A Study of Effect of FRP On Steel Girder Bridge Due to Moving Load

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Abstract- *The bridge engineer is to design economical structures which are safe, durable, Determining the dynamic response of bridges has been the topic of numerous studies in recent years. In this paper vibrations of steel deck bridge are calculated using FFT. based assessment of the bridge structure to evaluate the structural condition and overall integrity. A structural distress, locally or globally leads to de-creasing in stiffness and free energy stored in the system or structure. Due to moving load, force excitation, vibration response is influenced by system parameters (stiffness, mass and damping), changes in these parameters may lead to changes in the vibration response such as natural frequencies, mode shapes and modal damping. The dynamic response of the bridge structure is analyzed using FEA tool ANSYS WORKBENCH. Furthermore comparative study is done in accordance with FRP model of bridge. Finally conclusions are made using vibration analysis and IRC class AA loading*

Keywords- Steel deck bridg Moving Load, FRP, ANSYS

I. INTRODUCTION

1.1 General

Most human activities involve vibration in one form or other. For example, we hear because our eardrums vibrate and see because light waves undergo vibration. Breathing is associated with the vibration of lungs and walking involves (periodic) oscillatory motion of legs and hands. Human speech requires the oscillatory motion of larynges (and tongues

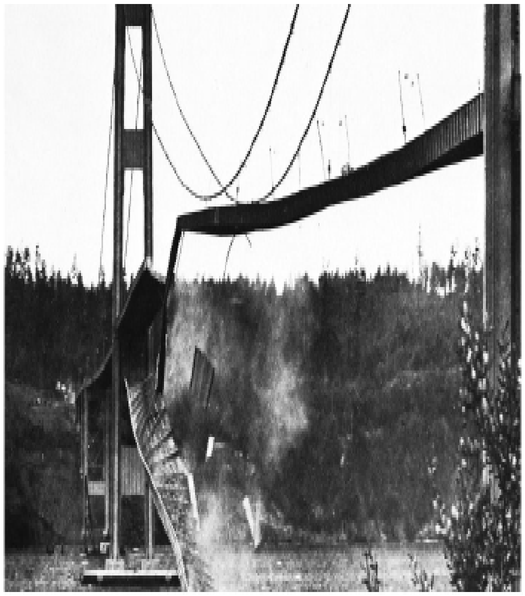
Understanding the natural phenomena and developing mathematical theories to describe the vibration of physical systems. In recent times, many investigations have been motivated by the engineering applications of vibration, such as the design of machines, foundations, structures, engines, turbines, and control systems.

Most prime movers have vibration problems due to the inherent unbalance in the engines. The unbalance may be due to faulty design or poor manufacture. Imbalance in diesel engines, for example, can cause ground waves sufficiently powerful to create a nuisance in urban areas. The wheels of some locomotives can rise more than a centimeter off the track at high speeds due to imbalance. In turbines, vibrations cause spectacular mechanical failures. Engineers have not yet been able to prevent the failures that result from blade and disk vibrations in turbines. Naturally, the structures designed to support heavy centrifugal machines, like motors and turbines, or reciprocating machines, like steam and gas engines and reciprocating pumps, are also subjected to vibration. In all these situations, the structure or machine component subjected to vibration can fail because of material fatigue resulting from the cyclic variation of the induced stress. Furthermore, the vibration causes more rapid wear of machine parts such as bearings and gears and also creates excessive noise. In machines, vibration can loosen fasteners such as nuts. In metal cutting processes, vibration can cause chatter, which leads to a poor surface finish. Whenever the natural frequency of vibration of a machine or structure coincides with the frequency of the external excitation, there occurs a phenomenon known as resonance, which leads to excessive deflections and failure. The literature is full of accounts of system

Failures brought about by resonance and excessive vibration of components and systems Vibratory systems comprise means for storing potential energy (spring), means for storing kinetic energy (mass or inertia), and means by which the energy is gradually lost (damper). The vibration of a system involves the alternating transfer of energybetween its potential and kinetic forms. In a damped system, some energy is dissipated at each cycle of vibration and must be replaced from an external source if asteady vibration is to be maintained. Although a single physical structure may store both kinetic and potential energy, and may dissipate energy, this chapter considers only lumped parameter systems composed of ideal springs, masses, and dampers wherein each element has only a single function. In translational motion, displacements are defined as linear distances; in rotational motion, displacements are defined as angular motions.

