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VIBRATION ANALYSIS OF STEEL DECK BRIDGE

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Abstract: The majority of human actions include some type of vibration. For instance, we hear due to the vibration of our eardrums and see due to the vibration of light waves. Breathing is connected with lungs vibrating, while walking is related with (periodic) oscillatory motions of the legs and hands. The oscillatory motion of the larynx (and tongue) is required for human speech. The early researchers in the subject of vibration focused on studying natural events and constructing mathematical models to describe the vibrating of physical systems. Numerous technical uses of vibration have been developed in recent years, including the design of machinery, foundations, buildings, engines, turbines, and control systems. The majority of primary movers have illogical difficulties as a result of the engines' intrinsic imbalance. The imbalance might be the result of poor design or production. For example, an imbalance in diesel engines can generate ground waves large enough to constitute a nuisance in metropolitan areas.

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I INTRODUCTION

The majority of human actions include some type of vibration. For instance, we hear due to the vibration of our eardrums and see due to the vibration of light waves. Breathing is connected with lungs vibrating, while walking is related with (periodic) oscillatory motions of the legs and hands. The oscillatory motion of the larynx is required for human speech (and tongues). The early researchers in the subject of vibration focused on studying natural events and constructing mathematical models to describe the vibrating of physical systems. Numerous studies have been prompted in recent years by engineering applications of vibration, including the design of machinery, foundations, structures, engines, turbines, and control systems.

The majority of prime movers exhibit vibrating issues as a result of the engines' inherent imbalance. The imbalance might be the result of poor design or production. For example, an imbalance in diesel engines can generate ground waves large enough to constitute a nuisance in metropolitan areas. At high speeds, the wheels of some locomotives can lift more than a centimetre off the track owing to imbalance. Vibrations trigger dramatic mechanical breakdowns in turbines. Engineers have not been able to completely eliminate turbine failures caused by blade and disc vibrations. Naturally, buildings supporting large centrifugal machines, such as motors and turbines, or reciprocating machines, such as steam and gas engines and reciprocating pumps, are also prone to vibration. In any of these cases, the vibrating structure or machine component may fail due to material fatigue caused by the cyclic fluctuation of the produced stress. Additionally, vibration accelerates the wear of machine components such as bearings and gears and generates excessive noise. Vibrations in machinery can release fasteners such as nuts. Vibration can result in chatter during metal cutting processes, resulting in a poor surface quality. When a machine or structure's inherent frequency of vibration coincides with the frequency of an external stimulation, a phenomenon known as resonance occurs, resulting in excessive deflections and failure. The literature is replete with stories of system failures caused by component resonance and excessive vibration. Vibratory systems include ways for storing potential energy (springs), kinetic energy (mass or inertia), and mechanisms for progressively losing energy (damper). A system's vibration occurs when energy is alternately transferred between its potential and kinetic states. In a damped system, some energy is lost with each cycle of vibration and must be replenished externally to maintain a constant vibration. Although a single physical structure can store and disperse kinetic and potential energy, this chapter addresses only lumped parameter systems made of ideal springs, masses, and dampers, each of which serves a single purpose. Displacements are defined in translational motion as linear lengths; in rotational motion, displacements are defined as angular movements.

1.1 Objectives

Within this over all aim the main objectives are defined as below,

1. Study of steel girder bridge under influence of moving Time in accordance with IRC.

2. To analyses design parameters such as type of truss, bridge behavior using finite element modeling tool in ANSYS and its verification.

3. To check Response of steel deck bridge under influence of moving Time using FRP.

II LITERATURE REVIEW:

It was discovered that a substantial amount of study has been undertaken on bridge vibration caused by movement time. The majority of existing literature and experimental effort has been devoted to the vibration of bridges caused by shifting time. The following literature searches were conducted for "A Study of Steel Deck Bridge Due to Moving Time Vibration."

Ana Lipeng, Dejian Li, Yua Peng, Yuan Peng To investigate the coupled dynamic response of a vehicle bridge and its change rule with respect to various parameters, a vehicle model with seven degrees of freedom was constructed and the total potential energy of the vehicle space vibration system was derived. The dynamic response equation for the vehicle–bridge coupled system was created using the elastic system concept of total potential energy with stationary value and the "set-in-right-position" rule. The dynamic response of a long span continuous girder bridge during vehicle time was investigated using a self-compiled Fortran application and bridge engineering. Additionally, this study calculated the vehicle impact coefficient, assessed vibration comfort, and analysed dynamic response characteristics. The results indicate that the impact coefficient varies with the number of lanes and is more than the value established by the "general code for highway bridges and culverts design in China". In typical conditions, the Dieckmann index of bridge vibration is also connected to the lane count, and the vibration comfort rating is favourable. The insights drawn from parametric calculations have practical implications for the dynamic design and operation of long-span continuous girder bridges on expressways. Safety and comfort are predicted to increase greatly when the vibration of the vehicle–bridge system is progressively controlled.

