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Analysis of Deck Type Bridge Considering Vehicular Loading Using Analysis Tool STAAD.PRO

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ABSTRACT

Bridge is an important structure required for the transportation network. Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost-effective structured system. For analysis and design of these bridges the most efficient methods are available. Different methods which can be used for analysis and design are AASHTO, Finite element method, Grillage and Finite strip method. In this study Deck type bridge is analyzed considering UHPC concrete and NaOH treated concrete for vehicular load as per I.R.C. specifications using analysis tool Staad.pro and Beava. Here it is observed that utilizing UHPC concrete results in economic structure with stability and minimum observation of forces, displacement, moment and cost.

Keywords : Bridge, deck, IRC, stresses, staad.pro, analysis, structure, forces, deflection

I. INTRODUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. In engineering, a bridge is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object". A "two-force member" is a structural component where force is applied to only two points. Although this rigorous definition allows the members to have any shape connected in any stable configuration, structure typically comprise five or more triangular units constructed with straight members whose ends are connected at joints referred to as nodes. In this typical context, external forces and reactions to those forces are considered to act only at the nodes and result in forces in the members that are either tensile or compressive. For straight members, moments (torques) are explicitly excluded because, and only because, all the joints in a truss are treated as revolutes, as is necessary for the links to be two-force members.

Fig: 1 : Bridge Structure

Rubberised Concrete:

Rubber from discarded tyres use in, floor mats, belts, gaskets, shoe soles, dock bumpers, seal, muffler hangers, shims and washers. 3% to 5% Rubber crumbs and upto 10% reclaimed rubber is particularly used in automobile tyres. Tyre pieces are used as fuel in cement and brick kiln. However, various local authorities are now banning the tyre burning due to atmosphere pollution. Whole tyres also used as highway crash barriers, furniture, boat bumpers on marine docks, etc. Land filling or burning tyres for energy have limited prospects as environmental authorities are acknowledging the need for its greener alternatives. Rubberized concrete have necessitated the need for the experimental investigations on rubberized concrete. Therefore, in this study an attempt has been made to identify the various properties necessary for the design of concrete mix with the coarse tyre rubber chips as aggregate in a systematic manner.

Fig 2 : Rubberized Concrete

NAOH Treated Rubberized Concrete:

It was found that the duration of 24 h for treatment of crumb rubber was the most promised duration, which resulted in favourable fresh and hardened concrete characteristics. Compared to rubberised concrete prepared with untreated rubber, rubberised concrete prepared with the 24-h NaOH treated method had 25% improvement in compressive and flexural strength, respectively. It is experimentally indicated that using this treatment method resulted in notable improvement for the compressive strength, and moderate enhancement in the flexural strength.

Objectives

The main objectives of the present study are as follows:-

1 To determine the enhancement in bridge strength using NAOH treated rubberized concrete.
2 To analyze a bridge structure for I.R.C. loading using Analysis tool Staad.pro
3 To determine effect of hydraulic loading at the vertical members (piers) of the bridge.
4 To perform cost analysis of a bridge using Ultrahigh performance concrete.
5 To understand The Behavior of Pre-stressed Concrete Superstructure of Bridge under Various Loading Condition.
6 To Design Prestressed Concrete Superstructure Design with Indian standards and codes using Staad.pro.
7 To analyze PSC super structure Bridge considering seismic load and find out maximum Bending Moment, Shear forces and Torsion.

II. LITERATURE REVIEW

Daniel et. al. (2018) This paper demonstrates a comprehensive national network-level analysis to determine the relative deteriorations and operational structural performances of the various types of bridge structural design and/or construction. The study analyzes the entire database of the U.S.National

Bridge Inventory for the year 2013 and considers bridge counts along with bridge deck areas that provide more significant results. Analysis of the proportional distribution of structural deficiency reveals issues of deterioration. Considering the structural deficiency, service life cycle and deterioration trends of bridge types over time, the multi-criteria equivalent structural performances incorporate the condition, durability, longevity, rate and pattern performances. The results provide support for more sustainable engineering and management decisions. Stringer/multi beam or girder (type 02) bridges are the most common bridge type, 40.75% by counts and 61.88% by areas.

Guohui et. al. (2018) A long-term load test of 420 days was performed on three prestressed steel–concrete composite continuous box beams (non-prestressed, partly prestressed, and fully prestressed) to investigate the combined effects of sustained load, shrinkage, creep, and prestressing. Several time-varying parameters, such as deflection, concrete strain, prestressing force, support reaction, and relative slippage between the concrete slab and the steel box beam, were monitored in the test. The long-term performance of the prestressed beams that was developed using a special law increased and decreased the support reactions at the middle and end piers over time, respectively, due to the distinct configuration of prestressed strands (i.e., installation was only at the negative moment area).

