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A REVIEW ON FINITE ELEMENT ANALYSIS AND OPTIMIZATION OF BRIDGE GIRDER USING ANSYS AND RSM

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Abstract

The bridge structures are designed to sustain heavy moving loads, wind loads. These loads tend to induce high stresses and deformation on the structure. The current research reviews the existing work on design and development of bridge structure. The sustainability, strength of bridge structure is assessed by various researchers and is presented in the study. The damages are incurred on the bridge girders and bridge deck due to environmental factors and loading conditions are also presented in the study.

Keywords: *Bridge, damage, natural frequency.*

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1. INTRODUCTION

The field of bridge engineering is basically a profession that deals with the study of the design, function, maintenance, construction and development of road infrastructures with various types of bridge works, such as piles and culverts [1]. However, low efficiency, high labor and increasing environmental impacts [2–4] are often seen as a trade-off in architecture, engineering and construction, with a large fraction of savings included. The construction of the bridge is shown in Figure 1 below.

Figure 1: Bridge structure

The bridge has three main elements. First, the substructure (foundation) transfers the loaded weight of the bridge to the ground; it consists of components such as columns (also called piers) and supports. The abutment is the connection between the end of the bridge and the road supported by the ground; provides support for the end sections of the bridge. Second, the bridge superstructure is a horizontal platform that spans the space between the columns.

2. LITERATURE REVIEW

Jeong-Tae Kim et. al. [1] studied a vibration-based damage monitoring scheme to alert the occurrence, location, and severity of damage under conditions of temperature-induced uncertainty. Both damage localization and damage sizing results were very accurate when the pre-damage and post-damage frequencies were obtained from the same temperature conditions. In contrast, this accuracy decreased with increasing temperature gap.

Brownjohn et al [2] conducted an ambient vibration survey of the Humber Bridge in July 2008 by a team from Great Britain, Portugal and Hong Kong. obtained using three techniques, the Natural Excitation Technique/Eigensystem Realization Algorithm, Stochastic Subspace Identification, and the Poly-Least Squares Frequency Domain method, are compared with each other and with those obtained from the 1985 bridge test, which shows several significant changes in the modal parameters over 23 years in cases where a direct comparison is possible. Approximate parameters show significant variability between different methods and variations within the same method, while also varying over time and having inherent variability. Bridge vibration is quite well known and many studies have been done and many parameters have been investigated. New technologies were used to monitor the condition of bridges.

Real-Time Wireless Vibration Monitoring for Functional Modal Analysis of Integral Abutment Highway Bridge Matthew J. Whelan et. al. [3]. Remote structural health monitoring systems using sensor-based quantitative assessment of structural health are seen as the future in long-term bridge management programs. The study found that the use of stochastic SSI subspace identification techniques to approximate modal parameters from only output experimental data was found to be preferable to the frequency domain decomposition FDD method despite the increased computational effort and subjectivity required to recognize the system poles.

A research and study of more than 500 bridge failures by Wardhana and Hadipriono [4] considering events from 1989 to 2000 concluded that common cases of failure occur due to a triggering event. Careful, short-term hydraulic events, long-term abrasion, collision, and overloading accounted for 73% of documented collapse, while structural element deterioration, design errors, and structural-related issues resulted in nearly 12% of failures. . The response of a sensor-based monitoring system would pre-emptively signal such deterioration that a renovation or closure plan could be implemented prior to unsafe operation.

A review of recent wireless sensor operations for monitoring the health of integral bridges (Pakzad et. al. [5], Paek et. al. [6], Lynch et. al. [7]) reveals that networks have generally relied on either local data logging and transmitting data from sensors after sampling or at a low sampling rate and/or limited number of sensors to focus on transceiver bandwidth limitations. Such allowances severely limit the flexibility and capability of a structural health monitoring system in terms of sampling period, data collection rate, and spatial resolution, as well as the quality of derived mode shapes.

Banerjee [8] presented a simplified method of free vibration and flutter analysis of integral bridges. An analytical method for the free vibration and oscillation analysis of bridge decks can be obtained by explicitly deriving each term required for the entire analysis. The method is free from the ill-conditioning problems usually associated with complex (numerical) matrix manipulation. The speed and frequency of oscillation of three illustrative examples of integral bridges were demonstrated using the proposed method. It is clearly seen that this field needs more research to discover the integral bridge vibration and to study the factors influencing the vibration analysis of integral bridges and the effect of integral bridge vibration due to traffic movement on integral bridge substructures and also the washing phenomenon.

Kim et al. [9] conducted extensive experiments on the variability of dynamic properties of bridges caused by changing temperature conditions. They sought to correlate modal properties with temperature and also to extend system identification models that could separate the effects of temperature from true indications of damage on dynamic modal parameters.

Yeunga and Smithb [10] developed a study for the perception of the onset of bridge damage, using the dynamic response spectrum evaluated from non-stop monitored instruments, together with neural networks for pattern recognition. Finally, a reliable damage identification rate of about 70% can be achieved even with a small amount of noise added to the dynamic response signals.

Brownjohn et al [11] conducted an ambient vibration survey of the Humber Bridge in July 2008 by a team from Great Britain, Portugal and Hong Kong. obtained using three techniques, the Natural Excitation Technique/Eigensystem Realization Algorithm, Stochastic Subspace Identification, and the Poly-Least Squares Frequency Domain method, are compared with each other and with those obtained from the 1985 bridge test, which shows several significant changes in the modal parameters over 23 years in cases where a direct comparison is possible. Approximate parameters show significant variability between different methods and variations within the same method, while also varying over time and having inherent variability. Bridge vibration is quite well known and many studies have been done and many parameters have been investigated. New technologies were used to monitor the condition of bridges.