Suren Chen, Yufen Zhou Vehicle ride comfort concerns affect drivers not just personally, but also in terms of driving safety and long-term health. A novel technique for analysing ride comfort for typical automobiles travelling on long-span bridges is described, taking into account actual traffic and climatic conditions such as wind excitations. Complex interactions between the long-span bridge, all cars in the traffic flow, and wind excitations are adequately represented using the modelling framework created earlier by the authors. The ride comfort condition of a vehicle is evaluated by extending the advanced procedures recommended in the ISO 2631-1 standard to scenarios involving multiple vehicles in stochastic traffic flow, including obtaining the whole-body vibration response, frequency weighting the original response, and calculating the Overall Vibration Total Value (OVTV). The suggested technique is then demonstrated using a prototype long span cable-stayed bridge and traffic system. The study begins with a baseline scenario in which cars are driven on a rigid road without regard for the supporting structure or wind excitations, and then moves on to situations in which cars are driven over a bridge. Additionally, the effects of dynamic interactions, the presence of other vehicles, and wind excitations on ride comfort are quantified statistically.

Zhang, Y., and Zhu, D. The random reactions of a linked vehicle-bridge system to track abnormalities are investigated in this article. Each vehicle in the train model is composed of a stiff body, two bogies, and four wheels, while the bridge is composed of three-dimensional Euler beam components. The train and bridge's motion equations are constructed separately. By removing the dependent DOFs, the coupled system's equation of motion may be obtained based on the displacement compatibility condition of the interface with track imperfections. When track abnormalities are viewed as stationary random processes, the coupled system is stochastically analysed using the pseudo-excitation method (PEM), and a technique for estimating the mean extreme value of non-stationary responses is provided.

Wroclaw, J. Zwolski Wroclaw, P. Rawa Wroclaw, J. Bie The forced vibration test is a technique that enables us to examine the dynamic features of steel bridge structures as they change. In some instances, it aids in the monitoring of their technical condition. This article describes the implementation of a monitoring system by a team from the Wroclaw University of Technology. The current paper describes a full computer-based system for programming and controlling vibration testing, as well as data collecting and processing. As an illustration of the monitoring system's practical utility, the results of steel footbridge testing are provided. Because the tested suspended structure was outfitted with mass dampers during refurbishment, extra attention was made to identifying changes in dynamic properties produced by the dampers.

Mr. Patel G R Vesmawala S G Vesmawala Vibration testing of bridges can provide extremely useful information on the behaviour and performance of the structure throughout its service life. Ongoing research is being conducted to examine the structural state and overall integrity of the bridge using vibration-based evaluation. Localized or global structural distress results in a decrease in the stiffness and free energy stored in the system or structure. Vibration response is regulated by system parameters (stiffness, mass, and damping) under the impact of ambient and force stimulation; changes in these factors may result in changes in vibration response characteristics such as natural frequencies, mode shapes, and modal damping. The bridge structure's dynamic reaction is determined. Modal and system characteristics can be determined from this measured response. These discovered characteristics can be utilised to monitor the bridge constructions' performance. Additionally, analytical models may be utilised to validate the application of these parameters. This article provides an in-depth examination of the ambient vibration testing of bridges.

Phyoe Thiri Kyaw Lin Htat, Ph.D. This article discusses the vibration analysis of a steel truss bridge across a range of movement times using the STAAD-Pro software. The planned bridge is a through-truss warren truss. The bridge spans 240 feet. On a bridge, the following timings are taken into account: dead times, live times, wind times, impact effects, seismic effects, and temperature effects. For vehicle live time, two forms of timing are considered (train and truck timings). The truck is an AASHTO-specified HS25-44 and the train is an IRS-specified metre gauge train. The bridge model is based on the AASHTO (2010) timing combination. The design of structural steel members is considered in accordance with the design criteria specified in the AISC-ASD Specifications. Deflection testing is used to ensure that the structure is safe at all times. Vibration analysis considers movement times as harmonic timing and then analyses the vibration effect. Finally, this vibration analysis is discussed and conclusions are drawn.

