"DESIGN AND COMPARATIVE ANALYSIS OF T BEAM AND BOX GIRDER BRIDGE USING FEA"

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ABSTRACT

This study conducts a comparative analysis of T-beam and box girder bridge designs using Finite Element Analysis (FEA) to evaluate their structural performance and efficiency. Through simulated load conditions, stress distribution, deflection, and overall stability are assessed. The research aims to discern the differences in behavior and structural integrity of these bridge types under varying loads, providing insights into their strengths and weaknesses. This analysis provides valuable insights into the material efficiency, cost-effectiveness, and resilience of T-beam and box girder bridges, crucial for optimal bridge design. The aims are to use Finite Element Analysis (FEA) to evaluate the structural performance of T-beam and box girder bridges, with a focus on stress distribution, deflection, and stability under varying load circumstances. The study also includes creating RCC T-beam and Rectangular/Trapezoidal box girder bridge models for comparative examination. The findings offer crucial insights into the comparative advantages and limitations of T-beam and box girder bridges, aiding in informed decision-making for future bridge construction projects.

Keywords: T-beam, box girder, bridge design, Finite Element Analysis (FEA), structural performance.

1. INTRODUCTION

Bridge is a structure that is built over a road, river, or railway to facilitate people and vehicles to cross from one side to the other. T-beam is a reinforced concrete bridge consisting of monolithic floor slab with supporting beams and its cross section resembles a series of T-beams. It is a load bearing structure that can be made more efficient structurally by inverting T beam with a floor slab or bridge deck joining the tops of the beams. Box girder bridge is a bridge in which the main beams consists of girders in the shape of hollow boxes. The box girder comprises either prestressed concrete, structural steel or combination steel and reinforced concrete. These bridges are usually used as elevated structures of rail transport and highway flyovers. In this study comparison between the 'Tee Beam Girder' and 'Box Girder' using Finite Element Analysis is carried out. This is helpful when researcher have two kinds for girder which can be used for same span; in that case the most economical one is to be selected. This comparison will give the clarity about selecting the deck type based on the span keeping economy in consideration. This investigation aims to evaluate the structural behavior, efficiency, and performance of these two common bridge types. Through comprehensive analysis, including simulated load conditions, stress distribution, and stability assessments, this study seeks to uncover the distinct advantages and limitations of T-beam and box girder bridges. Furthermore, the research explores the impact of dynamic loading, such as seismic activities or traffic-induced vibrations, on these structures, thereby enhancing insights into their resilience and safety.

Structural system got is influenced by fragments like economy and fancy being created. Code strategy engages us to pick structural system i.e. T- Beam Girder and Box Girder. The decision of sparing and constructible basic framework relies on upon the outcome.

A. T-Beam

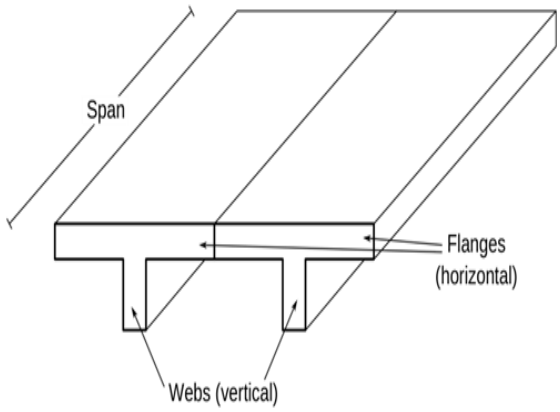

Fig 1. T-Beams

T-beam utilized as a part of construction, is a load bearing structure of reinforced concrete, wood or metal, with a t-formed cross area. The highest point of the t-molded cross segment fills in as a flange or pressure part in opposing compressive stress. The web (vertical area) of the beam beneath the compression flange serves to oppose shear stress and to give more noteworthy detachment to the coupled strengths of bending.

B. Girder

Girder is a term used in construction to refer to a supporting, horizontal beam that can be made from a variety of construction materials such as stainless steel, concrete, or a combination of these materials. A girder bridge is a basic, common type of bridge where the bridge deck is built on top of such supporting beams, that have in turn been placed on piers and abutments that support the span of the bridge.

