Use of FRP Composite in Bridge Deck

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Abstract— The aim of this paper is to present the state of the art in the use of FRP composites in bridge engineering with the focus on hybrid and all-composite structures. The paper will present the basic information about use of FRP in bridge deck. Composites, including the structural behavior of FRP material in place of traditional ,definition, description of the components, mechanical properties and general areas of application. Then, it will focus on modernization of construction techniques , describing manufacturing processes relevant to civil engineering applications like bridge deck systems, as well as its feasibility study in Indian market,. And it will compare the properties of FRP composites with those of traditional materials. Finite element analysis (ANSYS 19.2) is utilized to assess the overall structural behavior of the bridge under different load effects. The results show that a considerable reduction in stresses due to the light weight of the deck and composite action between FRP decks and steel girders can be obtained.

Keywords: FRP, Bridge, Composite, Life Cycle Cost Analysis, Sustainability

I. INTRODUCTION

The Construction industry is revolutionizing in two major ways. Emphasis on development of construction techniques is one way and advancement in high performance construction material is the other. Amongst these high performance materials, Fiber Reinforced Polymer (FRP) is gradually gaining acceptance in the market. FRP has certain advantages over the conventional materials like high tensile strength to weight ratio, ability to be molded into various shapes, potential resistance to severe environmental conditions and low maintenance cost. Reduction in dead load & increment in live load is a major objective. FRP composite are of great benefit in Bridge Engineering. FRP finds application on manufacturing of Bridge decks, column, beams and girder etc.

In India using of composite is not that much so we are going to focus on that so reducing the material like steel, cement while designing of structure so now We are focusing on designing of foot over bridge deck

So we are replacing steel reinforcement by using fiber i.e. E-glass, C-glass and concrete by using resins of as well as using filler and additives making of sandwich layer of all that and simulation and designing of deck by using ANSYS 19.2 and casting of deck by hand lay up method

II. WHY FRP

The composite possess following properties

- Light weight
- High strength to weight ratio
- Corrosion resistance
- Durable
- Allowing for partly consolidation
- No heat and electrical conductance

so that much of predominating characteristics shows using of FRP in deck while designing

A. Fiber

Fiber reinforcement provides carrying of applied load, strength and stiffness to the fiber composites, they have an orientation towards primary load there are wide varieties of fibers available in composite industry, each of which has its own advantages and disadvantages

FRP composites must possess following properties to perform the desirable functions

1) High modulus of elasticity
2) High ultimate strength
3) Low variation of strength among fibers
4) High stability of their strength during handling
5) High uniformity of diameter

Primary used materials are as follows

- E-GLASS
- S-GLASS
- GRAPHITE
- BORON
- KEVLAR-29/49

Material	Density (g/cm^3)	Tensile Modulus (E) (GPa)	Tensile Strength (σ) (GPa)	Specific Modulus (E/σ)	Specific Strength	Relative Cost
E-glass	2.54	70	3.45	27	1.35	Low
S-glass	2.50	86	4.50	34.5	1.8	Moderate
Graphite, high modulus	1.9	400	1.8	200	0.9	High
Graphite, high strength	1.7	240	2.6	140	1.5	High
Boron	2.6	400	3.5	155	1.3	High
Kevlar 29	1.45	80	2.8	55.5	1.9	Moderate
Kevlar 49	1.45	130	2.8	89.5	1.9	Moderate

Table 1.1:

B. Matrix Resins

The matrix is composed of molecules made from many simpler and smaller units. The matrix must Have a greater elongation and lower modulus as compared to fibres so that fibre can carry maximum loads. Functions of matrix resins generally consists of generally creating volume, transferring stresses between fibers , protecting fibers from mechanical environmental damage and providing lateral support to fiber against bulking . Two major types of polymer are available such as thermoplastic and thermosetting polymers.