Antonino Luca Della Longa,Morassi Rotaris, Anna This article discusses a type of free vibrations that occur during the operation of a two-span, two-lane steel-concrete bridge. The deck construction is described as a thin, homogenous, orthotropic plate that is strengthened along the bridge's longitudinal axis by beams. The variable separation approach is used to obtain exact solutions for a class of a structure's free vibrations. A comparison of analytical and experimental data for the bridge's inherent frequencies and vibration modes is provided and analysed.

Joel P. Conte1, Geert Lombaert Vehicle-bridge interaction has been investigated for a long period of time in order to better understand bridge structural behaviour and vehicle ride comfort. The author presents an innovative frequency domain strategy for solving the vehicle-bridge interaction issue in a frame of reference that travels with the vehicle. The contact force's Fourier transform is computed immediately from the vehicle and bridge compliance values, without requiring any iterations. The approach is particularly advantageous when a closed-form solution for the bridge compliance is known, as is the case when the bridge is modelled using a simply supported Euler-Bernoulli beam. As a result, the solution is well-suited for parametric investigations of the bridge and vehicle reaction characteristics and serves as a starting point for more complex bridge and vehicle models or more intricate bridge designs (e.g., continuous beam on multiple supports). Additionally, the frequency domain technique improves physical comprehension by demonstrating how the contact force decomposes into a term arising from the bridge's dynamic reaction to the continuous moving Time component and a term originating from road surface unevenness.

III METHODOLOGY:

The finite element method (FEM) is the most widely used approach for simulating and forecasting the physical behaviour of systems and structures. Due to the fact that analytical answers to the majority of daily issues in engineering sciences are not accessible, numerical approaches such as FEM have emerged to discover solutions to the governing equations of the particular problem. Over the last three decades, significant research has been conducted in the subject of numerical modelling, enabling engineers to do simulations that are near to reality. In structural mechanics, nonlinear phenomena such as nonlinear material behaviour, massive deformations, and contact difficulties have evolved into typical modelling jobs. Due to fast advancements in the hardware industry, which have resulted in increasingly powerful CPUs and reducing memory prices, it is now possible to simulate models with millions of degrees of freedom.

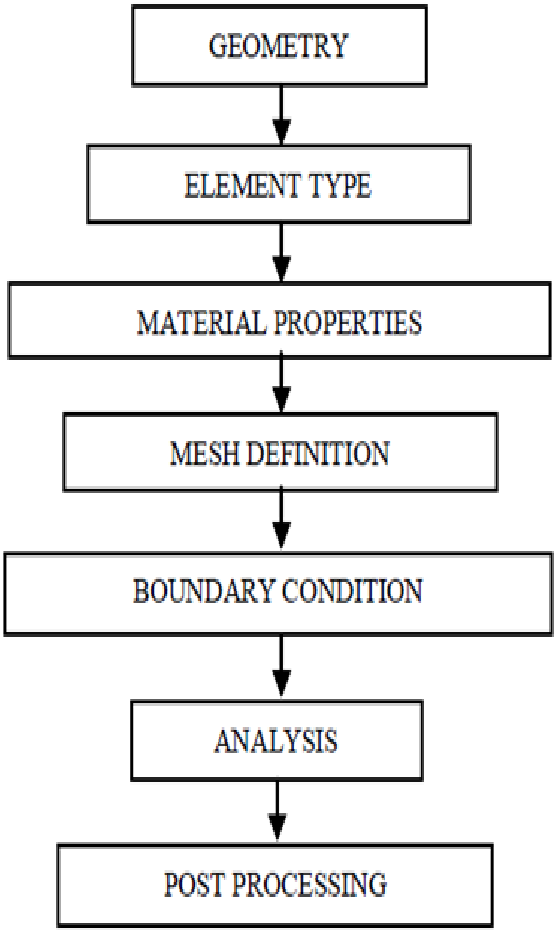

Fig.1 Solutions Technique and Steps

In a mathematical sense, a finite element solution always provides an approximation of the numerical solution to the issue at hand. It is not always straightforward for an engineer to determine if the solution achieved is excellent or poor. If experimental or analytical findings are provided, every finite element result may be easily verified. However, in order to reliably forecast any structural behaviour without doing tests, each user of a finite element programme needs have a working knowledge of the finite element approach in general. Additionally, he should have a firm grasp of the underlying programme in order to assess the suitability of the selected pieces and methods. This document will summarise ANSYS's capabilities for producing the most accurate finite element analysis results possible. Numerous ANSYS capabilities are demonstrated, and whenever feasible, we demonstrate what is currently implemented in ANSYS. Workbench 14.

