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Review on Box Girder Bridge Structures

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Abstract: The Bridge decks are one of the basic components of the bridge that forms its surface. This current research reviews and analyses focuses on various aspects of bridge design, evaluation, and performance under different loads and conditions. Researchers have conducted investigations into reinforced concrete girder bridges, seismic evaluations, structural deficiencies, and the use of innovative materials. The studies highlight the need for bridge upgrades, considering seismic actions and the desired performance level. The analysis of existing bridges reveals the importance of evaluating their capacity and implementing rehabilitation measures. These studies are based on both experimental and numerical techniques.

***IndexTerms* - Bridge deck, FEA**

I. Introduction

The Bridge decks are one of the basic components of the bridge that forms its surface. The bridge deck may either be cast-in-situ, precast, steel, wood, concrete, or other pavement systems which are supported on concrete or steel girders or beams (composite bridges). The bridge decks are most often defines the characteristics of the bridge. In a suspension bridge, the deck is suspended from the main structural element.

Figure 1: Bridge deck design [16]

In the case of a Tied arch or cable-stayed bridge, the deck is the main structural element that carries the load and transfers it via cables. Also, the deck has an important role in establishing the aesthetic appearance of the bridge. So while designing a bridge, it is very important to give special attention to decks to maintain good serviceability, safety, and appearance, etc. The deck system varies according to the bridge structure, types of construction methods. Here we discuss various types of bridge decks;

II. LITERATURE REVIEW

In their study, Dzolev et al. (2019) [1] examined reinforced concrete girder bridges constructed in compliance with the 19.2 standard. The bridges were constructed using both limited and unconfined concrete with and without geometric non-impact, with the aim of assessing the flexibility achieved in plastic hinges during displacement of targets for seismic action as specified for sections.

The seismic assessment case studies for an existing RC bridge were conducted by Kulkarni and Karadi [2] using static nonlinear (impulse) analysis. The current research focused on the assessment of a 4-span RC bridge located at SH-12 in Karnataka, India. The capacity spectrum approach (ATC 40) and SAP2000 software were employed to conduct a linear non-linear static analysis (thrust) of FEMA 356 for the purpose of span evaluation. The findings of this assessment suggest that the designated bridge necessitates enhancement to achieve the desired level of functionality. The pushover analysis is employed to determine the performance level of the bridge.

Sharma (2018) [3] employed static nonlinear analysis to perform assessments on pre-existing reinforced concrete bridges. The Hindon River bridge located in Ghaziabad, Uttar Pradesh, consisting of three spans, was chosen for seismic analysis. Due to its placement in Zone 4, the area exhibited a high degree of vulnerability to seismic events. Hence, it is plausible that a seismic event of considerable magnitude (potentially surpassing 7 on the Richter scale) could transpire within this locality. The software application was utilised to assess the seismic behaviour of the bridge in the event of an earthquake. The open view method was utilised to describe the various capabilities of the bridge by means of comparing several outcomes of nonlinear analysis, both static and dynamic in nature. An assessment was conducted utilising Chang and Mender's tangible materials. The aforementioned material was employed to assess the present capacity of the bridge to endure damage to its elements in the event of seismic activity.

The intended Krishna River bridge, which includes the current bridge connecting Sitanagaram and Mahanagar to Mahanadi Road, is discussed in detail by Kumar and Ram [4], who delve into its investigation and design. The bus terminal located in Vijayawada. The steel-type structures of the bridge's upper level facilitate a carriageway road with three lanes, whereas the lower level accommodates two railway tracks. The section's length corresponds to that of a neighbouring railway viaduct. The structural components of upper deck members, truss members, and lower deck members have been subjected to analysis utilising STAAD.Pro software. The design of the structural members, upper deck, and lower deck of the truss members was conducted in accordance with the Indian Railway Standard Code and the Indian Highway Congress Code. The integration of a singular structure for both road and rail traffic, as opposed to the implementation of two separate bridges, results in a reduction of construction expenses for the road and rail bridge. The purpose of this infrastructure is to cater to the increasing transportation needs of both rail and vehicular traffic in the vicinity of the Krishna River. The construction of a singular bridge mitigates the challenge of land acquisition.

The article by Kanth and Prasad [5] outlines a simplistic approach to bridge design. All facets of the redesign will be thoroughly examined. The scope of this endeavour was aimed at incorporating the architectural blueprint of the novel bridge, its ecological ramifications, and the operational aspects of its erection. The completion of this task necessitates the utilisation of a diverse range of sources. A comprehensive analysis of the bridge's history will be necessary to assess the inadequacies of the current structure, encompassing concerns such as elevation discrepancies and the quality of its piers. Furthermore, it is imperative to identify and implement the ASHHO design standards for the construction of this bridge.

Karthiga et al. [6] conducted a linear study on the rail substructure of the bridge, taking into consideration both the Class A IRC load and the IRS 25T rail load. The bridge is equipped with road spans that facilitate the functionality of the road. In contrast, it is noteworthy that the railway bridge has the capability to be operated from the rail situated above the spans. The objective of this endeavour was to discern the diverse forces exerted on the framework and scrutinise the railway and bridge intersections on the bridge utilising STAAD PRO. The Stad Pro was utilised to provide coverage for the flyover road of the bridge. A comparison is made between the crucial sections of bridge rail and pier. In the context of IRS and IRC codes, the assessment of burdens and combinations of loads is deemed significant.

