IFERP connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 10, Issue 9, September 2023

Structural Health Monitoring of Bridge Using Wireless Sensors

[1] Supriya Mane, [2] R.A. Chougule

[1] Student, Civil Engineering Department, A.D. college of engineering and technology, Ashta Maharashtra, India
[2] Professor Civil Engineering Department, A.D. college of engineering and technology, Ashta Maharashtra India
[1] supya09090@gmail.com

***Abstract*— This paper studies the structural health monitoring, damage detection and localization of bridges using wireless sensor networks (WSNs). Continuous monitoring of bridges to detect damage is a very useful tool to avoid unnecessary and costly emergency maintenance. The goal of optimal design is to maximize system lifetime, senser data accuracy, system reliability, and minimize system cost and complexity.**

The deployment of a wireless sensor network on an existing highway bridge in Qatar was carried out to evaluate the preliminary results of the project model, quantify the response of the current bridge, and demonstrate the ability of the SHM system to perform successfully on the bridge. The proposed technology will eventually be applied to the new stadium that Qatar will build in preparation for the 2022 World Cup. This monitoring system permanently records the vibration levels reaching all the carriages during each event, helping to assess the true state of health of the stadium. This gives you a chance to spot potentially dangerous situations before they become serious.

Finite element analysis (FEA) is performed using CSI Bridge software to determine sensor locations and measurement types, effectively minimizing the number of sensors, data to transmit, and amount of data to process.

Index Terms*— Finite Element Analysis FEA, Wireless Sensor Networks (WSN), highway bridge Analytical study, Experimental outcomes, reliability of code guidelines.

I. INTRODUCTION

Bridge structures, one of the most important components of urban infrastructure systems, are gradually deteriorating due to traffic loads and environmental factors. Bridge structures should be continuously monitored to assess their structural integrity and reduce maintenance and inspection costs. At the same time, safety provides the public with all measurements commonly used for bridge monitoring. Displacement is the most important variable to evaluate maintainability. The safety and integrity of the bridge is directly related to its carrying capacity.

However, it is generally difficult to measure the displacement response of full-scale bridges with currently available approaches due to limitations such as sensor cost, sensor placement, and accuracy. Structural health monitoring of bridge structures generally refers to the process of designing, developing and implementing damage diagnosis of the structural condition.

The structural health monitoring system is a method to evaluate and monitor the health of the structure. It is widely used in various engineering disciplines because it can improve structural reliability and life cycle management. In bridge maintenance, it is important to determine the displacement response of the bridge under live loads. Theoretically, displacement is the double integral of acceleration. Learn about the dynamic deformation that can cause stress and ultimately lead to a displacement injury. Bridges in service are constantly vibrating due to passing vehicles, and it is difficult to estimate boundary conditions and perform numerical integration. For this reason, I am working on a mobile app that provides direct navigation through an accelerometer.

II. METHODOLOGY

A. General

The study of this theory relies on linear and non-linear investigations of RC bridge structures with variable cross-sections. In this section, we provide an overview of the various boundaries that characterize the computational model, fundamental assumptions, and RCC calculation considered in this study. In nonlinear inspection, it is important to accurately represent the nonlinear characteristics of various fundamental components.

Computational Model

Display of structural receipts, display and collection of various load-bearing components that the model needs to be completed, discussion of printed circulation quality, hardness and deformation, material properties and basic components used in the present study. Using CSI Bridge2023 software for this study. A demonstration is provided below.

Design Data

Kerbs and railing M35,
Piers M15,
Pier cap M20
Abutment M15

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 10, Issue 9, September 2023

Abutment Cap Dirt Wall M20
Weep Holes M35
Returns M15
Railing M20
Sub-Structure M15
Steel Fe 415 for all sections
Concrete IS 456-2000.
Column Sizes:
Piers 11.885 X 1.27 M
Piers cap 13.76 X 2.50 M
Abutment bed 12.30 X 4.59 M
Abutment 12.00 X 3.99M
End beam size 0.9X0.96X0.30M
Slab thickness 0.20M

B. Figures of bridge

In bridge analysis we used piers, abutment, concrete slab etc. below is plan and elevation of bridge we are created model in CSI Bridge2023 software.

