same) than the values obtained by hand calculations. The analysis shows that the largest positive moment moments develop at the centre of the top and bottom slab when the culvert is operating at maximum capacity and when uniform lateral pressure brought on by a superimposed dead load operates alone. In contrast, the largest negative moment moments grow at the centre of the vertical wall. Because they require thinner sections and have lower maximum bending moment and shear force values than single-celled box culverts, the study shows that multi-celled box culverts are more cost-effective for longer spans.

ACKNOWLEDGMENT

The authors thank AIT, Chikkamagaluru, AJIET Manglore and ATME, Mysuru for providing the support and facilities in completing the work.

REFERENCES

1. P Leela Krishna, Dr. K Rajaskhar, "Analysis and Design of Box Culvert" volume-ISSN: 2349-784X, pp 114-156,

April 2018

1. Vasu ShekharTanwar, M.P Verma, SagarJamle (2018)," Analytic study of box culvert to reduce bending moments and displacements values" International journal of current engineering technology,
2. Afzal Hamif Sharif (2016), "Review paper on analysis and design of railway box bridge" International journal of scientificdevelopment& research, ISSN no.2455- 2631, Vol.01, Issue-07, p.p. 204-207SSN no.(o) 2277-4106, ISSN no.(p) 2347-5161,Vol.08, Issue-03, p.p. 762-764.
3. Kalyan shetti and S.A. Gosavi (2014), "The analysis is done byusing stiffness matrix method and a computer program in C language is developed for the cost evaluation''. The study is carried out related to variation in bending moment.
4. Lande Abhijeet Chandrakant, Patil Vidya Malgonda ( 2014),'' Analysed the box culvert by finite element method'''. Inthe paper, they presented the structural elements required to be designed to withstand maximum bending moment andshear force.
5. Neha Kolate, Molly Mathew, Snehal Mali, “Analysis and Design of RCC Box Culvert” Volume- 05, ISSN 2229- 5518, pp. 36-41, December 2014
6. M. G. Kalyan shetti, S. A. Goshavi (2014),’’ have analyzed the box structure for various conditions by changing the number of cells, for IRC class AA tracked load''.
7. Sujata Shreedhar, R. Shreedhar (2013)," Design coefficients for single and two cell box culvert" International journal of civil& structural engineering, ISSN no.0976-4399, Vol.03, Issue-03, p.p. 475-494
8. H. Chanson (2000 ). “Analyse the hydraulic design of culvert. The paper presents a new way to teach hydraulic design to civil and environmental engineering students in an undergraduate curriculum”.
9. Ahmed M et al91993)."Analyze to study the behavior of a double cell box culvert''. The main parameter taken is the soil pressure, moment, and deflection. 2011. ACI Committee 318.Building Code Requirements for Reinforced Concrete (ACI 318-11) American Concrete Institute. Detroit. The USA.
10. Bowles, J. E, P.E., S.E. 1996.FoundationAnalysis and Design. Fifth Edition. McGraw-Hill, USA. pp. 503- 506.
11. Coduto, D.P. 2001.Foundation Design Principles and Practices, second edition, Prentice-Hall, New Jersey. The USA.

pp. 358

1. IRC: 6-2016, “Standard Specifications and Code of Practice for Road Bridges” Section II
2. IRC 112,-2011, "Standard Specifications and Code of Limit State Method of Practice for Road Bridges",
3. IS 875 part 1 &2 “ Code of Practices for design dead and Live load

**UNIT- (Maximum Marks =20)**

Q.No. Description Marks

|  |  |  |
| --- | --- | --- |
| 4. |  |  |
| Page 1 of | | |