1.2 Importance of the Study of Vibration

Most human activities are involve in vibration one form or other. For example, we hear because our eardrums vibrate and see because light waves undergo vibration. Breathing is associated with the vibration of lungs and walking involves (periodic) oscillatory motion of legs and hands. Human speech requires the oscillatory motion of larynges (and tongues).Early scholars in the field of vibration concentrated their efforts on understanding the natural phenomena and developing mathematical theories to describe the vibration of physical systems. In recent times, many inv engineering applications of vibration, such as the design of machines, foundations, structures, engines, turbines, and control systems. Most prime movers have vibrational problems due to the inherent unbalance in the engines. The unbalance may be due to faulty design or poor manufacture. Imbalance in diesel engines, for example, can cause ground waves sufficiently powerful to create a nuisance in urban areas.



1.3 Free Vibration. If a system, after an initial disturbance, is left to vibrate on its own, the ensuing vibration is known as free vibration. No external force acts on the system. The oscillation of a simple pendulum is an example of free vibration.

1.4 Forced Vibration. If a system is subjected to an external force (often, a repeating type of force), the resulting vibration is known as forced vibration. The oscillation that arises in machines such as diesel engines is an example of forced vibration.

If the frequency of the external force coincides with one of the natural frequencies of the system, a condition known as resonance occurs, and the system undergoes dangerously large oscillations. Failures of such structures as buildings, bridges, turbines, and airplane wings have been associated with the occurrence of resonance.

1.5 Undamped and Damped Vibration

If no energy is lost or dissipated in friction or other resistance during oscillation, the vibration is known as undamped vibration. If any energy is lost in this way, however, it is called damped vibration. In many physical systems, the amount of damping is so small that it can be disregarded for most engineering purposes. However, consideration of damping becomes extremely important in analyzing vibratory systems near resonance

1.6 Linear and Nonlinear Vibration

If all the basic components of a vibratory system the spring, the mass, and the damper behave linearly, the resulting vibration is known as linear vibration. If, however, any of the basic components behave nonlinearly, the vibration is called nonlinear vibration. The differential equations that govern the behavior of linear and nonlinear vibratory systems are linear and nonlinear, respectively. If the vibration is linear, the principle of superposition holds, and the mathematical techniques of analysis are well developed. For nonlinear vibration, the superposition principle is not valid, and techniques of analysis are less well known. Since all vibratory systems tend to behave nonlinearly with increasing amplitude of oscillation, knowledge of nonlinear vibration is desirable in dealing with practical vibratory systems. If the value or magnitude of the excitation (force or motion) acting on a vibratory system is known at any given time, the excitation is called deterministic. The resulting vibration is known as deterministic vibration.

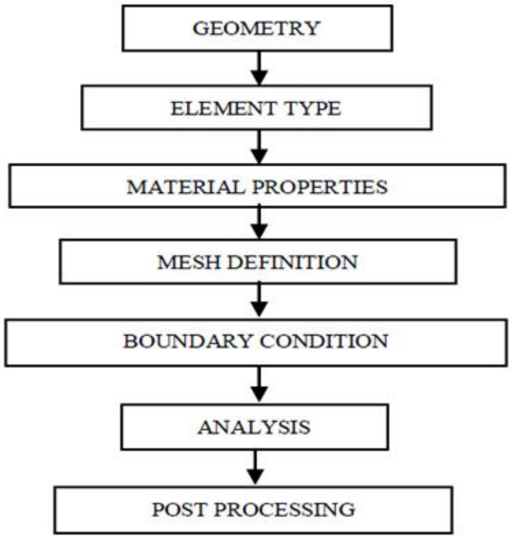


Fig.2 Solution technique and step

II. METHODOLOGY

The finite element method (FEM) is the most popular simulation method to predict the physical behaviour of systems and structures. Since analytical solutions are in general not available for most daily problems in engineering sciences numerical methods like FEM have been evolved to find a solution for the governing equations of the individual problem. Much research work has been done in the field of numerical modelling during the last thirty years which enables engineers today to perform simulations close to reality. Nonlinear phenomena in structural mechanics such as nonlinear material behaviour, large deformations or contact problems have become standard modelling tasks. Because of a rapid development in the hardware sector resulting in more and more powerful processors together with decreasing costs of memory it is nowadays possible to perform simulations even for models with millions of degrees of freedom. In a mathematical sense the finite element solution always just gives one an approximate numerical solution of the considered problem. Sometimes it is not always an easy task for an engineer to decide whether the obtained solution is a good or a bad one. If experimental or analytical results are available it is easily possible to verify any finite element result. However, to predict any structural behaviour in a reliable way without experiments every user of a finite element package should have a certain background about the finite element method in general. In addition, he should have fundamental knowledge about the applied software to be able to judge the appropriateness of the chosen elements and algorithms. This paper is intended to show a summary of ANSYS capabilities to obtain results of finite element analyses as accurate as possible. Many features of ANSYS are shown and where it is possible we show what is already implemented in ANSYS.16 Workbench.

