RESPONSE OF FRP BRIDGE DECK STRUCTURE UNDER MOVING LOAD

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***Abstract*: Many RCC bridge decks are showing the sign of distress due to corrosion of the reinforcements much before its design life span. Use of fiber reinforced polymer (FRP) bridge deck structures is increasingly rapidly all over the world due to its many advantages over the conventional materials. The FRP bridge deck is lighter, durable, easy to work with, maintenance free and expected to have low life cycle cost. In this dissertation work, the structural behavior of FRP bridge deck structure is studied. FRP bridge deck is a sandwich structure. This configuration dramatically reduces the weight of the deck and also reduces the chances of possible modes of failure due to design loads. First and results obtained are compared with the work done by previous researchers. In all the cases the results obtained by the present FE model compared very well. As such the finite element model is based on ANSYS 16.0 is used to generate many new results for FRP bridge deck subjected to under Indian loading conditions (IRC). The present numerical study should be quite useful for further research and implementation of FRP bridge deck in India in near future.**

***Index Terms*— Bridge deck, Fiber reinforced polymers (FRP), Finite element analysis (FEA), Moving load response**

I. INTRODUCTION

Fiber reinforced polymer (FRP) can give points of interest over the customary materials for development of extensions, for example, diminishment in dead load and resulting increment in live load rating, recovery of memorable structure, broadening of a scaffold without forcing extra dead load, speedier establishment, decreasing cost and movement blockage, and improved administration life even under brutal environment. The attributes of extensions with FRP decks, like, mass, firmness, and damping are altogether not the same as those of scaffolds with conventional solid decks. The heap appropriation component qualities and element reaction of c FRP deck scaffolds are bigger than those of solid deck spans.

FRP deck spans with incompletely composite conditions have a bigger brace load dispersion and a bigger element uprooting than those of the solid deck spans with completely composite conditions. Utilizing tentatively approved limited component models to lead dynamic time-history examination with an AASHTO weariness truck over the extension. FRP materials will be utilized all the more generally to give savvy other options to steel and cement. Potential applications for FRP decks resemble new outlines, substitution of under-quality decks in existing scaffolds, and the procurement transitory running surfaces.

The essential refinements between FRP deck and routine decks are the distinctions in firmness and geometry. The anxiety appropriation profile for steel patch stacking has been investigated and its pertinence in FRP deck frameworks analyzed. Association of tire with deck surface creates comparable weight dissemination which is a long way from uniform. Another reproduced tire patch stacking has been proposed which copies the anxiety profile of real truck tire. Tire contact region and contact weight are portrayed utilizing weight delicate film sensors. Proposed comparable weight profile has been connected to limited component reenactment to advance investigate the issues and break down reaction of FRP composite deck frameworks.

In this work, the conduct of FRP scaffold deck of various arrangements is to be considered by ANSYS16.

Fig.1 FRP Bridge, Bentley Creek Bridge, New York

1.1 BACKGROUNDS OF FRP BRIDGE DECKS

1.1.1 FRP Material

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.

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reinforcements. Fillers and additives, as a third component, can improve certain characteristics of the final product.

The main functions of matrix resins are creating volume, transferring stresses between fibers, protecting fibers from mechanical and environmental damage, and providing lateral support to fibers against buckling. Two types of polymeric matrices are widely used for FRP composites: thermosetting polymers and thermoplastic polymers. Thermosetting polymers are low molecular-weight liquids with very low viscosity, and thermosetting polymers cannot be reshaped after curing, because uncontrolled reheating causes the material to reach its decomposition temperature before its increased melting point.

Fig.2 Roadway for Bentley Creek Bridge

1.1.2 Matrix Resin

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1.1.3 Fiber Reinforcement

The main functions of fiber reinforcements are to carrying the applied load, and providing strength and stiffness to the FRP composites. The fiber reinforcements are usually oriented in the direction of the primary loads. There are a large variety of fibers available in the composites industry.

1.1.4 Other Constituents

a. Fillers b. Additives

1.2 FUNDAMENTALS OF FRP COMPOSITE BRIDGE DECKS

1.2.1 What is an FRP bridge deck?

The main functions of fiber reinforcements are to carrying the applied load, and providing strength and stiffness to the FRP composites. The fiber reinforcements are usually oriented in the direction of the primary loads. There are a large variety of fibers available in the composites industry. Various terms ordinarily used to depict a scaffold's superstructure are shown in Fig.3. The segments of the extension over the orientation are alluded to as superstructure, while the substructure incorporates all parts underneath. The principle body of the scaffold superstructure is known as the deck and braces/shafts. A FRP span deck in this exchange is characterized as an auxiliary component produced using FRP materials that exchanges stacks transversely to the scaffold backings, for example, longitudinal running braces, cross shafts, and/or stringers that bear on projections.