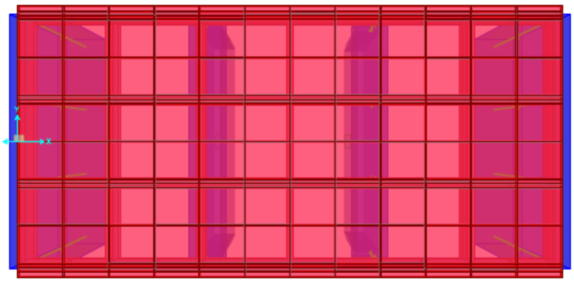

Fig-1 plan view of bridge

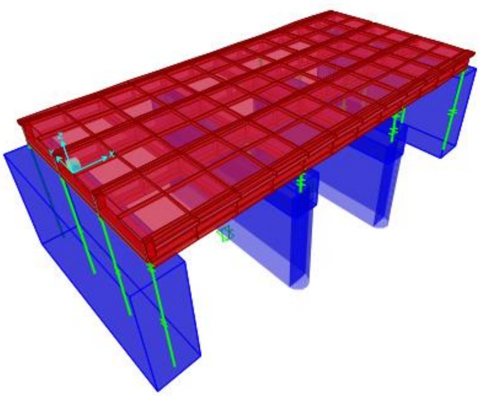

Fig-2 3D View of Bridge

III. LOAD AND LOAD COMBINATION

1) Dead load: - Dead load is a static force that remains relatively constant over time.

2) Live loads: - Live loads include temporary or transient forces.

3) Wind load: - Wind load is used to refer to the pressure or force exerted by the wind on the building or structure.

4) Seismic loading: - Seismic loading is one of the basic concepts in earthquake engineering, meaning the use of earthquakes in structures caused by earthquakes. This can occur in the ground of a structure, in contact with an adjacent structure, or with gravity waves from a tsunami.

5) Barrier Load: - The barrier load shall consider the applied load that the barrier shall bear during use.

6) Sidewalk load: - The sidewalk load is the part of the sidewalk that is located between the curb line and the street line and must be built according to the specifications of the Ministry of Transportation for concrete sidewalks.

7) Temperature: - Changes in the effective temperature of the bridge cause expansion and contraction of the slab. The temperature difference between the top surface of the deck and the various surfaces throughout the depth of the deck causes the deck to deform.

8) Railings:- Bridge railings are protection systems designed to prevent people and vehicles from falling off the bridge. It can be made of concrete or steel.

9) Shock loads: - Shock loads on bridges are due to sudden loads caused by the movement of vehicles on the bridge. When the wheels are in motion, the live load periodically changes from one wheel to another, resulting in an impact load on the bridge.

10) Vehicle load:- Vehicle load is a type of vehicle that moves on the bridge.

We are giving here tow type of load combination service and resistant showing in figure.

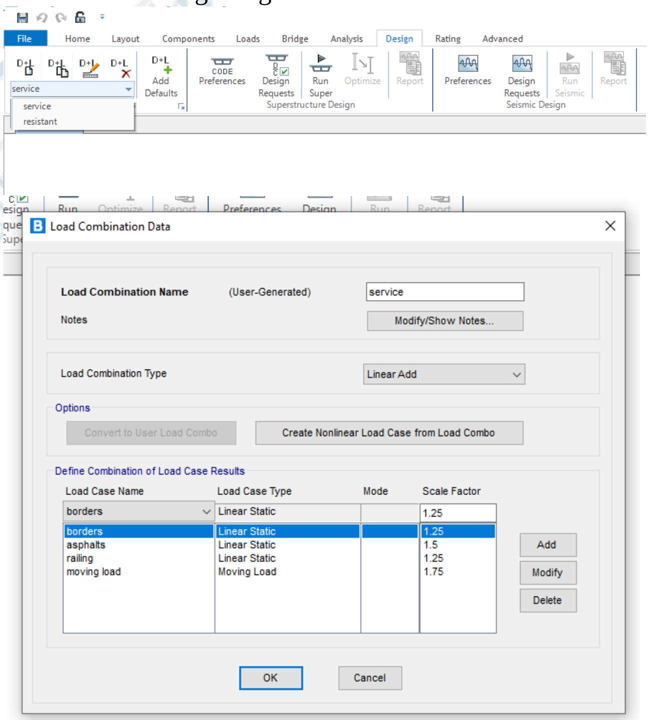

Fig-3 Load Combination Data

IV. RESULTS

The strategy embraced using SHM device and recorded reading. The outcomes (Output) are determined after the

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 10, Issue 9, September 2023

examination is begun. At that point these techniques are analyzed in conversations of results.

A. SHM Device Results

This shows vibration range plots got from different vehicle as show in below.