3.1 Material Modelling

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials. The geometrical representation of is show in SOLID186

3.2 Failure criterion

Two limits are established to define the ultimate Time for each finite element investigation: a lower and an upper bound, corresponding to concrete compressive strains of 0.2%, and 0.35%, respectively. These two limits define an interval in which the composite beam collapse Time is located. A third limit condition, hereinafter referred to as the stud failure point, can also be reached when the composite beam's most heavily Timed stud reaches its ultimate Time, as defined from the appropriate push-out tests. If the stud failure point is located before the lower bound of concrete (i.e., the corresponding Time of the stud failure point is smaller than the lower bound Time) then the mode of failure of the composite beam is considered as being stud failure. Conversely, if the stud failure point is located after the upper bound of concrete, the mode of failure is assumed as being concrete crushing. For the intermediate case, where the stud failure point lies between the lower and upper bounds of concrete, than the mode of failure could be either of them. Therefore, the proposed finite element model is able to predict the failure modes associated with either slab crushing or stud failure.

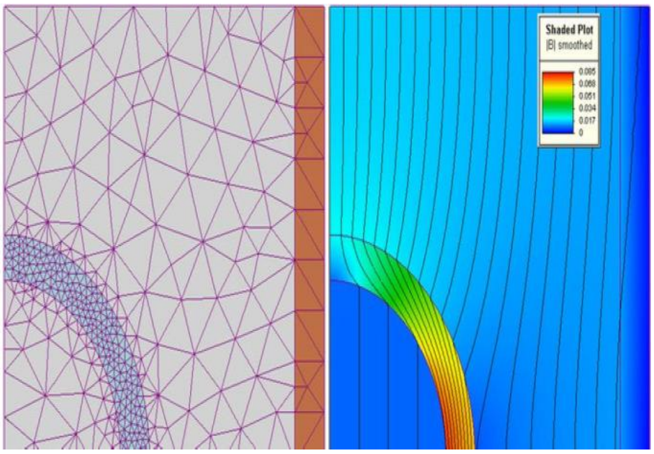

Fig.2 Finite Element Method

FEA is a technique used to evaluate structures and systems. It is advantageous for problems with complex geometries, timings, and material characteristics that cannot be solved analytically. For many years, the finite element approach was the logical option for modelling and analysis of reinforced concrete structures. Finite elements are exceptional in their ability to adapt to nearly any shape that is physically realisable. Thus, the finite element approach has gained popularity as a suitable tool for the study of flat plates, particularly those with extremely irregular or unique geometries that do not lend themselves to direct design or analogous frame procedures. It can be demonstrated that the finite element approach properly solves for the stress distribution. Few of these accomplishments have been translated into practical applications for structural engineers working in design offices. While much theoretical work has been devoted to the application of nonlinear constitutive modelling to reinforced concrete, the majority of currently deployed software packages only support linear elastic finite elements.

3.3 Problem Statement

This chapter analyses a steel deck bridge with an effective span of 35m, a slab thickness of 100 mm, and a section area of 85.91cm2. The deck has a section depth of 350mm, a flange width of 250mm, and a web thickness of 8.3 mm. Ixx=19159.7 centimetres, Iyy=2451.4 centimetres, rxx=14.93 centimetres ryy=5.34 kilogrammes, w=67.4 kilogrammes

Material Characteristics

SOLID STEEL fy=248 MPa yield strength (33 ksi) Elastic modulus, Es= 200 GPa (29,000 ksi)

CONSISTENT Ec =26.3 GPa modulus of elasticity (3.81 ksi)

FRP Elastic modulus, E = 30 GPa Xt =1700 MPa ultimate tensile strength Xc = 639.54 MPa ultimate compression strength Density = 2100 kilogrammes per cubic metre