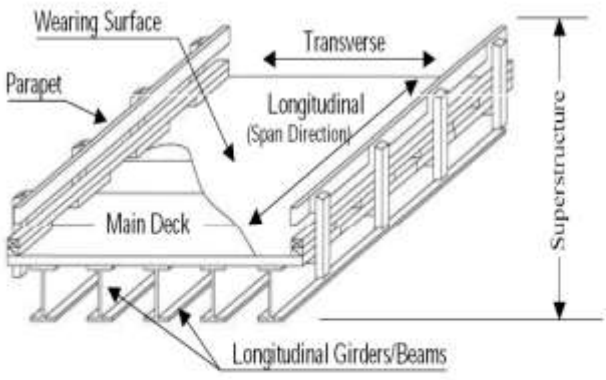

Fig.3 Superstructure of a bridge illustrating bridge engineering terms

1.2.2 Why FRP composite bridge deck

The issue of breaking down of common foundation is progressively turning into a basic worry over the world. A 2001 report on America's base gave by the American Society of Civil Engineers demonstrates that starting 1998, 29% of the country's extensions were basically insufficient or practically out of date. It is estimated that bridges in the U.S. on average last 68 years, whereas their decks last only 35 years; about half of the average bridge life. A similar deterioration and deficiency situation also occurs in many European and Asian countries. In addition to the problem of deterioration and deficiency, renewing bridges today often requires increased load rating over that for which the bridge was initially designed to accommodate increased traffic loads. Likewise, the FRP material can be altered to measurements of conventional decks and permits the monetary reuse of existing bolster structures. The aforementioned requests in scaffold building have brought about a critical deck substitution showcase and made enormous open doors for FRP span decks.

1.3 FIBER-REINFORCED POLYMER COMPOSITES IN BRIDGE ENGINEERING

The matrix composites is a subdivision of the composites field in which the matrix is a polymer and the reinforcement is a fiber (continuous and discontinous). Fiber-reinforced polymer was patented in 1916 [Munley, 2000]. The first known FRP composite product was a boat hull manufactured in the mid-1930s. The application of FRP composites in these bridge projects can be summarized as two categories.

1) <u>Bridge Renewal:</u> primary areas are bridge structures rehabilitation (repair, strengthening and seismic retrofitting) and bridge superstructures (decks, girders) replacement.

2) <u>New Bridge Construction</u>*:* bridge structures made entirely of FRP composites (primarily for pedestrian bridges); concrete bridges with FRP rebar reinforcement, FRP wrapped concrete piles or pylons, and external FRP cable stays

High performance and innovative FRP materials developed in last century are finding further uses in the civil and bridge infrastructures. Currently, there are more vehicular bridge projects using FRP materials in the U.S. than in any other country.

FRP bridge decks have successfully transitioned over the past decade from the experimental research stage to the field application stage. More than 100 bridges have been built or repaired with FRP bridge deck systems in the USA alone. This section summarizes the main benefits and challenges of FRP bridge decks based on their laboratory results and field performances.

1.4 BENEFITS AND CHALLENGES OF FRP DECKS

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The benefits of using FRP bridge deck systems are as follows:

1) Non-destructive properties of FRP can broaden the administration life of FRP extension deck.
2) High quality results from very much controlled industrial facility environment.
3) Construction of FRP scaffold decks is simpler and speedier than ordinary extension deck development, which prompts less activity control time, and less negative natural effect.
4) FRP bridge decks are excellent replacements for 19th and 20th century steel truss bridges and moveable bridge.

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:

1) High initial cost is the major barrier to develop the FRP bridge deck market.
2) The design of FRP bridge deck is based on finite element analysis. No official guidelines or specifications for the design and construction of FRP bridge decks are available on the market.
3) For field installation, the joint details need to be examined and further developed, which include joints between FRP panels.

Exchange of knowledge is still required between composite engineers and bridge engineers.