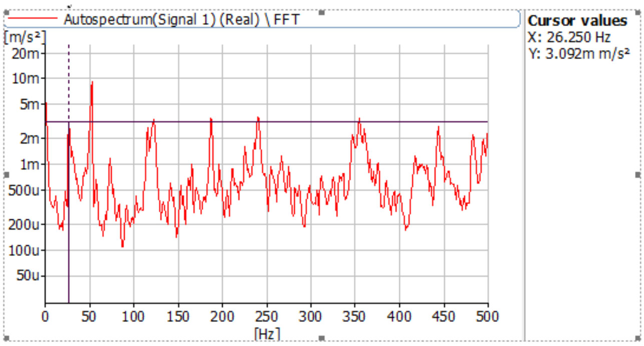

Fig-4 Cycle Reading

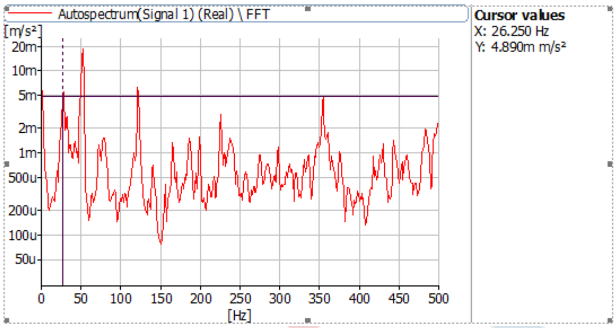

Fig-5 two wheeler reading

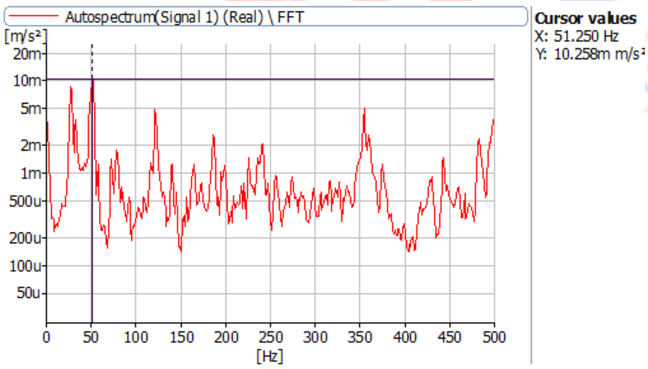

Fig-6 four wheeler reading

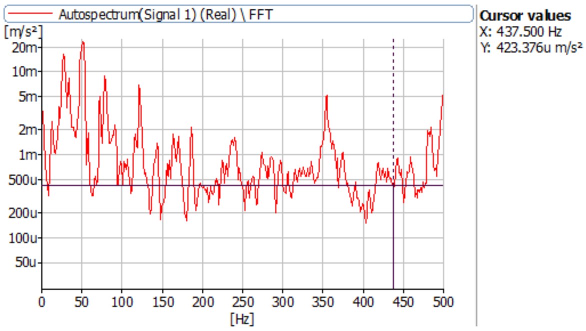

Fig-7 Truck wheeler reading

B. Software Analysis Results

We are using CSI-bridge for modling of bridge. So we can applying all type of load like dead load, live load, vehicle load, pedestrian load, railing load etc. following results are given software CSI Bridge.

Output Case	Step Type	GlobalFX	GlobalFY	GlobalFZ
Text	Text	KN	KN	KN
service	Max	-8.248E-07	3.045E-07	31403
service	Min	-8.248E-07	3.045E-07	31403
resistant	Max	-8.248E-07	3.045E-07	31403
resistant	Min	-8.248E-07	3.045E-07	31403

Table-1 Base Reaction

Joint	U1	U2	U3
	m	m	m
1	-0.001034	0.000621	-0.001987
1	-0.001693	0.00044	-0.002109
1	-0.001034	0.000621	-0.001987
1	-0.001693	0.00044	-0.002109
169	-0.002428	0.000182	-0.00066
169	-0.002933	-0.000182	-0.002545
169	-0.002428	0.000182	-0.00066
169	-0.002933	-0.000182	-0.002545
270	-0.002458	-0.000016	-0.003448
270	-0.002996	-0.000231	-0.005415
270	-0.002458	-0.000016	-0.003448
270	-0.002996	-0.000231	-0.005415

Table-2 Joint Displacement

OutputCase	Item	Static	Dynamic
Text	Text	Percent	Percent
MODAL	UX	98.954	41.7305
MODAL	UY	76.822	24.2027
MODAL	UZ	91.5662	20.2177

Table-3 Modal Load Participation Ratios

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 10, Issue 9, September 2023

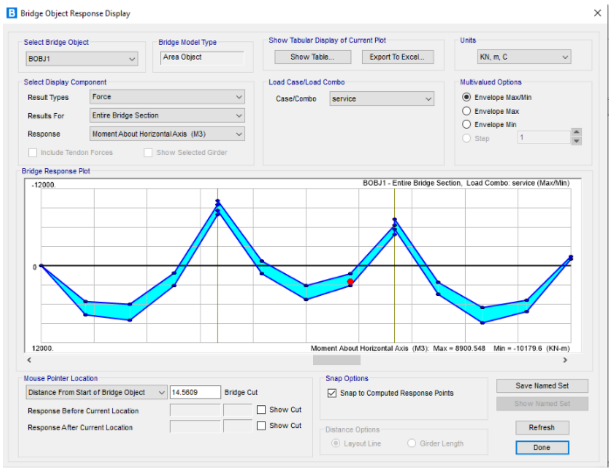

Fig-8 B.M. For load combination (service)

