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Comprehensive Study on Design and Construction Methodology of Precast Box-Type Minor Bridge

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Abstract: ***Bridges are crucial elements in modern transportation infrastructure, facilitating connectivity across different points on roads. In areas with challenging topography and site conditions, such as rivers or streams, it becomes essential to construct structures that allow for the unobstructed flow of water. These structures, commonly known as bridges and culverts, are vital for maintaining natural water flow. The flow rate through these water bodies is a key consideration in the design of bridges, culverts, and other drainage structures. This study focuses on the design of precast box type minor bridge, exploring alternative design modules that incorporate fixed and hinged end condition for both top and bottom slabs of single and double box cells. The objective is to determine the optimal design configuration for box Type Minor Bridge components, balancing considerations of functionality, efficiency, and cost-effectiveness.***

Keywords: Bridge, site selection, data, catchment area, hydraulic Calculation, discharge, critical length, design model, optimum section, economy.

I. INTRODUCTION

Road infrastructure plays a vital role in facilitating transportation and connectivity in modern societies. However, the construction of roads often disrupts the natural flow of storm water, necessitating the implementation of cross drainage structures such as culverts and bridges to allow runoff flows U\S to D\S of roads embankment. The structures allows such flow across the proposed road are called Culverts, Minor Bridges & Major Bridges depending on their span lengths which in turn depend on Discharge. The Culverts cover upto waterway of 6.0m and be of two types Slab culvert and Box Culverts. Minor bridges cover upto waterways of above 6.0m to 60.0m below & Major Bridges cover upto waterways of above 60.0m and varies type of bridge are introduces mainly be of three types, are widely use Box type, RCC types & PSC types. Current construction practices for in-situ Box Type minor bridge involve several challenges. These include the requirement for ample space for material stacking, difficulties in transportation and equipment handling, issues with formwork placement, and concerns regarding material theft and spillage. Moreover, inadequate curing during construction can lead to disruptions in traffic flow, especially in densely populated areas, and prolonged construction times exacerbate these challenges, particularly during adverse weather conditions like the rainy season. Furthermore, construction in hilly or forested areas presents additional obstacles, such as the lack of suitable space for road diversions and difficulties in ensuring quality control in remote locations. These constraints not only hinder construction efficiency but also lead to increased costs due to delays and disruptions. To address these challenges, alternative construction methods such as precast concrete segmental Box Type minor bridge have emerged as promising solutions. Precast segments, manufactured in controlled environments, offer advantages such as reduced material handling, enhanced quality control, and expedited construction processes. Additionally, precast technology enables efficient construction management in remote areas, potentially mitigating costs and minimizing disruptions to traffic and the environment. Box Type Minor Bridge designing process starts with the hydraulic calculation for a particular site of crossing in this process catchment area along with its critical length of toposheet available in 1:50000 scale for a region. After getting the required data design discharge is calculated by using different methods given in IRC: SP: 13-2022 (Guidelines for the design of small Bridges and culverts) and then finally span arrangement is decided for the required site of crossing. Once the span is decided then design of structure takes place. Box Type Minor Bridge is a monolithic structure generally used when the safe bearing capacity of the soil is ascertained to be very less. Different structural member act as whole to resist the characteristics load for which it is designed. This research project aims to provide a detailed study of the design and construction methodology for precast box-type minor bridges. Precast construction methods have gained popularity due to their efficiency, durability, and cost-effectiveness. The project will delve into the various aspects of designing and building such bridges, encompassing structural considerations, materials, construction techniques, and sustainability aspects.

The main aim of the study is to arrive at the most economical and practical precast modular sections of box cells for box Type Minor Bridge.

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II. HISTORICAL DEVELOPMENT

Saevesh Dubey, Gaurav Tiwari, Abhay Kumar Jha, Barun Kumar Mishra. Development of civil Engineering, Laxshmi Narain Collage of Technology, Bhopal (M.P) has study the Behaviour of Box Type Bridge with Different Height and Same Width for the IRC Loadings. This paper presents all the structure components are analyzed using Staad-Pro software and Excel sheet as well as codal provisions. The structures is Designed by LSM Method & IRC Coads. The IRC Coads are follows for load and its combination for all the analysis. According to models are designed and results are compared.

N J Jain, S Sangita Mishra was designed dynamic response of prestressed segmental composite concrete bridges doesn't give the actual behavior of the structure subjected to the huge in-elastic deformation. The most suitable analytical approach shall be followed in order to minimize the failures at their construction stages. The simulation performed using the final element analysis helps to determine a fatigue failure life which cause due to the cyclic loading throughout its life. The conceptual framework methodology represents the step-by-step procedure to be followed for solving the structure or the precast segmental bridge using the finite element-based tool.

Sandeep Salve, Prof. Afzal Khan, studied on design & analysis of precast box for road bridge construction using stadd-Pro. In designing of structure the two major factors should be kept in mind i.e. is economy & safety. If the load is overestimated than the structure will be uneconomical whereas is the load is underestimated the safety of structure will be compromised. Hence the calculation of load & their combination should be done very precisely. The study included estimation of PCC & RCC Cut off & Curtain wall to comparative results in SOR-2017.