C. Box Girder

The Box Girder Bridge whose principal beam consists of some kind of hollow box-shaped girder. Generally, the box girder is composed from either from before the concrete, structural steel, or perhaps a combination of structural steel as well as reinforced cement. Its cross section was generally a rectangle or a square. Both traditional flyovers for expressways and cutting-edge viaducts for light rail transportation have made use of box girder bridges. Despite the fact that crates box girder bridges are typically beam bridges, box girder could also be employed for cable-stayed bridges as well as other structures**.**

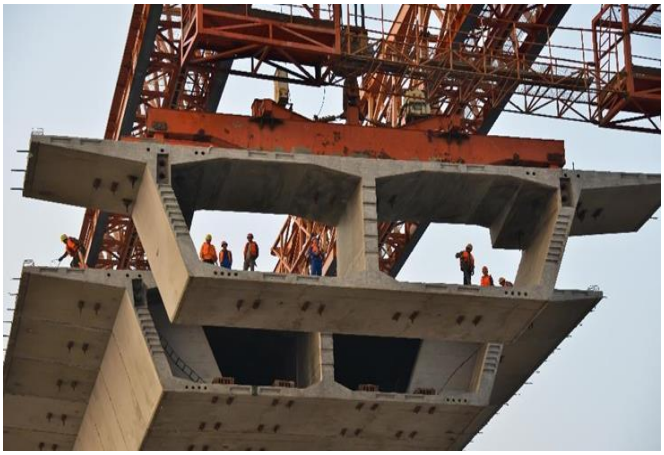

Fig 2. Box girder

1.1 Comparison of T-beam and box girder bridges using Finite Element Analysis (FEA)

Aspect	**T-Beam Bridge**	**Box Girder Bridge**
Structural Configuration	Shallow beam with a T-shaped cross-section	Deep beam with a box-shaped cross-section
Structural Efficiency	Less efficient due to lower moment of inertia	More efficient due to higher moment of inertia
Material Usage	Typically requires less material	Typically requires more material
Construction Complexity	Generally simpler construction	More complex construction process
Structural Stiffness	Lower stiffness	Higher stiffness
Structural Strength	Lower strength	Higher strength
Span Length	Suitable for shorter spans	Suitable for longer spans
Deflection	Higher deflection under loads	Lower deflection under loads
Cost	Lower initial cost	Higher initial cost

III LITERATURE REVIEW

Srikrishna Dhale (2018), comparison between the 'Tee Beam Girder' and 'Box Girder' is carried out. This is helpful when we have two kinds for girder which can be used for same span; in that case the most economical one is to be selected. A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for road, railway, pedestrians, canal or pipeline. In present study our main concern is with T-Beam Girder Bridge and Box Girder Bridge. This investigation aims to evaluate the structural behavior, efficiency, and performance of these two common bridge types. Through comprehensive analysis, including simulated load conditions, stress distribution, and stability assessments, this study seeks to uncover the distinct advantages and limitations of T-beam and box girder bridges.

Prof. Sonal T. Pawar (2016), develop finite element method for analysis of box girder with haunches. Parametric investigations will be performed for box type of bridges with and without haunches Span range is more for box bridge girder as compare to T-beam Girder Bridge resulting in comparatively lesser number of piers for the same valley width and hence results in economy. A bridge is a structure providing passage over an obstacle without closing the way beneath. Recent developments in the field of Bridge engineering, Box Girder Bridges have heightened the need for improving the ability to carry the live load and undertaken as a result of code provisions. In this paper deals with response of haunches in box girder bridges when subjected to standard moving load. Analysis of box girder bridges can be accurately done by finite element method. Maximum bending moment occurs at the junctions of box girder, therefore provision of haunches at junctions may lead to economic solution.

Raghabendra Yadav (2018), study the comparison of maximum bending moment due to live load in a girder and slab bridge for varying span length as 15m, 20m and 25m respectively of T Beam bridge using conventional method. The same bridge is analyzed as a three-dimensional model in finite element software as SAP2000, apply the same loading done for conventional methods and compared the results. The maximum bending moment results obtained from finite element model are lesser than Courbon's method which looks more conservative. The most commonly and popular type of bridge used in Nepal is T beam bridge due to it's simple in design, construction and maintenance than other types. T-beam Bridge comprises of a concrete slab integral with girders. This type of bridges is more preferred when it comes to connectivity to short distances. So, it is necessary to update the analysis and design methods.