Monteiro et al. [7] aimed to employ modelling techniques to tackle the aforementioned matter. Most contemporary seismic analyses of structures integrate hinge structural models that are either plastic or fiber-based. The accounting of nonlinear behaviour of components necessitates the development of diverse approaches, parameters, and calibration procedures, contingent upon the chosen option. Parametric research was conducted to compare the accuracy of modelling options in various bridge designs. This research involved contrasting thrust curves and NSP findings, which utilise these thrust curves. Every modelling type addresses concerns regarding its applicability, encompassing its benefits and/or constraints.

Paolacci et al. (2019) [8] state that flat steel rods are typically used in the design of structures intended for gravity loading. The insufficient seismic expansion in bridges has resulted in suboptimal structural performance during seismic events. Given the uncommon state of the art in the field of existing bridges, it was imperative to establish dependable methodologies for assessing the seismic vulnerability of extant bridge structures. The purpose of the document was to furnish extensive directives for the seismic assessment and enhancement of bridges.

Li et al. (2019) [9] conducted a study on the seismic responses of reinforced concrete (RC) bridges affected by rust corrosion under earthquakes of different intensities. The study investigated the phenomenon of corrosion induced by chloride. The degree of severe corrosion at the bridge piers was assessed by measuring the fluctuation in chloride corrosion current density over time. The

Monte Carlo simulation method is utilised to calculate the probability distribution of the reinforcement diameter of the bridge column and the elastic limit at different time stages subsequent to service in the bridge.

According to Cao and Yuan's research [10], it is imperative to consider the non-elastic impact of the second mode in the primary examination of bridges that have raised pile foundation systems. The practicality of applying generalised analysis directly is not feasible in this particular scenario. A novel approach, known as the modified generalized-push method, was devised to assess the seismic demands of bridges featuring elevated-pile foundation systems. The analysis of bridges utilising raised pile foundation systems involves the application of modified generalised impulse techniques, modal impulse analysis, and incremental dynamic analysis.

The authors Mahmood and Al-Ghabsha [11] utilised the finite element method to analyse the cross-sectional properties of a prism and employed the Fourier series to accurately represent its longitudinal behaviour, thereby providing support for the boundary conditions in a bus. The extremes have been satisfied. The explicit time integration method was employed to solve the motion equation for each bridge and vehicle. The current investigation involved the formulation of the bridge motion equation, which was developed without consideration for damping. Due to the distinct nature of each equation, it is unfeasible to determine a solution for the complete system of equations.

The investigation of a T-frame bridge was conducted by Lu et al. [12] through the utilisation of a spatial grid model. The study compares the static and dynamic outcomes of the spatial grid model for the T-frame bridge, based on the results obtained from field testing. Empirical evidence suggests that the utilisation of the spatial grid model is a viable approach to conducting T-frame bridge analysis, characterised by a degree of ease and straightforwardness.

The Bhil structure was deemed susceptible to potential collapse in the absence of identification and remediation of any underlying structural deficiencies. Numerous bridges across the globe were designed to their maximum capacity when the bridge code did not account for unstable design or when the provisions for such design were in compliance with this criterion. Furthermore, a significant number of bridges in India are experiencing degradation due to the natural process of ageing and the subsequent exponential rise in transportation volumes and magnitudes. The restoration and rehabilitation of old and deteriorated bridges is imperative to maintain their load-bearing capacity and repair functionality. This is due to the fact that building new bridges is a costly and time-consuming process [13].

The authors Abbasi and Pahwa [14] conducted a comprehensive analysis of the dynamic and static parameters associated with a bridge structure that utilises cable suspension. According to simulations, the primary factor responsible for displacement on cable suspension bridges is heavy traffic, rather than air pressure. Thus, it is evident from our analysis that the cable suspension bridge necessitates traffic monitoring. Furthermore, we have derived results from static analysis that explicitly eliminate traffic, however, it would be advantageous to present a more all-encompassing perspective of the entire endeavour.

The rheological properties of gussasphalt were examined by Zhong et al. (2019a) [15] through dynamic shear test and bending beam rheological test, with a focus on the impact of different superheat ageing conditions. Fourier transform infrared spectroscopy (FTIR) was utilised to examine alterations in functional groups pre and post ageing, leading to the identification of macroscopic and mesoscopic ageing mechanisms of gussasphalt.

In 2022, Jiang and colleagues introduced a new polyurethane composite (PUC) utilising polycarbonate diol, which exhibits remarkable resistance to rutting and low-temperature fracture. This finding was reported in their publication [16].

III. CONCLUSION

In conclusion, these studies contribute to the understanding of bridge design, evaluation, and performance enhancement, covering areas such as seismic analysis, structural deficiencies, load capacity, rehabilitation, and material properties. The findings emphasize the need for upgrading existing bridges, considering environmental impacts, and applying appropriate design standards for improved performance and safety.

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