III. PROBLEM STATEMENT

In this chapter the steel deck bridge analyses
With effective span 30m , slab thickness
100m and section area 85.91cm^2.The deck
having depth of section(h) 350mm, width of flange
(b) 250mm, thickness of web (tw) 8.3 mm
Ixx=19159.7 cm^4, Iyy=2451.4cm^4 rxx=14.93cm
ryy=5.34 ,w=67.4kg

Material Property
STEEL
Yield strength, fy= 248 MPa (33 ksi)
Modulus of elasticity, Es= 200 GPa (29,000 ksi)
CONCRETE
Modulus of elasticity, Ec =26.3 GPa (3.81 ksi)
FRP
Modulus of elasticity, E = 30 GPa
Ultimate tensile strength, Xt =1700 MPa
Ultimate compression strength, Xc = 639.54 MPa
Density = 2100 kg/m^3

IV. RESULT AND DISCUSSION

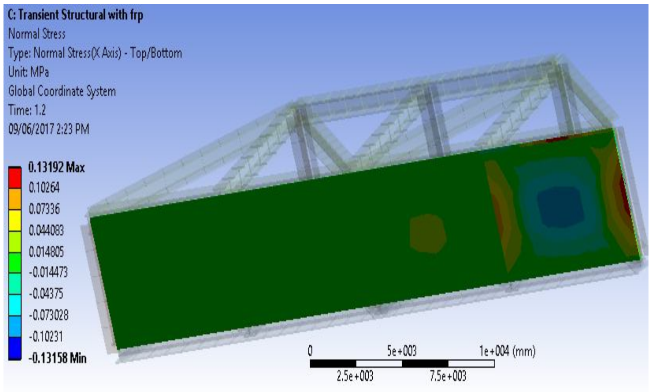


Fig.3 Normal stress with frp

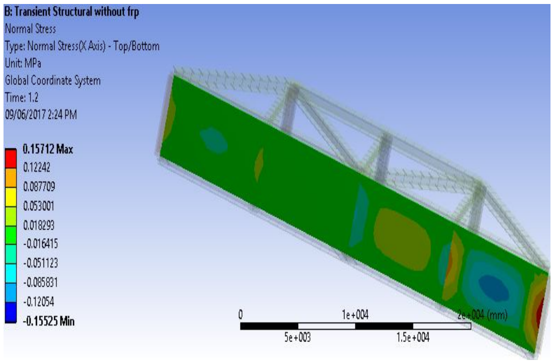


Fig.4 Normal stress without frp

Table No 1 With frp and without frp

FREQUENCY	WITHOUT FRP	WITH FRP
0	0	0
4.71	0.94505	0.75604
7.4016	0.10123	0.080984
10.093	2.19E-02	0.0174848
12.785	9.81E-02	0.078452
15.476	3.42E-02	0.0273704
18.168	8.99E-03	0.00719168
20.859	1.68E-03	0.00134448
23.551	2.36E-03	0.00188552
26.243	2.34E-03	0.001868
28.934	2.01E-03	0.00160848
31.626	1.75E-03	0.00140368
34.317	1.55E-03	0.00123864
37.009	1.38E-03	0.00110336
39.701	1.24E-03	0.00099088
42.392	1.12E-03	0.00089616
45.084	1.02E-03	0.00081552
47.775	9.33E-04	0.000746216
50.467	8.58E-04	0.000686136
53.158	7.92E-04	0.000633648
55.85	7.34E-04	0.000587488

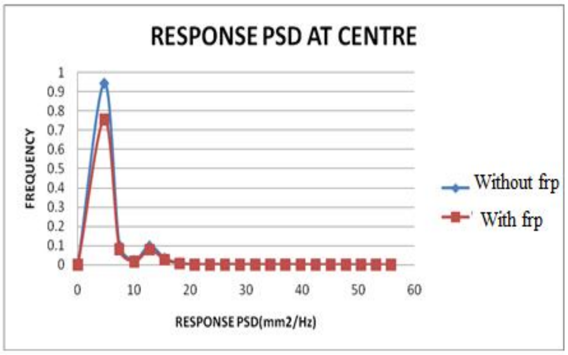


Fig.5 Response PSD at center

In this graph Peak pseudo displacement is obtain at the center of bridge which obverted less in frp bridge model

