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Design of Beam Bridge

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Abstract
The design of a beam bridge involves applying core engineering concepts to create a structure that is secure, functional, and economical. The project demands a deep understanding of material properties, structural analysis methods, and the load-bearing capabilities of the bridge components. The process begins with outlining the bridge's dimensions, factoring in elements like span length, width, and height. Next, the most suitable materials for the beams and other parts are chosen based on site-specific conditions and environmental considerations. The designer then calculates the necessary number of beams and their dimensions, ensuring they can safely bear the expected loads. Structural analysis tools may be employed to model the bridge's performance under different stress conditions, helping to detect any potential vulnerabilities. The design is then refined according to the results of the analysis, aiming for the most efficient and safe configuration. The final phase involves creating comprehensive plans and specifications to guide the construction.
The beam bridge project focuses on designing and building a bridge structure supported by beams that spans a body of water. The process includes several phases, such as the initial design, analysis, and actual construction. During the analysis phase, structural software is used to model and assess the bridge's behavior under various circumstances. The completed beam bridge provides a vital transportation route for the community, allowing safe and smooth movement of people and goods across the water.

Keywords: Ultimate limit, Serviceability limit, column pier,Bearings.

1. Introduction

The significant damage to bridges worldwide during earthquakes has sparked considerable interest among engineers and researchers regarding the seismic design of new bridges and the retrofitting of existing ones. Before the establishment of modern design codes, bridges were designed to withstand minimal seismic forces without incorporating provisions for ductility. Seismic design codes began including ductility requirements only after 1970. As a result, bridges constructed before this time may not be adequately equipped to handle the impact of future earthquakes, and these structures might require seismic assessment and retrofitting. In recent years, evaluating the condition and rehabilitating existing bridges, or constructing new ones, has become a persistent issue for bridge owners and administrators in developed nations. The primary purpose of building a bridge is to facilitate the passage of traffic from one side to the other. The Beam Bridge, also referred to as the Girder Bridge, is one of the most prevalent and commonly used types of bridges. Beam Bridges represent the simplest structural form for bridge spans, supported by abutments or piers at either end. Essentially, it is a horizontal slab or beam supported at both ends. A Beam Bridge is a typical bridge type that is held in place by supports at its ends. In this kind of bridge, no bending moments are transferred through the supports, which is why it is categorized as simply supported. Beam bridges are capable of carrying pedestrians, trucks, light rail, heavy rail, and more. It is crucial to calculate all the bending moments within a beam to ensure a safe design for constructing beam bridges.

PARTS OF BEAM BRIDGE:

Deck: The deck is the upper surface of the bridge that supports traffic or other loads. It is typically constructed from concrete, steel, wood, or various other materials.

Beams: The beams are the horizontal elements that support the deck. They are typically constructed from steel, reinforced concrete, or wood.

Piers / Columns: The piers are the vertical supports that hold up the beams. They are generally made from concrete or steel.

Abutments: The abutments are the structures located at either end of the bridge that anchor the beams and keep them in place. They are typically made from concrete or masonry. **Bearings**: Bearings are components that allow the bridge to expand and contract due to temperature variations or other forces, without damaging the structure. They are usually made from steel or rubber.

Expansion Joints: Expansion joints are the spaces in the bridge deck that accommodate its expansion and contraction. These gaps are typically filled with a flexible material that can adapt to the movement of the bridge.

Guardrails / Parapet: Guardrails are safety barriers that prevent vehicles and pedestrians from falling off the bridge. They are often constructed from steel or concrete.

Piles: Piles are used to transfer the weight of the bridge deck and the loads crossing the bridge to a deeper, more stable layer of soil or rock below the surface.

OBJECTIVES

To design a bridge that fulfills current needs.

To design a structure that provides a route over obstacles.

To develop the framework ensuring durability, robustness, and functionality.