B. Sravanthi, G. Ramakrishna, Dr. M. Kameshwra Rao has study on A Comparative Design of One Cell and Twin Cell RCC Box Type Minor Bridge. Ts paper studied the design of box is covered by three load cases deal in this paper. The forth situation when whole box is submerged underwater, provide design moments, etc. less than given by the three load cases hence need not be considered. The design of box with cushion done by STADD- Pro computer software compares very closed to manual.

Saurav, Ishaan Pandey, was done comparative study of analysis of conventional method using STADD Software & finite element method using ANSYS Software for developing economic design & safety. Analysis & modeling has been done in both the software. The comparison of both the method i.e. conventional method in STADD & FEM in ANSYS has been done with respect to maximum bending moment, are of steel reinforcement required & cost of steel. This paper shows there is significant reduction in moment which reduced cost of project. Therefore this study concluded that culvert if design through finite element method rather than conventional method would only save the material & money but also make the design safer.

M G Kalyansheti, S A Gosavi has made an attempt to evaluate optimum thickness for economical design. In this paper they considered 12 m channel lenth for analysis with 2m ton6m height variation which is again divided into single cell, double cell and triple cell. IRC class AA tracked live load is considered. The analysis has been done by using stiffness matrix method and a computer program in C language has been developed for cost evaluation. They studied variation in bending moment; subsequently cost comparison was made for different aspect ratio. The percentage reduction in cost of single cell, double cell, and triple cell based on optimum thickness presented. The optimum thickness presented over this paper has been used to achieve the economical design of box culvert. Based on this optimum thikness, optimum cost per meter width of single cell, double cell & triple cell has been evaluated. According to this paper the cost of box culvert reduces if the optimum thicknesses are considered.

A D Patil, A A Galatage studied the behavior of box culvert with cushion & without cushion load for different aspect ratio & also studied the effect of different loading as per IRC codes & their combination which produce worst effect of loding for safe structural design. The soil pressure was considered to acting on side walls from outside & water pressure from inside. The loading were found by manual calculation & modeled in SAP 2000. Study showed the variation of maximum bending moments under cushion and without cushion loadings for different aspect ratio. Study concluded that, load combination with empty box was found to be critical for all values of aspect ratio. Bending moment for aspect ratio 1&1.5 were found to be varying whereas aspect ratio 2&3 were found to be constant for all load combinations. Effect of soil pressure & water pressure was considerable or aspect ratio 1&1.5 and negligible for 2&3.

Ketan Kishor Sahu, Shraddha Sharma was compared & studied different aspect ratio of box culvert. This paper deals with box culverts constructed in reinforced concrete having one, two or three cells and varying their operating conditions and analysis for their design. The cost by considering optimum thickness and the cost without considering optimum thickness has been compared. Accordingly results have been presented which justifies that optimum thicknesses presented over here are leads to economical design of box culvert. The charts of bending moment for top and bottom members have been generated. Such that from these charts at any intermediate aspect ratio the values of bending moments can be evaluated. The average percentage reduction in the cost for single cell, double cell and triple cell has been presented.

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Therefore this study concluded that, with the help of this designing part there are three different sections with the L:H ratio of 4:2, size of box culvert will be more in velocity, depth of water, perimeter, area, hydraulic mean depth, volume of concrete, and the end moments values will be less minimum as on top slab, bottom slab, vertical wall portion as well as the maximum bending moment of this section will be more safe, compared to other sections.

Komal S. Kattimani and R. Shreedhar studied some of the design parameters of box culvert like angle of dispersion of live load, effect of coefficient of earth pressure and depth of cushion provided on top slab of box culverts. In this paper, Komal S. Kattimani and R. Shreedhar has represented the end moments & center moments through graph by using effect of variation of angle of dispersion, variation in coefficient of earth pressure and variation of cushion. Therefore from the parametric studies that is by variation of angle of dispersion, coefficient of earth pressure and cushion depth, they concluded that, angle of dispersion increases the intensity of live load but when overall effect of all loads is taken, the moments remain constant. Therefore angle of dispersion as considered in IRC 6-2000 which is 450 can be considered for design. The coefficient of earth pressure has a little influence on the final moments therefore for safer design the coefficient of earth pressure can be taken 0.5 which gives higher result than 0.33 and moments for no cushion are higher than the moments for cushion of 5meters.

A. Objective

1) Compare various models & arrives at the most economical model.
2) To evaluate the various end conditions at different location joints, to minimize the handling & transportation cost.
3) Finding out the practical & most economical precast elements for ease of construction at site.

B. Design Consideration

1) Site selection & basic data.
2) STAAD Pro software is used for modeling of box Type Minor Bridge.
3) Limit state method is used for designing.
4) Models are made for following type of box cell.
   a) Single box cell with rigid joint cast-in-situ.
   b) Single box cell with precast segmental.
   c) Single box cell with top slab & detachable U-Section of bottom slab-Side wall fixed joint.