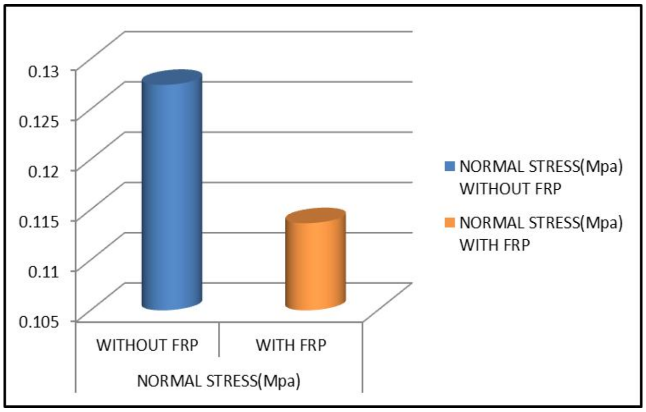


Fig.6 Graph of Normal stress

In this graph normal stress graph is obtain at which using with frp normal stress is less

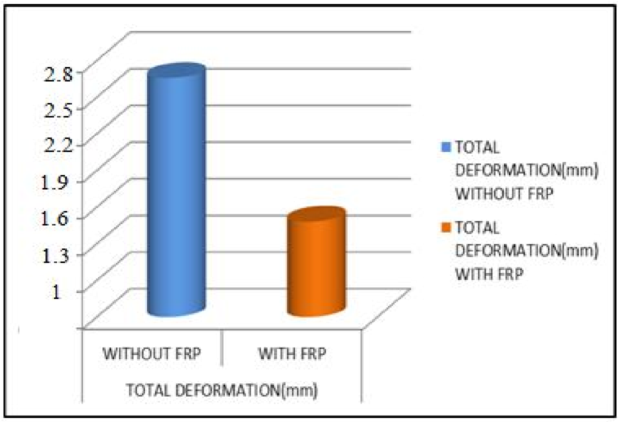


Fig.7Total deformation after loading

In this graph total deformation after loading is obtain at which using frp deformation is less

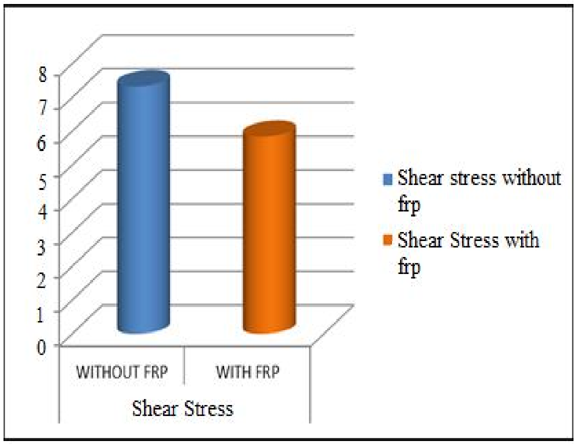


Fig.8 Graph of Shear stress

In this graph bending stress is obtain at which using frp is less

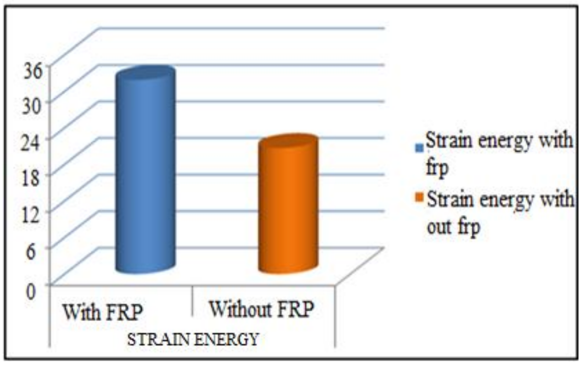


Fig.9 Graph of strain energy

In this graph using frp strain energy is less

V. CONCLUSION

In this paper vibration analysis of steel deck bridge is done in accordance with IRC loading. The vibrations are measured experimentally using mechanical device FFT and moving load according IRC and following conclusions are obtained:

- The response PSD reduced by 23% by using FRP layer at a surface coat.
- Total Deformation is reduced using FRP by 25% which can effect the design approach of steel deck bridge
- Strain energy observed more than without FRP
- Normal stress is 20% less than without FRP
- shear stress is observed 20% to 25%less without FRP it indicate better shear resistance against vibration induce due to moving load

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