Narendra Singh (2022), In this study about dynamic analysis of PSC precast I-girder bridge and PSC box girder bridge for different parametric variation and different span range have been studied by various researchers. The parameters are geometric parameters, span range, mending moment, shear force, displacement, base shear, base moment, time period, natural frequency, and method of analysis based on different codes. On the above parameters base reaction, base moment, time period, natural frequency, absolute displacement and girder forces of bridge is essential and major concern for the analysis of bridge structure.

Rao Jang Sher (2020), analysis and design of box and T beam girder has been performed using SAP2000 in order to find out the most suitable type of bridge superstructure. The main objective of this study is to compare the structural behavior, optimization of materials used in each component and cost comparison of box and T beam girder bridge. Previous research in this regard is based upon working stress method but this research follows limit state design. Detailed comparison shows that box girder is more suitable as compared to T beam girder even for shorter span in terms of structural stability and cost efficiency. Bridges are the most important component of transportation system of any country due to their ability of accelerating the development of the nation. Design of bridge highly depends on its function, nature of soil strata where it is constructed and the material used to construct it.

Patil M.B (2016), investigates the composite bridge gives the maximum strength in comparison to other bridges. The design and analysis of various girders for steel and concrete by using various software, in that

paper for composite bridge calculate the bending moment for T girder and finding which is more effective. The efforts will make to carry out to check the analysis of bridge by using SAP 2000 software. To determine the static analysis of T girder by using manual method as well as software. The results obtained from the software in structural analysis are compare the results obtained from manual calculations. **Meghana K V (2020),** study the effects of T – beam and Box girder bridge of various spans under moving load using software and by manual methods. Methods of analysis and design carried out are determined. The bridges are designed for different IRC vehicle loadings and T–Beam deck system and box girder system are studied. Bridge is a structure that is built over a road, river, or railway to facilitate people and vehicles to cross from one side to the other. Selections of most suitable section in bridges of different span length, comparative studies are conducted. The results of the software are verified against the manual methods. The parametric study is conducted on the parameters such as Bending Moments, & Shear Forces.

Amit Saxena (2013), purpose of present study is the design of bridge structure for 25 m of span. The most obvious choice of this span is T- Beam and Box Girder. They have their own characteristics and limitations as T-Beam has easy construction mythology, whereas Box girder has sophisticated and costly formwork. In present study a two lane simply supported RCC T- Beam Girder and RCC Box Girder Bridge was analyse for dead load and IRC moving load. The dead load calculation has been done manually and for live load linear analysis is done on Staad Pro. The goal of study is to determine most favourable option from above two. The decisions based on obvious element of engineering that are safety, serviceability and economy. Following these aspect, a design for both T-Beam and Box Girder has been performed. After calculation two basics material consumption steel and concrete the most economical has been selected. This study is on the basis of moment of resistance of section, shear capacity of section and cost effective solution from both T-Beam and Box Girder Bridge.

Sandesh Sandesh Upadhyaya K. (2016), The aim of our study was to determine the beam configuration of deck slab. In this study configurations of these bridges, namely ordinary deck slab slab supported on girders and T- sheets for conventional design which gives maximum conventionally analysed for IRC class AA loading study we have considered span lengths of 20m, 24m and loading using Courbon's method. The process was made and 28m. The deck slab has been maximum Bending Moment and Shear Force values made faster by formulating excel arising due to dead load and live slab, girders and cross beams.

Dilip Patidar (2003), investigate the effect of different dimensional variables on strength of box Girder Bridge using techniques of Finite Element Analysis. The CAD modelling and FEA simulation of box Girder Bridge is conducted using ANSYS simulation package. The deformation obtained on the bridge structure is not uniform and found to be mostly at the zones of load application and reduces on other zones. The deformation pattern is almost uniform across length and width of the bridge structure. The bending stress distribution is also observed to be non-uniform and is maximum at the regions of load application. From the structural analysis conducted on box Girder Bridge structure the structural stability is established.