LITERATURE REVIEW

1. . Ivana Stimac Grandic et al. (31-Jan-2011), in their study titled "Parametric Analysis of Wind Action on Slab Bridge Deck," conducted an evaluation of wind effects on bridge decks under varying conditions. The wind forces on the bridge deck were computed based on the following factors: wind exposure area, terrain classification, road barrier system, and the elevation of the deck above the ground. The findings indicate significant variations in wind forces resulting from changes in these parameters. Given that similar slab bridge decks are frequently employed in various regions of Croatia, it is crucial to consider that wind loads on bridges can vary substantially depending on the location when designing standardized bridges
2. . R. V. Raikar et al. (01-Jan-2014), a professor in the Department of Civil Engineering, K.L.E.S. College of Engineering, Udaumbaug, Belgaum, Karnataka, in their paper titled "Clear Water Scour Around a Circular Bridge Pier Under Steady Flow for Different Opening Ratios," discussed that the loose, non-cohesive material through which a river passes is typically referred to as sediment. Localized scour at bridge piers and abutments is a primary cause of bridge failures in alluvial sediment regions. Clear water scour describes a condition where the approaching flow does not supply sediment in the scour zone. Numerous researchers have examined various facets of scour, but studies

focusing on steady flow conditions with constant discharge and depth for varying pier diameters remain scarce. In the current study, laboratory experiments were conducted on circular piers of different sizes, maintaining a constant discharge under clear water scour conditions. The findings revealed that the non-dimensional scour depth gradient varies, with a gentler slope observed up to an opening ratio of 0.8, and a steeper slope beyond this ratio.

3. . Mahmoud Sayed-Ahmed et al. (2014), in their study titled "Bridge Deck and Guardrail Anchorage Detailing for Sustainable Construction," discussed the application of glass fiber-reinforced polymer (GFRP). The research explores using GFRP bar bents as stirrups at the connection between steel guardrail posts and a bridge deck slab cantilever. Additionally, GFRP bars with headed ends were employed to enhance anchorage at the post-deck joint. Four full-scale cantilever post specimens were constructed and tested to failure. Two specimens were reinforced with steel bars as central reinforcements, while the other two were reinforced with GFRP straight bars, bent bars, and headed bars at the relevant positions. All specimens exhibited similar failure patterns due to the breakout of the curb's external side face. Failure occurred in the unconfined concrete cover due to high compressive and frictional shear stresses combined with torsional effects, leading to spalling at the cantilever's side face beneath the posts. It was suggested to increase the edge distance of posts to avoid early failure in unconfined concrete cover. However, the experimental capacity of the post-curb area was deemed adequate to withstand design loads.To determine the portion of design lateral loads borne by each post, both linear finite element analysis (FEA) and a simplified FEA were utilized. The results indicated that the load share of each post decreases as the spacing between posts reduces. The minimum recorded experimental lateral ultimate
4. Load was 151.8 kNm, sufficient to resist the load share on each post of the guardrail system, provided the post spacing is less than 2.5 m. The GFRP-reinforced specimens performed comparably to their steel-reinforced counterparts in terms of ultimate load-bearing capacity observed experimentally.
5. .C. A. Graciano et al. (01-April-2015), in their paper titled "Effect of Longitudinal Stiffening on Bridge Girder Webs at Incremental Launching Stage," discussed the concept of patch loading. Patch loading is a critical load condition during the incremental launching of bridges. To enhance shear and bending strength during service, bridge girder webs are often equipped with longitudinal stiffeners, with their impact accounted for in design codes. However, no clear guidelines are provided to quantify the contribution of these stiffeners in increasing patch loading resistance. The study reviews several existing formulas from the literature for predicting the ultimate strength of girders, including standards from European, American, and Colombian design codes. Moreover, a nonlinear finite element analysis was performed on three case studies of real launched bridges to evaluate the influence of longitudinal stiffeners and girder depth on girder capacity. Variations in load-displacement behavior were observed depending on the girder depth. The finite element analysis further highlights the extent to which longitudinal stiffeners can enhance the patch loading capacity of bridge girder webs during the launching process.
6. .Thanushree H et al. (3-March-2016), in their paper titled "Analysis of RCC and PSC Bridge Deck Slab for Various Spans," explored the impact of different spans on single-span reinforced concrete (RCC) and prestressed concrete (PSC) bridges. The analysis was conducted using the finite element method, and the findings are detailed in this study. The research examines RCC and PSC bridge deck slabs to understand the effects of aspect ratio, span length, and load type. Finite element analysis

results for bridges were compared with reference analytical solutions for dead loads and IRC Class AA loading. A comparative assessment of the behavior of RCC and PSC slab bridge decks versus equivalent FEM analysis outcomes was also performed. Several bridge models were analyzed to evaluate variations stresses, and support reactions, against analytical solutions. The study highlights that the advantages of prestressing are most evident in the significant increases in longitudinal bending moments and longitudinal stresses.

