A Study Of Steel Girder Bridge Due To Vibration Of Moving Load

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Abstract- *The goal of the bridge engineer is to design economical structures which are safe, durable, and serviceable. 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 deckbridge,Moving Load,FRP,ANSYS

I. INTRODUCTION

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)[. 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 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.

Importance of the Study of Vibration

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).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.

Fig.1 Tacoma narrow bridge during wind induced vibration.The bridge open on july 1 1940 and collapsed on November 7 1940

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.

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.

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

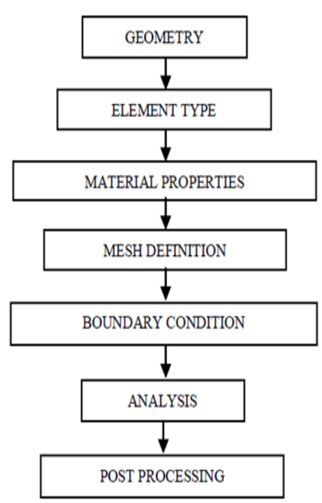
Linear and Nonlinear Vibration

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.*

II. METHODOLOGY

Solution technique and step



Finite element method (FEM) is a numerical method for solving a differential or integral equation. It has been applied to a number of physical problems, where the governing differential equations are available. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. The method is illustrated with the help of the plane stress and plane strain formulationThe finite element method originated from the need for solving complex elasticity and structural analysis problems in civil and aeronautical engineering. Its development can be traced back to the work by Alexander Hrennikoff (1941) and Richard Courant (1942). While the approaches used by these pioneers are different, they share one essential characteristic: mesh discretization of a continuous domain into a set of discrete sub-domains, usually called elements. Starting in 1947, Olgierd Zienkiewicz from Imperial College gathered those methods together into what would be called the Finite Element Method, building the pioneering mathematical formalism of the method. Hrennikoff's work discretizes the domain by using a lattice analogy, while Courant's approach divides the domain into finite triangular subregions to solve second order elliptic partial differential equations (PDEs) that arise from the problem of torsion of a cylinder. Courant's contribution was evolutionary, drawing on a large body of earlier results for PDEs developed by Rayleigh, Ritz, and Galerkin.

Development of the finite element method began in earnest in the middle to late 1950s for airframe and structural analysis and gathered momentum at the University of Stuttgart through the work of John Argyris and at Berkeley through the work of Ray W. Clough in the 1960s for use in civil engineering. By late 1950s, the key concepts of stiffness matrix and element assembly existed essentially in the form used today. NASA issued a request for proposals for the development of the finite element software NASTRAN in 1965. The method was again provided with a rigorous mathematical foundation in 1973 with the publication of Strang and Fix's An Analysis of The Finite Element Method and has since been generalized into a branch of applied mathematics for numerical modeling of physical systems in a wide variety of engineering disciplines, e.g., electromagnetism and fluid dynamics.

III. PROBLEM STATEMENT

In this chapter the steel deck bridge analyses With effective span 35 , slab thickness 200mm and section area 85.91cm2.The deck having depth of section(h) 350mm, width of flange
(b) 250mm, thickness of web (tw) 8.3 mm
Ixx=19159.7 cm4, Iyy=2451.4cm4 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)
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
There are3 cases included
Case 1. FRP Thickness 50mm
Case 2. FRP Thickness 100mm
Case 3. FRP Thickness 150mm

5. RESULT

Case 1- FRP Thickness 50 mm
In this study transient analysis is performed in ANSYS 16 which time dependant. A moving load apply according to IRC Class AA loading for wheel load is 40 tunes is passing through bridge deck for time period of 1.2 second .Hence the time interval is taken as 0.2 second for each step.