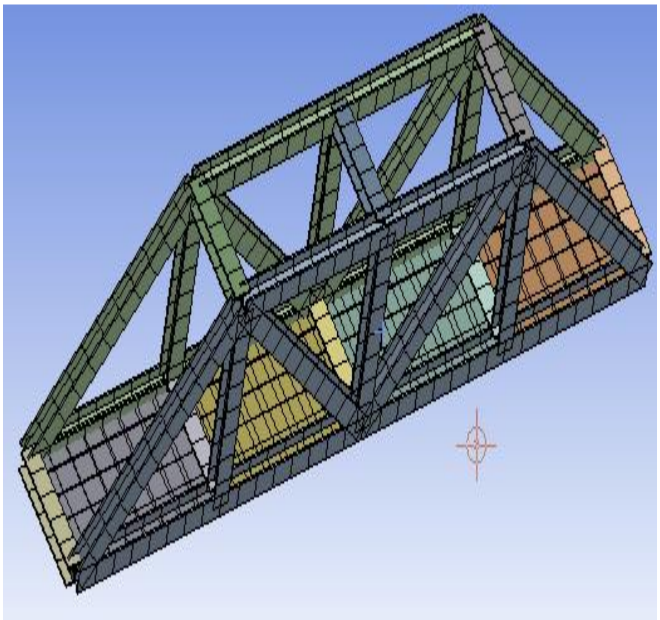

Fig.3 Mesh Formation

Cases Consideration

- Case 1 - FRP Thickness 50 mm
- Case 2 - FRP Thickness 100mm
- Case 3 - FRP Thickness 150mm

Timing Consideration

1. IRC Class AA
2. IRC Class A

In this study transient analysis is performed in ANSYS 16 which time dependant. A moving Time apply according to IRC Class AA Timing and IRC Class A Timing is passing through bridge deck for time period of 1min. Hence the time interval is taken as 0.2 second for each step.

IV THEORETICAL CONTENTS

4.1 What is an FRP bridge deck?

The phrases superstructure and substructure are frequently used to refer to the components of a bridge above the bearings. The superstructure refers to the components of the bridge above the bearings, while the substructure refers to everything below the bearings. The deck and girders/beams are the primary components of the bridge superstructure (Figure 1.1). In this discussion, a FRP bridge deck is described as a structural part constructed of FRP materials that transmits time transversely to the bridge supports, which may include longitudinal running girders, cross beams, and/or stringers bearing on abutments.

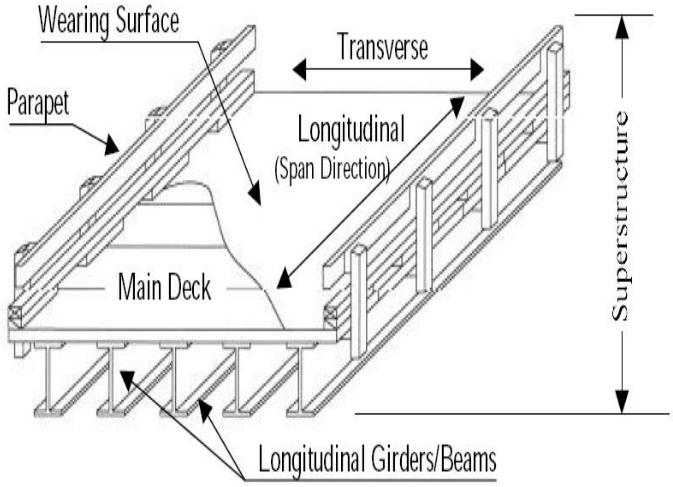

Fig.4 Superstructure of a bridge illustrating bridge engineering terms

Different from conventional construction materials, FRP is an engineered material. Engineers can design the material properties and structural shapes of FRPs based on their requirements. Therefore, it is essential to know the composition of FRP material. FRP material consists of two major components: a polymer matrix resin and fiber reinforcements. Fillers and additives, as a third component, can improve certain characteristics of the final product.

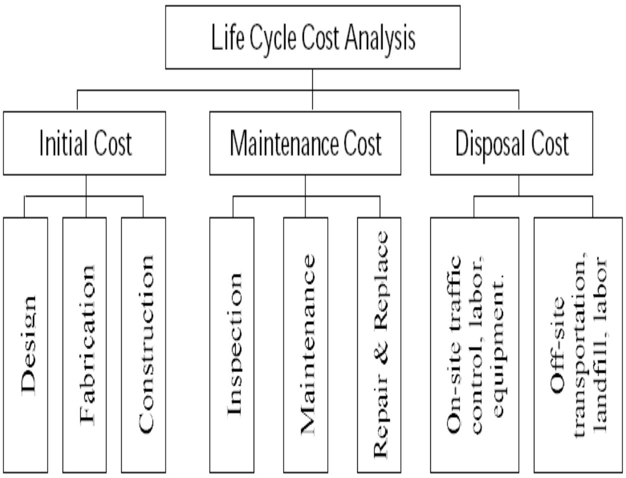

Fig.5 Cost classification scheme for FRP bridge decks

4.2 Benefits and Challenges of FRP Bridge Decks

Over the last decade, FRP bridge decking have effectively transitioned from experimental research to field use. In the United States alone, over 100 bridges have been built or rebuilt using FRP bridge deck technology. This section outlines the major advantages and disadvantages of FRP bridge decking based on laboratory and field testing results.

