Review on Parametric study of cable stayed bridge

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Abstract-This collection of research papers presents a comprehensive overview of various aspects of cable-stayed bridge engineering, covering topics such as initial shape computation, optimization strategies, vibration analysis, material innovations, historical perspectives, and pylon design. The studies delve into finite element computation techniques for determining initial bridge shapes, emphasizing considerations of nonlinear effects and prestress distribution. Additionally, they explore optimization methodologies, historical insights into British engineering expertise, and practical applications of advanced materials like Carbon Fiber Reinforced Polymer (CFRP) tendons. Furthermore, the papers analyse the impact of different pylon shapes on bridge response, investigate classification based on cable patterns, and assess the efficiency of various design elements using computational tools like CSI Bridge and STAAD Pro software. Overall, this compilation serves as a valuable resource for engineers, researchers, and practitioners involved in cable-stayed bridge design, providing insights into structural analysis, optimization techniques, material innovations, and historical context.

Keywords: Cable-free segment, behaviour, Pilon height, span to depth ratio, Types of cable arrangement.

I. INTRODUCTION

This compilation of research papers delves into various aspects of cable-stayed bridge engineering, covering a wide range of topics from initial shape computation to optimization strategies, vibration analysis, material innovations, historical perspectives, and pylon design. Cable-stayed bridges, renowned for their efficiency in load transfer and structural stability, have garnered significant attention from engineers and researchers worldwide. The papers explore diverse methodologies for enhancing the performance and reliability of these bridges, including finite element computation procedures for determining initial shapes, optimization techniques for managing cable forces, and analyses of vibration characteristics crucial for predicting dynamic responses. Additionally, the collection sheds light on the historical context of bridge engineering, showcasing the contributions of British expertise and highlighting notable examples of cable-stayed bridges from around the world. Furthermore, studies delve into classification methodologies based on cable patterns and the impact of different pylon shapes on bridge responses, offering valuable insights for optimizing bridge design and construction practices. Overall, this compilation serves as a comprehensive resource for researchers, engineers, and practitioners involved in cable-stayed bridge design and construction, providing a platform for advancing knowledge and fostering innovation in the field.

II. LITERATURE REVIEW

A significant amount of research work has been done on studying the Parametric study of Cable stayed bridge.

A. Anson K. H. Hui, et.al [01]

Cable-stayed bridges are an economically viable and efficient solution in civil engineering, benefiting from recent advancements in structural systems. They consist of a bridge deck supported by girders, with various types of cables, such as helically wound galvanized strands, parallel wire strands, and locked coil strands, transmitting loads to towers and anchorages. Parallel wire strands are particularly valued for their excellent modulus of elasticity. Iconic examples include the Vidyasagar Sethu Bridge in India, the Octavia Frias Bridge in Brazil, and the Golden Gate Bridge in the USA. Known for their stiffness, earthquake resistance, and cost-effectiveness, cable-stayed bridges are set to play a crucial role in future infrastructure development.

B. Bahareh Bannazadeh, et.al [02]

Cable-stayed bridges, with over 600 examples worldwide, span distances from 100 to 500 meters and are categorized into harp, fan, and radial cable configurations. The harp configuration is the most prevalent due to its ease of implementation. Since 2005, around 41% of these bridges have been built, with fan and harp configurations comprising 13% and 26%, respectively. The United States and Japan lead in cable bridge construction, reflecting their commitment to innovative infrastructure. These bridges typically have a main span to total length ratio of 0.1 to 0.45, showcasing diverse structural designs tailored to specific conditions and requirements. Diagrams illustrate global trends in cable patterns and span lengths, providing a comprehensive overview of cable-stayed bridge construction.

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C. Wang, T. C. Tseng, C. G. Yang [03]

The paper presented a finite element computation procedure for determining the initial shape of cable-stayed bridges, considering nonlinear effects such as beam-column, cable sag, and large displacement. The system equation was solved incrementally, with two iteration cycles introduced for equilibrium and shape iteration. The algorithm efficiently found an initial shape that reduced deflection and bending moments in girders, achieving a more accurate and uniform prestress distribution. The study provided a comprehensive approach to shape-finding for cable-stayed bridges, enhancing accuracy and efficiency in the computational process.

D. Alberto M.B. Martinsa, Luís M.C. Simoesa, Joao H.J.O. Negraoa [04]

Optimization in cable-stayed bridges had traditionally centered on managing cable forces and minimizing costs, but recent research expanded to include diverse applications such as sensor placement optimization. However, the use of metaheuristic algorithms in this field remained limited, with only 14.7% of works incorporating them due to their complexity. Future trends indicated a growing interest in innovative cable arrangements and optimizing for dynamic effects. Overall, there was a noticeable increase in research focusing on applying optimization algorithms across various bridge-related topics.

E. Wei-Xinrena, B, Xue-Lin Penga, You-Qin Lina [05]

The analysis of the cable-stayed bridge included free vibration analysis, which involved linear static analysis for initial equilibrium and pre-stressed modal analysis to enhance natural frequencies, crucial for predicting dynamic responses like earthquakes. Ambient vibration tests accurately predicted bridge modes, especially noting the low natural frequencies typical for cable-stayed bridges, with successful applications in various large-scale bridges. Modal parameter identification extracted damping properties through resampling and filtering for the frequency range of interest, enabling input-free vibration data analysis for health monitoring. The bridge itself, a 5-span composite structure with the longest main span of 605m among composite-deck bridges, was completed in 2000 and opened to traffic in 2002. Cable tension evaluation utilized the "taut string" chord equation for calculating cable tension, with ambient vibration measurements playing a key role in assessing stay cables, emphasizing the importance of accurately identified frequencies for cable evaluation.