Following resin materials are widely used

- Epoxy
- Phenolic
- Polyester
- Nylon
- Polyester
- Acetal

Resin Material	Density (g/cm^3)	Tensile Modulus GPa (10^6 psi)	Tensile Strength MPa (10^3 psi)
Epoxy	1.2-1.4	2.5-5.0 (0.36-0.72)	50-110 (7.2-16)
Phenolic	1.2-1.4	2.7-4.1 (0.4-0.6)	35-60 (5-9)
Polyester	1.1-1.4	1.6-4.1 (0.23-0.6)	35-95 (5.0-13.8)
Nylon	1.1	1.3-3.5 (0.2-0.5)	55-90 (8-13)
PEEK	1.3-1.35	3.5-4.4 (0.5-0.6)	100 (14.5)
PPS	1.3-1.4	3.4 (0.49)	80 (11.6)
Polyester	1.3-1.4	2.1-2.8 (0.3-0.4)	55-60 (8-8.7)
Polycarbonate	1.2	2.1-3.5 (0.3-0.5)	55-70 (8-10)
Acetal	1.4	3.5 (0.5)	70 (10)
Polyethylene	0.9-1.0	0.7-1.4 (0.1-0.2)	20-35 (2.9-5)
Teflon	2.1-2.3	-	10-35 (1.5-5.0)

Table 1.2:

C. Other Constituents

– Fillers
– Additives

III. Experimental Procedure

The whole procedure is based on two stages

– Analysis and design by using ANSYS 19.2
– Casting by using Hand layup method

A. Analysis and design by using ANSYS 19.2

ANALYSIS OF BRIDGE DECK USING ANSYS SOFTWARE

The Process of Making Composite Model

– Static structure

1) Engineering data-In engineering we have to add the material and defining the material properties of FRP
2) Geometry- In the geometry designing and defining property to the given structural member i.e deck system

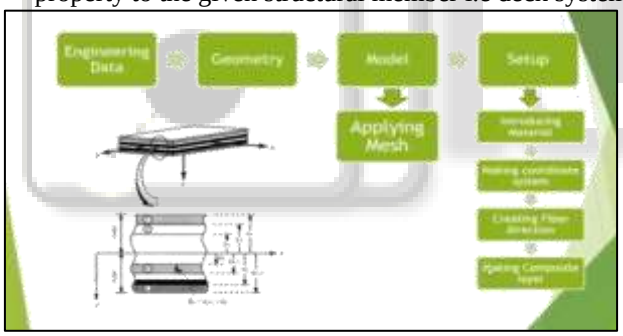

Fig. 1.1:

3) Model – design of model and making the connections and adding support and loading condition on surface of deck
4) Setup- defining the sandwich structure of FRP layer to deck
5) Solution
6) Result

B. Casting by using Hand layup method

1) Hand layup method

spread the gel on the mold surface to avoid the sticking of polymer to the surface. By using Thin plastic sheets at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of strand mats are cut as per the mold size and placed at the surface of mold after Perspex sheet. Then using of resins in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The resin is equally spread with the help of brush.

Next layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the fiber sheet, spread the gel on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied.

After curing either at normal room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The schematic of hand lay-up is shown in fig no 1. The time of curing depends on type of resin used for composite processing. For example, for epoxy resin based system, normal curing time at room temperature is 24-48 hours

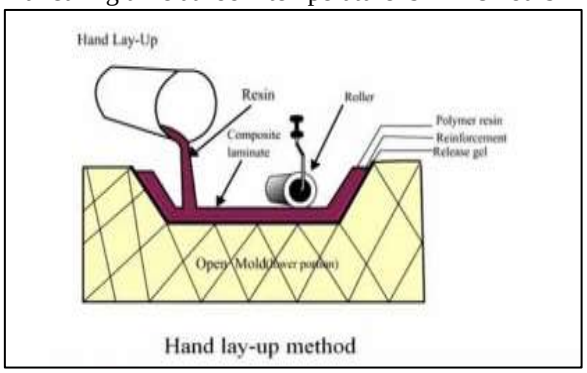

Fig. 1.2:

IV. Feasibility Study of FRP Indian Market

UNIT COST	COST	UNIT
Steel	49000	Per ft cu
concrete	270	Per ft cu
Steel girder	1020	Per ft cu
Steel cable	5100	Per ft cu
GFRP	620	Per ft cu
Note it include labour cost also		

Table 1.3:

By analysing above market survey for all engineering material so FRP material is comparatively small so we are preferring FRP for designing economical structure of bridge deck

V. Conclusion

Using of FRP composite in bridge deck is very feasible as well it show the all the characteristics i.e. durable, corrosion resistance, bad conductor of heat and electricity .It have several advantages over traditional material Its advantages, in term of mechanical behaviours and durability, can be predetermined during manufacturing process.

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