Abhinav Kumar, (2020), provides a comprehensive analysis of concrete T-beam girder bridges, focusing on various aspects crucial to their structural integrity and performance. Evaluating a range of research articles, structural analyses, and design methodologies, this review aims to summarize and critically assess the key factors impacting the behavior and efficiency of T-beam girder bridges. It explores the influence of parameters such as material properties, load conditions, and construction techniques on the bridges' overall performance. Bridges are the life line of road network, both in urban and country zones. With fast innovation development, the commonplace bridge has been supplanted by creative practical structural system. One of these courses of action presents basic RCC framework that is T Beam and ordinary Beam.

Abrar Ahmed, (2017), identify the suitable section for bridges of different spans. The Prestressed concrete sections have been considered in this case as the spans designed are

more than 25 metres for which the Reinforced concrete sections are uneconomical. The aim and objective of the work is to analyse and design the sections for different Indian Road Congress, IRC vehicles. This has been done by analysing the structure by CSI bridge software and validating with manual results by developing the Microsoft Excel Sheets using Working Stress Method and by adopting Courbon's theory. It is found that the IRC 70R vehicle producing maximum effect on the sections.

2.1 Research Gap

The literature extensively compares T-beam and box girder bridges, focusing on their performance under various weights and spans. However, there is a research gap in terms of employing modern design methodologies, such as optimization algorithms or novel building processes, to enhance the performance of these bridges while saving money. In addition, environmental and sustainability considerations have received little attention while selecting and developing bridges. Future research might close these gaps and make bridge architecture more efficient and environmentally benign. Addressing these issues can help progress bridge engineering, resulting in safer, more cost-effective, and environmentally friendly infrastructure solutions.

IV. METHODOLOGY

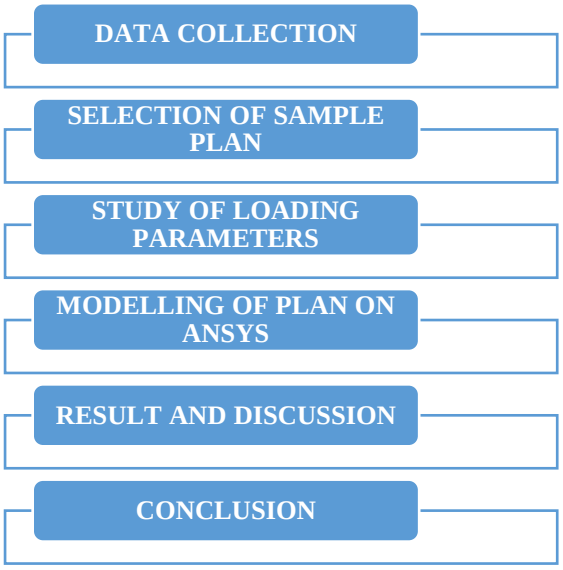

Fig.3.1. Methodology Process

IV CONCLUSION

In conclusion, the comparative analysis using Finite Element Analysis (FEA) between T-beam and box girder bridge designs has revealed crucial insights into their structural performance. The evaluation of stress distribution, deflection, and stability under varying load conditions highlighted distinct differences between the two designs. T-beam bridges displayed advantages in cost-effectiveness and ease of construction, while box girder bridges exhibited superior load-bearing capacity and overall structural resilience. The impact of dynamic loading, including seismic events and traffic-induced vibrations, showcased different responses in both designs, emphasizing their varying degrees of durability and safety. This study's outcomes contribute significantly to bridge engineering by providing a nuanced understanding of the strengths and limitations of T-beam and box girder bridges, aiding engineers in making informed decisions for future bridge construction projects.

IV. FUTURE SCOPE

Future developments in the design and analysis of T-beam and box girder bridges utilizing Finite Element Analysis (FEA) have enormous promise. Using FEA enables for more realistic models of bridge behavior under a variety of loads and circumstances. Future study might concentrate on optimizing bridge designs to increase structural efficiency and performance while reducing material consumption and construction costs. Furthermore, there is room to experiment with novel building processes and materials to improve bridge durability and lifetime. To produce more sustainable bridge solutions, environmental issues such as lowering carbon emissions and minimizing ecological damage should be included into the design process. Also, advances in computer tools and modelling approaches allow for more comprehensive assessments, such as parametric studies and optimization algorithms, to discover the most efficient bridge designs. Collaboration among academics, engineers, and politicians is also required to guarantee that novel bridge designs fit regulatory criteria and serve social demands.

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