F. Er. Rajinder Singh2, Ashwani3, Parasram Pandit [06]

Cable Stayed Bridges were essential structures for load transfer, utilizing various types of cables such as helically wound galvanized strands, parallel wire strands, and locked coil strands, with parallel wire strands commonly preferred due to their high modulus of elasticity. Notable examples of Cable Stayed Bridges included the Vidyasagar Sethu Bridge in Kolkata, India, the Octavia Frias Bridge in Brazil, and the iconic Golden Gate Bridge in the USA. These bridges offered advantages such as stiffness, earthquake resistance, rapid construction, and cost-effectiveness compared to traditional suspension bridges, indicating a promising future for this structural design.

G. Ahmed M. Fawzy, Khaled F. El-Kashif And Hany A. Abdalla [07]

The study focused on the impact of different pylon shapes on the static and dynamic responses of cable-stayed bridges. It included details on form-finding techniques, stay cable variations based on span lengths, and comparisons of seismic performance among various pylon shapes. The research also analyzed the seismic effects on the bridge structure, particularly in terms of longitudinal and transverse moments, shear forces, and torsional moments. Additionally, references to previous studies on cable-stayed bridges and pylon design were provided for context and comparison.

H. Rohini R. Kavathekar, 2dr. N.K. Patil [08]

The study focused on a cable-stayed bridge, analyzing spans of 100m to 300m using CSI Bridge software. The bridge impact factor was determined to be 1.088, with concrete of grade M75 and steel Fe1860. The modeling process involved selecting layout lines, frame and material properties, drawing pylons, cables, and defining construction stages. The analysis included parameters such as deck moment, response variations with span, pylon height, and girder thickness. Results indicated an increase in vertical forces, bending moments, pylon height, and cable numbers as the span length increased. The study provided insights into the behavior of the bridge under different loading conditions and span lengths, contributing to the understanding of cable-stayed bridge design and performance.

I. Thomas Blesson B. and S. P. Thakkar [09]

The analysis of vibration characteristics in the bridge revealed simple early space vibration modes with significant frequency differences, indicating weakened torsion coupling due to the pylon-girder connection. The implementation of Carbon Fiber Reinforced Polymer (CFRP) cables in the bridge offered solutions to corrosion and fatigue issues, while also reducing self-weight, enhancing span capacity, and minimizing substructure dimensions. The fabrication process involved precise tendon calculations, positioning plates, and alcohol cleaning for optimal performance. Seismic response analysis demonstrated that the values were lower than the static structure control values, ensuring the structure met ultimate bearing capacity and service requirements. The successful integration of CFRP tendons in the cable-stayed bridge marked a significant achievement, being the first of its kind in China, showcasing the effectiveness and reliability of this innovative construction approach.

J. R. Karthik Kumar Yadav E.Charan Deep Chand Goud Shaik Mohammed Sohail L.Dayananda M.Pavan Sai[10]

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The document discussed the historical significance of British engineering expertise in bridge construction, particularly highlighting their specialization in track bridge design and their innovative solutions to challenges posed by river flow and sediment. It also delved into the history of bridges in India, showcasing examples like the Attack Bridge that exemplified British engineering prowess. The report provided detailed insights into various types of bridges, including cable-stayed, box-girder, and rigid frame structures, along with in-depth calculations for dead loads, bending moments, and shear forces essential for design considerations.

K. Priyanka Singh1, Mirza Jahangir Baig1, Bhumika Pandey1, And Kartik Papreja1 [11]

The study focused on analyzing cable-stayed bridges with inverted Y-type, H-type, and A-type pylons using STAAD Pro software to compare shear force, bending moment, and displacement. The findings indicated that the A-type pylon design exhibited the highest efficiency among the three types. As a result, the study recommended the A-type pylon as the most efficient choice for cable-stayed bridges. Further research was suggested to explore the stability and efficiency of various components in bridge design.

L. Bahareh Bannazadeh1, A, Zahra Sadat Zomorodian2, B Mohammad Reza Maghareh [12]

This research paper focused on the classification of cable-stayed bridges based on cable patterns, specifically harp, fan, and radial patterns, and their relationship with the main span length. The study analyzed 103 cable bridges and found that harp patterns were predominantly used, while fan patterns were preferred for longer spans due to their efficiency in conducting forces. The results indicated that fan patterns accounted for only 13% of the cases, showcasing the dominance of harp patterns in cable-stayed bridge construction.

III. FINDINGS

Study on cable-stayed bridges Design, Behaviour, and Performance

1. It is seen that Cable stayed bridge on MIDAS civil analysis is rarely carried on.

2. The angle of a cable-stayed bridge gives a huge impact on the bridge.

3. The proposed finite element computation procedure effectively determined the initial shape of cable-stayed bridges, addressing nonlinear effects such as beam-column interaction, cable sag, and large displacement. This approach resulted in an initial shape that reduced deflection and bending moments in girders, achieving a more accurate and uniform prestress distribution.

4. While traditional optimization in cable-stayed bridges focused on managing cable forces and minimizing costs, recent research has diversified to include sensor placement optimization. However, the adoption of metaheuristic algorithms remains limited due to their complexity. Future trends suggest a growing interest in innovative cable arrangements and optimization for dynamic effects.

5. Analysis focused on the impact of different pylon shapes on cable-stayed bridge responses. The study highlighted the A-type pylon design as exhibiting the highest efficiency among the tested types, recommending further research to explore the stability and efficiency of various components in bridge design.

6. The classification study of cable-stayed bridges based on cable patterns revealed that harp patterns were predominantly used, with fan patterns preferred for longer spans due to their efficiency in conducting forces. Notably, fan patterns accounted for only 13% of the cases, showcasing the dominance of harp patterns in cable-stayed bridge construction.

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