An assessment and measurement of vibration-based damage detection for an integral abutment bridge was carried out by Siddique et al [12]. It was found that localized damage to the upper concrete cover of the bridge deck could be reliably detected and located if the sensors were placed close enough to the damage and if the uncertainty in the mode shapes was mitigated using a reasonable number of retests. .

Real-Time Wireless Vibration Monitoring for Functional Modal Analysis of Integral Abutment Highway Bridge Matthew J. Whelan et. al. [13]. Remote structural health monitoring systems using sensor-based quantitative assessment of structural health are seen as the future in long-term bridge management programs. The study found that the use of stochastic SSI subspace identification techniques to approximate modal parameters from only output experimental data was found to be preferable to the frequency domain decomposition FDD method despite the increased computational effort and subjectivity required to recognize the system poles.

A research and study of more than 500 bridge failures by Wardhana and Hadipriono [14] considering the events from 1989 to 2000 concluded that common cases of failure occur due to a triggering event. Careful, short-term hydraulic events, long-term abrasion, collision, and overloading accounted for 73% of documented collapse, while structural element deterioration, design errors, and structural-related issues resulted in nearly 12% of failures. . The response of a sensor-based monitoring system would pre-emptively signal such deterioration that a renovation or closure plan could be implemented prior to unsafe operation.

A review of recent wireless sensor operations for monitoring the health of integral bridges (Pakzad et. al. [15], Paek et. al. [16], Lynch et. al. [17]) reveals that networks have generally relied on either local data logging and transmitting data from sensors after sampling or at a low sampling rate and/or limited number of sensors to focus on transceiver bandwidth limitations. Such allowances severely limit the flexibility and capability of a structural health monitoring system in terms of sampling period, data acquisition rate, and spatial resolution, as well as the quality of derived mode shapes.

Banerjee [18] presented a simplified method for free vibration and flutter analysis of integral bridges. An analytical method for free vibration and bridge bridge shake analysis can be obtained by explicitly deriving each term required for the entire analysis. The method is free from the ill-conditioning problems usually associated with complex (numerical) matrix manipulation. The speed and frequency of oscillation of three illustrative examples of integral bridges were demonstrated using the proposed method. It is clearly seen that this field needs more research to discover integral bridge vibration and to study the factors influencing the vibration analysis of integral bridges and the effect of integral bridge vibration due to traffic movement on integral bridge substructures as well as scouring phenomenon.

Pramod et. al. [19] This paper deals with evaluation studies for an existing RC bridge using nonlinear static analysis. A 3-span bridge located on the Hindon River in Ghaziabad (Uttar Pradesh) is selected for the seismic assessment of the bridge. This area is highly vulnerable to seismic activity as it lies in zone – 4. An earthquake of magnitude (may be greater than 7 degrees) can occur in this area. . The open see software is used for the seismic evaluation of the bridge at the time of the earthquake. The open tables model is used to describe different bridge performances. By comparing different results obtained through non-linear analysis (static and dynamic). The concrete developed by Chang and Mander is used for the assessment. This new material is used in the assessment of increasing the existing bridge capacity against damage to the bridge element during seismic activity. From the various evaluation results, it is worked out that the bridge structure under the designed seismic oscillation is safe, and the results obtained from this displacement analysis are verified through the results obtained from the dynamic analysis. This work is basically based on the use of force-based beam-column elements and their formulation of concentrated plasticity element and distributed plasticity element models. Open software is used in this work to create finite element models using this software.

Krishna Kumar et al [20] This paper deals with the analysis and design of the superstructure of road and rail bridge over river Krishna proposed on the downstream side of the existing bridge between Mahanadu road from Sithanagaram and P.N.Bus station, Vijayawada. The bridge is made of steel truss type, which carries two railway tracks in the lower level and a three-lane carriageway in the upper level. The length of the span corresponds to the length of the existing nearby railway bridge. Analyzes of upper story members, truss members, and lower story members are performed using STAAD.Pro. The design of truss structural members, upper deck members and lower deck members is done as per Indian Railway Standard Code and Indian Road Congress Code. In which they concluded that the Road with Railway Bridge reduces construction costs by providing one bridge for both rail traffic and road traffic instead of providing two separate bridges. It meets the increased needs of rail and road transport across the Krishna River.

Karthiga et al [21] This paper deals with adesign minor Bridge. We plan on covering every aspect of the redesign. This is going to include the design of the actual replacement bridge, the affect this bridge will have on the surrounding area through an environmental impact, and the logistics associated with the construction phase. In completing this project, we are going to have to use a number of tools. We will have to get bridge history reports in order to see the deficiencies of the current bridge, including height issues and pier quality. We are also going to have to determine what the ASHTO design standards are and apply them to this bridge. Through these events, along with others, we expect to get a good understanding of the construction phase and end up with a product similar to what was designed and approved by Mass Highway for this bridge. STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion.

3. CONCLUSION

The damage assessment is conducted on bridge structure by various researchers. Their research findings have shown that vibration, heavy traffic and corrosion are the major factors causing damage to the bridge structures. The girder design, pier design and brick deck thickness significantly affect the vibration characteristics and stability of bridge. The damage on the bridge structures can be determined using various types of numerical and experimental techniques. Some of the experimental techniques include stochastic subspace identification SSI techniques, sensor-based monitoring system and Frequency Domain Decomposition.

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