C. Problem Formulation

The following model & design parameters are considered for designing.
Span arrangement Single cell 1 x 10.0 x 6.0m with different end condition.
Total outer width of structure – 12.0m
Total carriageway width – 11.0m
Crash barrier Width – 0.50m
Wearing coat thickness – 65.0m (bituminous concrete 40.0mm + Mastic asphalt 25.0mm)
Concrete unit weight – 25 KN/m^3
Earth unit weight – 20.0KN\m^3
Wearing coat Unit weight – 22KN/m^3
Safe bearing capacity of soil – 150KN\M^2
Grade of Concrete – M30
Grade of Steel – Fe500

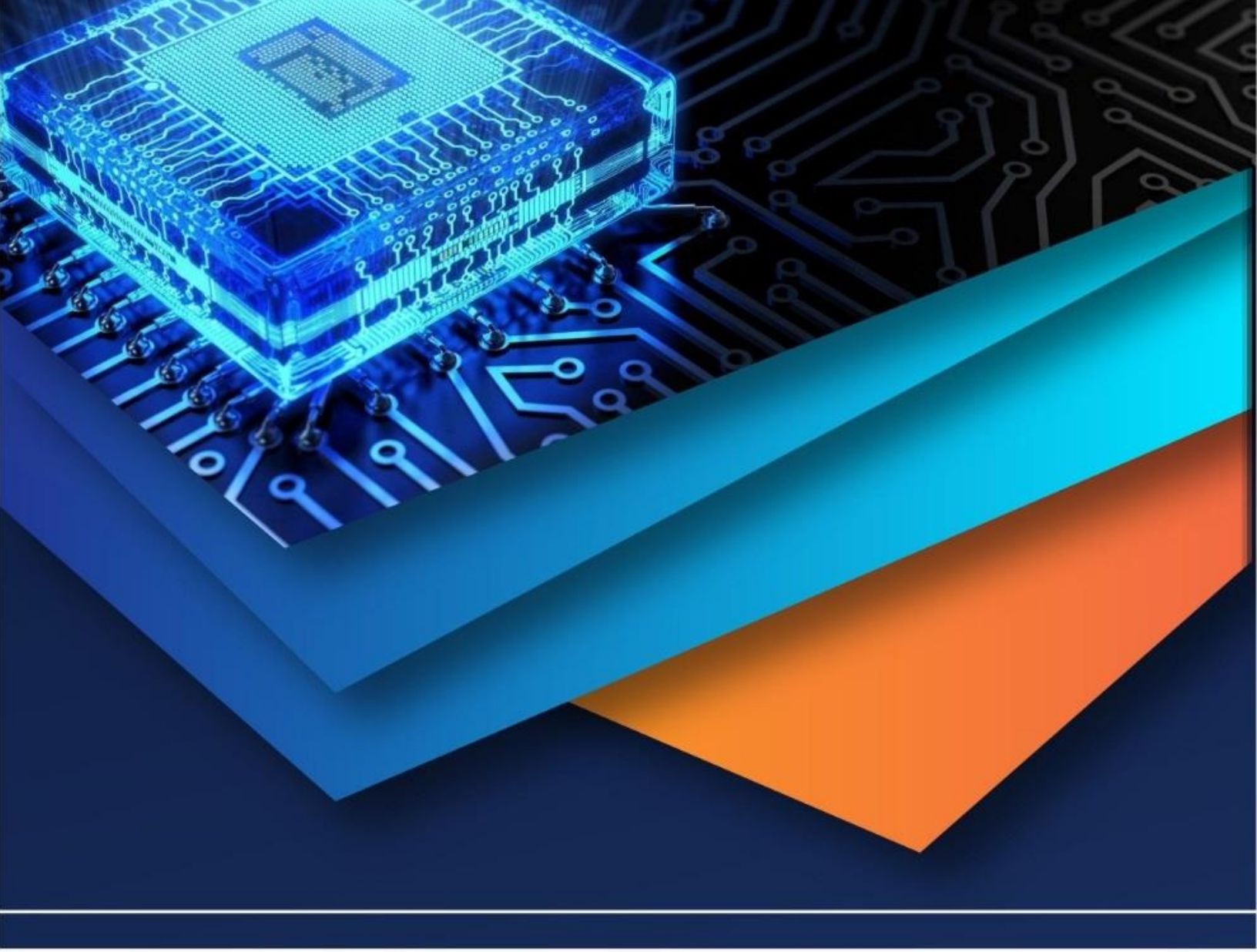
III. CONCLUSION

The Analysis & research on the Box Type Minor Bridge Design divulge that optimum sectional size of the Bridges shall be best economical design. Which Reduces the transportation & handling expenses. The design & modeling methodology mostly affected the economy of the construction of Box Type Minor Bridge.

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Cite all the sources, codes, and standards used in the study. Remember that the specifics of the design and construction methodology will vary based on local regulations, site conditions, and project requirements. It's crucial to work with experienced engineers, designers, and contractors who are well-versed in precast box-type bridge construction

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