7. . Umang Parekh et al. (11-May-2016), an assistant professor in the Department of Civil Engineering at L.J.I.E.T, Ahmedabad, India, in their paper titled "Analysis of Tall Pier Bridges," presented a methodology for analyzing prestressed reinforced concrete (RC) tall pier bridges, commonly used in viaducts spanning deep valleys. Piers are classified as tall when their shaft height exceeds 30 meters. A parametric study was conducted for different pier heights and deck lengths under varying load conditions. Several analyses were carried out for prestressed RC bridges using the CSI BRIDGE software. The primary goal of the study was to identify the governing load case for design, as well as the load case resulting in the highest displacement and moment values.
8. . Kearthi S et al. (02-July-2016), a P.G. scholar from the Department of Civil Engineering, Bannari Amman Institute of Technology, Sathya Mangalam, Tamil Nadu, India, in their paper titled "Analysis of T-Beam Bridge Deck Slab," discussed that structures are subjected to two types of forces: static and dynamic. However, most civil engineering structures are designed under the assumption that all applied loads are static. The influence of dynamic loads is often excluded because structures are rarely exposed to them, and incorporating dynamic loads into the analysis increases complexity and computation time.
9. . Chandan Roy (April-2017), from the Department of Civil Engineering, Maharishi Markandeshwar University, Mullana, Ambala, Haryana, India, in his paper titled "Effect of Bridge Pier Geometry on Local Scouring," discussed that local scour around bridge piers is a primary cause of hydraulic structure failures, such as at piers and abutments. The extent of local scour near a bridge pier significantly depends on the pier's shape and its design efficiency from a construction standpoint. Local scour is a complex process influenced by factors such as discharge rate, flow depth, pier geometry, and sediment particle type. This study primarily focuses on pier geometry. Experiments were conducted on three pier shapes—rectangular, circular, and oblong—to identify the optimal pier shape under varying flow velocities of 0.146 m/s, 0.231 m/s, and 0.323 m/s in a 15-meter hydraulic flume, using natural sand as the bed material under clear water conditions in the university's laboratory. The results indicate that scour at the upstream face is directly proportional to the exposed area of the pier's upstream nose. Among the tested shapes, the rectangular pier experienced the highest scour, while the oblong pier exhibited the least.
10. Abolfazl Rafat et al. (25-Nov-2017), from the Department of Civil Engineering, Sirjan Industrial 1998-1-2004. While the details of these codes vary, they share fundamental principles and are broadly comparable. All standards account for seismic risk, spectral content, building importance, structural response, and soil/foundation interaction with seismic loads. To analyze the parameters affecting seismic forces on buildings, the researchers employed the modern structural engineering software package ETABS. Analytical studies were performed on various structural systems, and similarities and differences across the four codes were highlighted. This approach allows engineers to better understand the provisions in IS 1893 (Part 1):2002, UBC 1997, NZS 1170.5–2004, and BS EN 1998-1-2004, particularly in relation to each other. The impact of zone factors on seismic forces was

discussed, demonstrating how seismic effects change when the same building is situated in different regions. Neural Networks (SOM)," discussed that scour is caused by the erosion of the riverbed due to water flow and sediment transport. This study focuses on estimating the depth of scour using a self- organizing neural network (SOM). The results obtained were compared with those of other models, revealing that the self- organizing neural network (SOM) showed a higher correlation coefficient (0.98) than other methods. Additionally, it had a lower root mean square error (RMSE = 0.112) compared to alternative approaches. The findings demonstrated that estimating scouring depth with the SOM method provided better accuracy. The correlation coefficient was higher when the program was executed using dimensional data compared to non-dimensional data. Furthermore, the RMSE was reduced to 0.09 in the case of dimensional data. The study also utilized sensitivity analysis, showing that when the SOM program was run with dimensional data, it exhibited greater sensitivity to the parameter representing the average diameter of sediment particles.