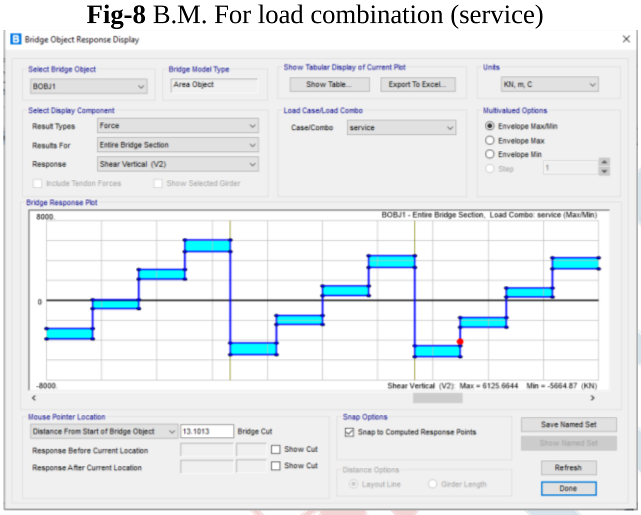

Fig-9 S.F.For load combination (service)

V. Conclusion

Based on the results and discussion presented in Chapter 5, the following conclusions can be drawn.

- This paper studies bridge structure health monitoring, damage detection and localization using wireless sensors (WS). The motivation of this research is the need to improve the efficiency and accuracy of the inspection and maintenance operations of the current road bridge. The use of SHM in bridge structures enables continuous monitoring of bridge conditions and avoids unnecessary and costly emergency maintenance. To this end, wireless monitoring systems provide a new approach, maximizing system lifetime, measuring data accuracy, system reliability, and minimizing system cost, thus reducing the costs of current SMH systems.
- First, an extensive literature review on structural health monitoring, vibration-based damage detection techniques, and operational modal analysis will be presented. By comparing the relative advantages and disadvantages of the various methods presented so far, promising techniques and areas for further research are identified.
- Finite element analysis (FEA) was performed using CSI Bridge v23.3.1 software to simulate the behavior of a reduced reinforced concrete frame three-span bridge. Show the model development for each structure. The types of elements used in the model are covered in each section along with the assumptions and constitutive parameters for different materials. In addition, the model geometry, loads and boundary conditions are also shown. The mode shapes obtained from the modal frequency analysis are displayed. The dynamic load analysis of a three-span bridge was carried out using CSI bridge facilities and seismography.
- Designing a SHM system is a systematic effort that integrates different expertise. Chapter 3 first describes SHM design criteria for large-scale bridges. In the following, the common types of sensory systems used are introduced. This chapter will focus on wireless monitoring as a new and promising approach to sensing, transmission and monitoring systems. In addition, the design and implementation of power harvesting and power consumption optimization for autonomous operation of SMH monitoring systems using wireless sensor networks are also briefly described. Finally, a long-term structural health monitoring system using wireless sensor networks (WSN) on a highway bridge is presented. The results obtained from FEA are used to determine the location of the sensors and the type of measurement, the number of sensors (here we provide sensors in the middle and both ends of the bridge), the data to transmit, and effectively the amount of data to process.

REFERENCES

[1] Mohd Zulkifli Mohd Yumsa, Nuremira tbrahimh and Fatimah Shafinar Ahmid “A Review on Bridge Dynamic Displacement Monitoring Using Global Positioning System and Accelerometer” (2018)

[2] Chiara Bedon, Enrico Bergamo, Matteo Izzi and Salvatore Noé “Prototyping and Validation Of MEMS Accelerometers for Structural Health Monitoring The Case Study of the Pietrutalita Cable Stayed Bridge” (2018)

[3] Cristian-Claudiu Comisua,*, Nicolae Taranub , Gheorghita Boacaa , Maria-Cristina Scutaru “Structural health monitoring system of bridges” (2017)

[4] Hidebiko Sekiya, Kentaro Kimura and Chitoshi Miki “Technique for Determining Bridge Displacement Response Using MEMS Accelerometers” (2016).

[5] Shinae Jang and Billie F. Spencer, Jr., “Structural Health Monitoring for Bridge Structures using Smart Sensors” NSEL-035 May 2015.

[6] Jong-Woong Park, Sung-Hun Sim and Hyung-lo Jang “Wireless displacement sensing system for bridges using multi-sensor fusion” (2014)..

[7] Andrea E. Del Grosso “Structural Health Monitoring research and practice” (2014).

[8] Sabato “Pedestrian bridge vibration monitoring wing a wireless MEMS Accelerometer board” (2013).

[9] Ignacio González, “Study and Application of Modern Bridge Monitoring Techniques,” ISRN KTH/BKN/B-110-SE November 2011.