II. LITERATURE REVIEW

(1)Albert F. Daly*, John R. Cuninghame [April 2005] "Performance of a fibre- reinforced polymer bridge deck under dynamic wheel loading"

The paper depicts the examination did to inspect the execution of Fiber Reinforced Polymer (FRP) span decks under neighborhood wheel stacking. The goal of the examination was to deliver a draft standard giving nonexclusive outline prerequisites for specialized endorsement of FRP deck frameworks. The venture incorporated the definition of outline rules for weakness. Tests were done on a full-scale glass FRP span deck under static and element wheel stacking. The heaps were forced utilizing the Trafficking Test Facility, which duplicates the impacts of the wheel of a substantial merchandise vehicle. The deck was subjected to more than 4.6 million cycles of a 4 tone wheel load, identical to 30-40 years of administration movement. An easier endorsement test is proposed, applying stress cycles to little segments of deck to reenact the entry of wheels. The paper incorporates a depiction of the FRP deck, the testing and a rundown of the execution of the deck.

(2)Methee Chiewanichakorn a,*, Amjad J. Aref b, Sreenivas Alampalli c [Octomber 2006] "Dynamic and fatigue response of a truss bridge with fiber reinforced polymer deck"

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(3)Yin Zhanga,1, C.S. Caib, [September 2006] " Load distribution and dynamic response of multi-girder bridges with FRP decks"

Spans with FRP decks are picking up fame, and there is a developing need to comprehend the conduct of FRP deck spans. The qualities of scaffolds with FRP decks, (for example, mass, firmness, and damping) are fundamentally not the same as those of extensions with conventional solid decks. Therefore, nitty gritty limited component examinations are utilized as a part of the present study to explore the heap appropriation and the dynamic reaction of FRP deck spans. The bridge–vehicle cooperation in view of a three dimensional vehicle–bridge coupled model is done on both steel and cements multi-brace spans. The dynamic reaction of scaffolds is gotten in the time area considering the street harshness of the deck as a vertical excitation to the vehicles. The heap dispersion and the dynamic reaction of extensions are looked at between the FRP deck and solid deck spans what's more; there are a few contentions whether a composite activity between the deck and supports ought to be sought after or if a straightforward non-composite outline ought to be utilized for FRP deck spans. Examinations on this perspective have been made by displaying both the completely composite and somewhat composite FRP deck spans.

III. Objectives

A. To analyze dynamic response of FRP deck bridge including displacement and stress.

B. Comparing Convectional Bridge with FRP Deck Bridge.

IV. Methodology

Material modeling

The meaning of the proposed numerical model was made by utilizing limited components accessible as a part of the ANSYS code default library. SOLID186 is a higher request 3-D 20-hub strong component that shows quadratic dislodging conduct. The component is characterized by 20 hubs having three degrees of opportunity for each hub: interpretations in the nodal x, y, and z bearings. The component bolsters versatility, hyper elasticity, creep, stress solidifying, huge redirection, and expansive strain capacities.

The component SHELL43 is characterized by four hubs having six degrees of opportunity at every hub. The distortion shapes are straight in both in-plane bearings. The component takes into account pliancy, creep, stress hardening, extensive diversions, and substantial strain abilities. The representation of the steel segment was made by the SHELL 43 components, which take into consideration the thought of non-linearity of the material and show direct disfigurement on the plane in which it is available.

Sr.No.	Material	Property	Value
1	Structural steel	Yield stress(MPa)	248
		Young's modulus Es(GPa)	200
2	FRP (QM 6408)	Ultimate compressive strength(MPa)	476
		Ultimate tensile strength(MPa)	621
		Young's modulus E_f(MPa)	29724
		Poisson's ratio μ_f	0.15
3	Concrete	Young's modulus E_c(MPa)	26300

The geometrical representation of CONTA174 is show in fig4. Contact sets couple general axisymmetric components with standard 3-D components. A hub to-surface contact component speaks to contact between two surfaces by determining one surface as a gathering of hubs. The geometrical representation of is show in TARGET 170. The TARGET 170 and C0NTA 174 components were utilized to speak to the contact chunk shaft interface. These components can mimic the presence of weight between them when there is contact, and detachment between them when there is most certainly not. The two material contacts likewise consider grating and attachment between the gatherings.

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.