11. Walid Al-Sayed Mohamed (02-Feb-2020), an associate professor of irrigation and hydraulics at Al Azhar University, in his paper titled "Effect of Local Scour on Foundation of Hydraulic Structure," emphasized that optimal foundation design for hydraulic structures necessitates precise estimation of the maximum potential scour depth in the stream. An experimental study on local scour around piles and pile groups for bridges over rivers was conducted in the laboratory at the Faculty of Engineering, Al-Azhar University. The experiment aimed to identify the optimal separation distance between piles to minimize local scour. The results indicated that the depth of scour decreases as the spacing between piles increases. Additionally, it was observed that circular piles exhibit less scour depth compared to square piles. Specifically, circular pile groups reduce scour depth by 29.5% compared to square pile groups. The research also highlighted the significance of arranging piles in a streamlined configuration. In such cases, the scour depth was found to reduce to one-third of the depth observed in non- streamlined arrangements.
12. M. Velayutham and K. Subramanian (09-Mar-2020), professors and heads of the Civil Engineering Department at Coimbatore Institute of Technology, Anna University, Chennai, in their paper titled "Influence of Seismic Zone Factor and the International Codal Provisions for Various Lateral Load Resisting Systems in Multi-Storey Buildings," conducted an investigation into zone factors and seismic forces.The study examined the primary factors influencing seismic loads, comparing dynamic analysis results for various structural systems with different zone factors. This comparison was based on codal provisions from IS 1893 (Part 1):2002, UBC 1997, NZS 1170.5–2004, and BS EN
13. level be set at least 150 mm above the maximum water surface height.
14. Balaji Venkateshwara (28-Mar-2021), from the Department of Civil Engineering, Anna University, Chennai, Tamil Nadu, India, in his paper titled "Sustainable Practice in Bridge Construction," highlighted the significance of
15. sustainability in in bridge construction. The paper discusses various techniques to achieve sustainability throughout the different stages of a bridge project, from planning and design to maintenance during its operational lifespan. It emphasizes the need to establish regulations that mandate sustainability as a critical requirement. The conclusion underscores that bridges are essential infrastructure for any economy, and as economies grow, so does the demand for bridge development. Therefore, integrating sustainability into bridge construction ensures that these structures are not only environmentally friendly but also cost-efficient. This approach leads to significant economic savings,

especially in developing nations. Sustainability should thus be considered a fundamental element in the budgeting of bridge projects. The paper advocates for the implementation of global construction policies to prioritize sustainability in all bridge projects.

16. 13 Dr. Sachine S. Saraf et al. (09-Sep-2022), an assistant professor in the Department of Civil Engineering at DIGIT&R, Amaravati, Maharashtra, India, in their paper titled "Hydraulic and Hydrological Impact on Bridges," conducted a study on hydrologic and hydraulic bridge systems to estimate the 100-year water surface elevation at a specific project site. Bridges, as high- cost hydraulic structures, are typically designed for a lifespan of
17. 100 years. However, many bridges fail prematurely due to flooding. In regions like Pakistan, such crucial studies are often overlooked, leading to structural collapse before the design life is reached. This research emphasizes using various hydrologic and hydraulic methodologies to determine the 100-year flood discharge at the long branch culvert site along Guinea Road in Virginia, USA. The study employed Anderson's method to evaluate adjustments for different return periods. Based on the freeboard values obtained, bridge engineers can revise road levels for culverts or bridges to ensure they do not obstruct a flood with a 100-year recurrence interval. The research suggests that as waterways narrow, the likelihood of bank erosion increases. To mitigate such risks, river regulation works extending 1 km upstream and downstream are recommended, along with continuous monitoring during and after the construction of such structures.

DISCUSSION

The beam bridge is an ideal choice for many applications where simplicity and cost are critical factors. However, its efficiency decreases with increasing span length, necessitating alternative designs like truss or cantilever bridges for longer distances. Advances in materials, such as pre-stressed concrete and high-strength steel, have extended the possible span length of beam bridges, making them more versatile.

In urban settings, beam bridges are often favored for their rapid construction and minimal disruption to existing infrastructure.

Conversely, in rural or environmentally sensitive areas, their straightforward design minimizes environmental impact.

CONCLUSION

Planning and designing a beam bridge project is a complex yet fulfilling task that necessitates a thorough understanding of various engineering concepts, material selection, and load specifications. The design process must account for factors such as the bridge's location, span length, traffic density, and environmental conditions.

The endeavor also demands meticulous planning and collaboration among team members to ensure the bridge's design and construction align with the project goals. The project strategy should outline a detailed schedule, cost estimation, and resource distribution, while establishing effective communication channels among all stakeholders. Throughout the design phase, prioritizing safety is critical to ensure the bridge can endure anticipated loads and maintain structural integrity over time. Additionally, the bridge's design must accommodate future maintenance needs, with a plan in place to address ongoing upkeep requirements.

In conclusion, designing a beam bridge is a significant and intricate process that requires an in- depth understanding of engineering fundamentals, precise planning, and seamless coordination among project stakeholders. By adhering to industry standards and employing best practices, the beam bridge project can be successfully completed, delivering a durable and secure transportation infrastructure for the community for years to come.

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