The following benefits outline the use of FRP bridge deck systems:

1) FRP's non-corrosive qualities can help extend the life of a FRP bridge deck;
2) Superior results from a tightly controlled production environment;
3) FRP bridge decks are easier and faster to construct than conventional bridge decks, resulting in reduced traffic control time and less negative environmental impact;
4) Due to the lightweight nature of FRP bridge decking, it is possible to improve a bridge's live time carrying capacity without modifying the substructure;
5) In comparison to conventional materials, FRP has a high strength-to-weight ratio but a low rigidity. Due to the rigidity requirements for FRP bridge deck systems, this novel bridge deck has a very high safety factor.
6) FRP bridge decks are an excellent alternative for steel truss bridges and moveable bridges from the nineteenth and twentieth centuries, as they may reduce deck dead time and increase structural integrity.
7) The expected endurance of FRP material translates in significant cost savings associated with bridge deck replacement and maintenance, resulting in lower life cycle costs.

Although many benefits have been proven by laboratory tests and field projects, there are still some challenges in the use of FRP bridge deck systems:

The high initial cost is a significant impediment to the development of the FRP bridge deck business. Constrained construction budgets make it difficult to justify allocating more expenditures at the start, despite the comparatively cheap life cycle cost of FRP bridge decks;

The FRP bridge deck was designed using finite element analysis. On the market, there are no established criteria or requirements for the design and construction of FRP bridge decks;

Due to the lightweight nature of FRP bridge decks, the superstructure of the bridge may be aerodynamically unstable, particularly for large-scale bridges (Tang, 2003);

For field installation, the joint details, which include those between FRP panels, must be checked and refined.

The wearing surface's durability must be carefully considered;

There is still a need for knowledge exchange between composite engineers and bridge engineers.

V CONCLUSIONS:

The following conclusions have been drawn based on the results obtained from present study:

1. For movement time, a FRP bridge deck performs better.
2. FRP reduces total deformation by 25%, which can have an effect on the design approach for steel deck bridges.
3. Strain energy was shown to be greater in the presence of FRP than in the absence of FRP.
4. Normal stress is 20% less than it is without FRP.
5. Without FRP, shear stress is 20% to 25% less, indicating improved shear resistance against vibration caused by moving. The passage of time
6. FRP layers can be utilised to repair bridge decks.
7. In accordance with the time step Total deformation normal stress, shear stress, and strain energy are continuously decreased when a FRP layer is used for IRC Class A. Total deformation normal stress, shear stress, and strain energy are continually decreased with the use of a FRP layer for IRC Class AA.
8. In ANSYS vibration study, the use of FRP reduces the response peak displacement by 15%.

VI SCOPE FOR FUTURE WORK

- Another area that could benefit from extensive research is the vibration analysis and design of precast girders with base isolation systems.
- The study of structural system vibrational behaviour could be expanded by using additional software.

REFERENCES:

[1] M. Kawatani, S. Nishiyama, Y. Yamada, Dynamic response analysis of highway girder bridges under moving vehicles, Technology Reports of the Osaka University 43 (1993) 109–118.

[2] P.K. Chatterjee, T.K. Datta, Vibration of continues bridges under moving vehicles, J. Sound Vib. 169 (1994) 619–632.

[3] T.L. Wang, D.Z. Huang, Cable-stayed bridge vibration due to road surface roughness, J. Struct. Eng. ASCE 118 (1992) 1354–1373.

Y.F. Song, Highway Bridge Dynamics, China Communications Press, Beijing,

[4] AASHTO – LRFD Bridge Design Specifications, Fifth Edition, 2010.

Bridge Rules by Indian Railway Standard, 2008.

[5] Structural Steel Designer's Handbook by Robert L.Nickerson and Dennis Mertz.

[6]Dynamics of Structures, 3rd Edition by Ray W.Clough and Joseph Penzien.

[7] Dynamic Behavior and Vibration Control of High Speed Railway Bridge through Tuned Mass Dampers.

[8] Vibration and Shock Handbook by Clarence W.de Silva.

Benčat, J. Technical Report, Monitoring Test Results of the D–201–HMO Highway Bridge – Lafranconi,.