Table 1-Percentile Decrease of Normal stress

Load	Without FRP	With FRP	% Decrease
0.2	5.5986	2.8686	46.45
0.4	5.8424	2.8611	51.02
0.6	5.5885	1.5358	72.51
0.8	5.6375	4.3821	22.26
1	5.7998	4.5256	21.96
1.2	0.15172	0.13192	13.05

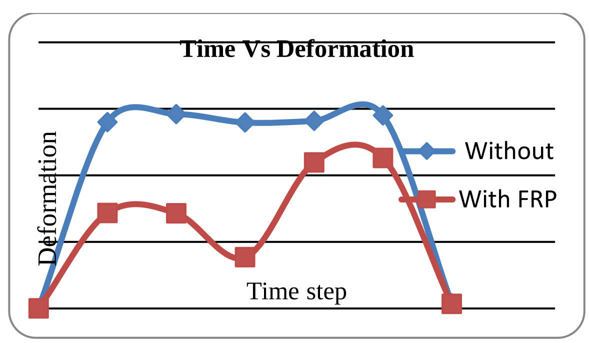


Table 2-Percentile Decrease of Total Deformation

Load	Without FRP	With FRP	%Decrease
0.2	12971	7289.4	43.80

0.4	14168	6558	53.71
0.6	14390	6480.5	54.96
0.8	14366	12321	62.33
1	14249	11763	80.80
1.2	17238	27.746	60.95

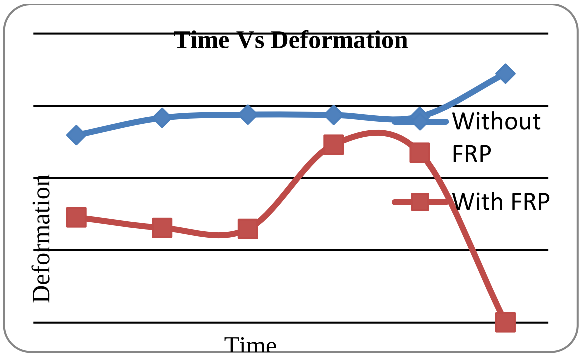


Table 3-Percenties Decrease of Shear Stress

Load	WithoutFRP	With FRP	%Decrease
0.2	7.6907e-003	2.709e-003	64.77
0.4	8.5334e-003	2.7818e-003	63.50
0.6	8.0602e-003	1.092e-003	93.17
0.8	7.9504e-003	6.2407e-003	21.50
1	8.2481e-003	6.5795e-003	21.23
1.2	6.136e-006	3.3254e-006	4.11

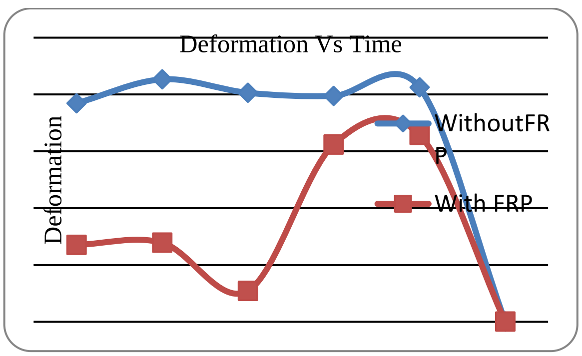
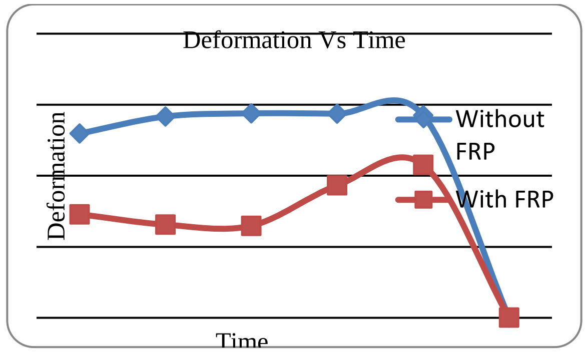


Table 4-Percenties Decrease of Strain Energy

Load	Without FRP	With FRP	%Decrease
0.2	12971	7289.4	43.80
0.4	14168	6558	53.71
0.6	14390	6480.5	54.96
0.8	14366	9321	35.11
1	14259	10763	24.51
1.2	17.238	9.746	43.46



IV. CONCLUSION

In this paper steel deck bridge is analysis subjected to moving load as per IRC class AA following conclusion are obtain with using ansys software

1. From table no.1 it is concluded that normal stress is reduce by 20 to 50 % by using 50mm FRP thickness
2. Form table no.2 total deformation is reduce by 50 to 60% by using 50mm FRP thickness which can effect the design approach of steel deck bridge
3. From table no.3 shear stress is observed 20% to 25%less without FRP it indicate better shear resistance against vibration induce due to moving load
4. From table no. 4 strain energy is reduce by 25 to 45 % by using FRP 50mm thickness

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