V. Problem Statement

5.1 Fiber-Reinforced Polymer Bridge Superstructure Geometric Properties
Bridge has following dimensions:

Length 35m
Width 5m
Height 8m
FRP thickness 100mm
Moving load 39 kN (IRC CLASS B)

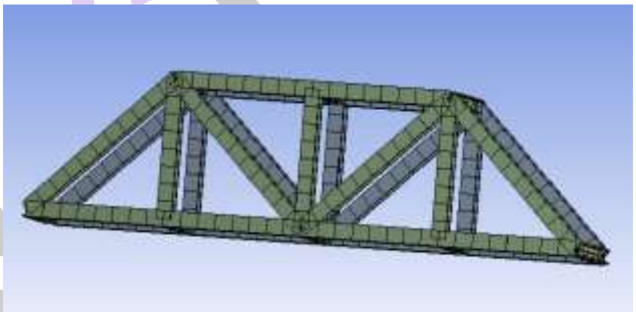


Fig. 4 FRP Bridge

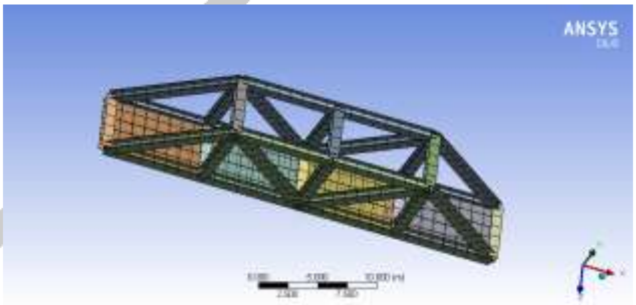


Fig. 5 FRP Bridge mesh

5.2 Material Property:

Table 1 Material Properties

5.3 Loading Consideration

In this paper transient analysis is performed in ANSYS.16 which is time dependent. A moving load of 39 kN is passing through bridge deck for a time period of 1.5 seconds. Hence the time interval is taken as 0.25 seconds for each step.

VI. RESULT

A moving load is applied over the bridge model. Then results for Deformation, normal stress, Shear stress and Strain Energy are plotted on graph. The graphs of moving loads for bridge with FRP and without FRP are as follows:

The models of bridges with FRP and Without FRP after loading are as follows:

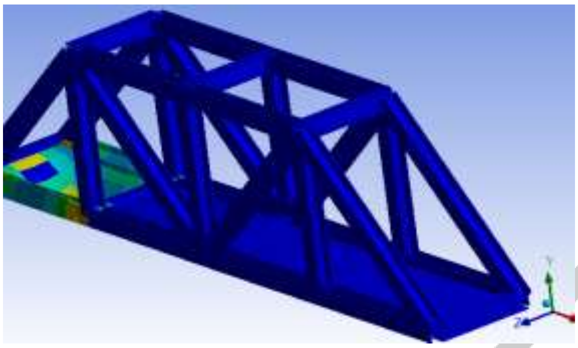


Fig 6-Model for Deck without FRP

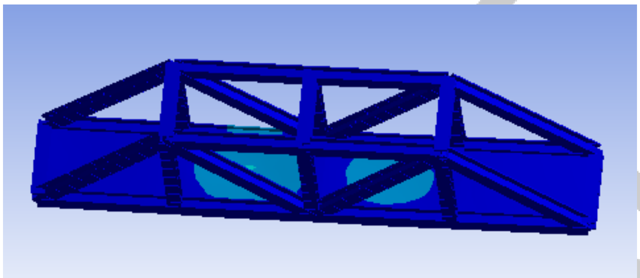


Fig 7- Model for Deck with FRP

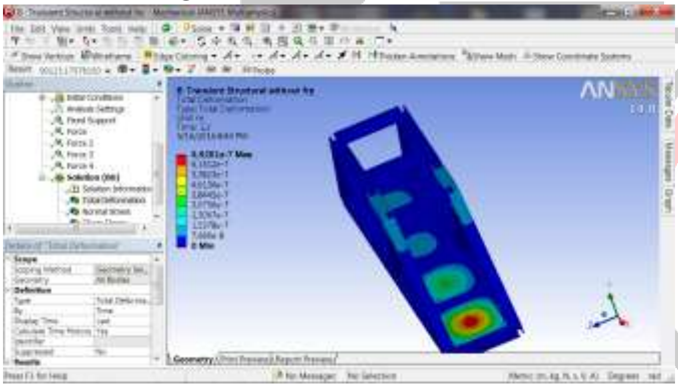


Fig 8- Model for Deck without FRP for Deformation

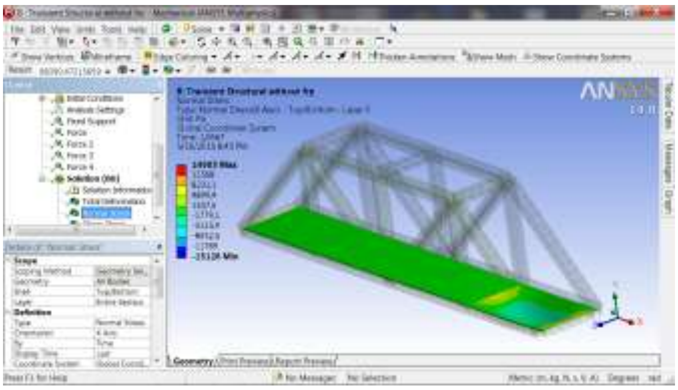
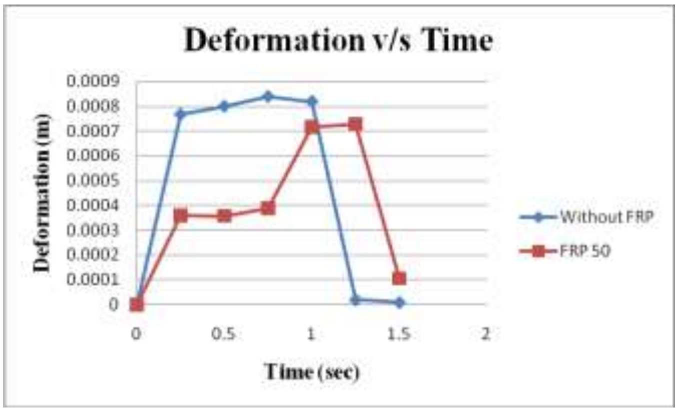
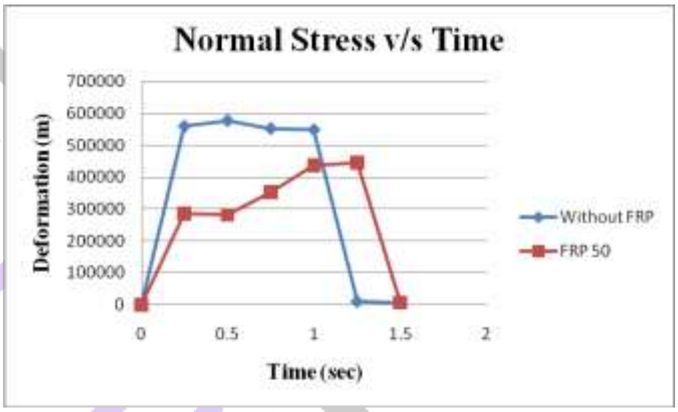


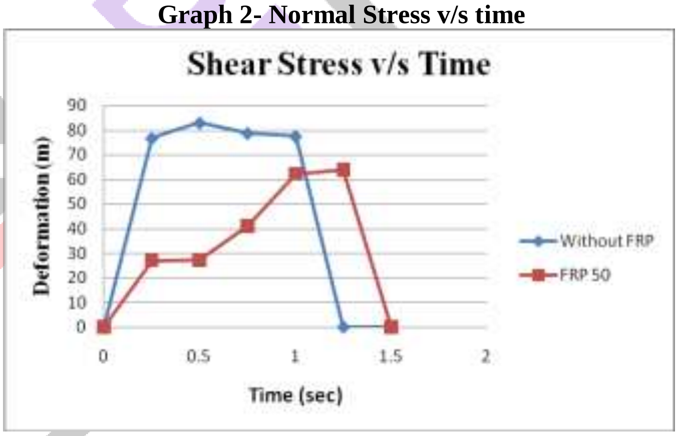
Fig 9- Model for Deck with FRP for Normal Stress



Graph 1- Deformation v/s time



Graph 2- Normal Stress v/s time



Graph 3- Shear Stress v/s time

The above graphs give us information about the deformation, normal stress and shear stress. The values are decreased for FRP model.

VII. CONCLUSION

In this paper the parametric study of steel deck bridge is done using FEA simulation tool ANSYS16.0

Following conclusions can be made after comparison

- For moving load FRP bridge deck gives better performance
- Deformation ,Shear stress and Normal stresses are considerably reduced by using FRP layers on deck
- FRP layers can be used of rehabilitation of bridge deck.

VIII. FUTURE SCOPE

- Comparison can be made for seismic performance combined with moving load
- Different type of bridges can be analyzed in same manner
- Skew angle effect need to be studied.

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