Neeladharan et. al. (2017) Structural design requires a full understanding and knowledge of all the components comprising the structure. A suspension bridge is a type of bridge in which the deck (the load-bearing portion) is hung below suspension cables on vertical suspenders. The design of modern suspension bridges allows them to cover longer distances than other types of bridges. The main element of a cable suspended bridge is the cable system. Bridges are normally designed for dead load, live load and other occasional loads. All loading and unloading conditions in analysis and design are provided as per IRC codal specifications. The whole modeling of the suspension parts of the bridge was done by using SAP2000. Suspension cable bridge having 1km span with single lane road, the intensity of road is given has 20 numbers of vehicles each loaded with 350KN (heavy loading class A-A track load) is analysed by SAP2000. The output of the software presents results including moments, axial loads, shear force and displacements.

Literature Outcome

The literature review has suggested that use of a finite element modeling of the superstructure. So it has been decided to use STAAD.Pro for the Finite Element Modeling. With the help of this software study of bridge structure has been done. STAAD.Pro also helps in Finite Element Modeling in view of that different type of forces can apply to get the actual results.

III. METHODOLOGY

Step 1: Selection the geometry of superstructure by using coordinate system in STAAD Pro or plot over the AUTO CAD, which can be import in Staad-Pro as per dimension of girder, c/c distance of bearing, expansion to expansion distance and no.of diaphragm etc. Schematic sketch of the superstructure are shown in below figures.

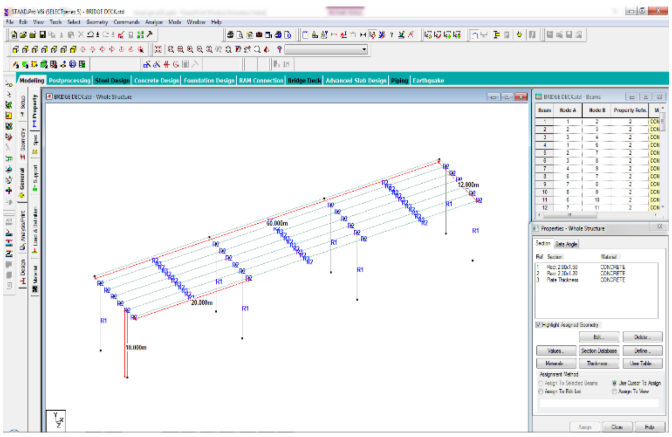

Fig : 3 R.C.C Bridge Type

Step 2: Different type of bridge material and models are prepared of same dimension and same loadings as per Indian standards. finite element modeling of the model considering the above parameters. The dimensions like 60 length, 12 meter wide, which include in the girder property and steel material property of the structure as per Indian sections.

Different types of bridge sections considered are as follows:

A. Deck Slab Bridge :

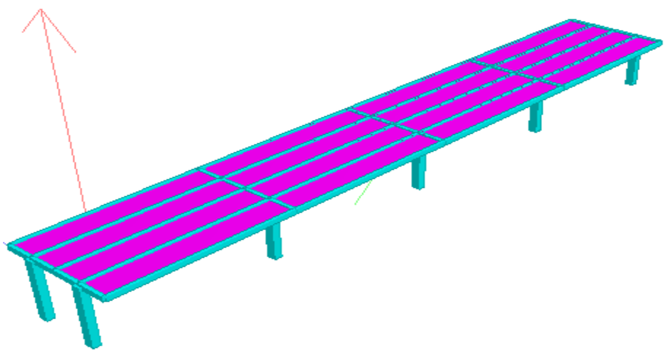

Fig : 4 Deck Bridge

A Deck Bridge (fig 4) is the surface of a bridge, and is one structural element of the superstructure of a bridge. It is not to be confused with any deck of a ship. The deck may be constructed of concrete, steel, open grating, or wood. Sometimes the deck is covered with asphalt concrete or other pavement

Step 3: Apply the material property as shown in above figures, after that support condition has been considered at the bearing locations of the superstructure which is pinned / hinged as shown in below figure.

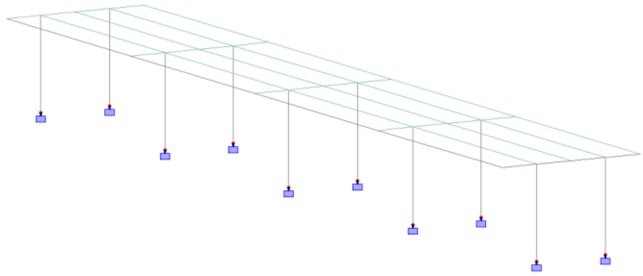

Fig : 5 Support Condition

Step 4: After apply the support condition, now the next step to be considered for the Deal Load of the superstructure i.e. “selfweight”.

Step 5: After apply the Dead Load, now the next step to be considered for the **Equivalent Uniformly Distributed Loads (EUDL)** load

For Bending Moment, L is equal to the effective span in metres. For Shear Force, L is the loaded length in metres to give the maximum Shear Force in the member under consideration. The Equivalent Uniformly Distributed Load (EUDL) for Bending Moment (BM), for spans upto 10m, is that uniformly distributed load which produces the BM at the centre of the span equal to the absolute maximum BM developed under the standard loads. For spans above 10m, the EUDL for BM is that uniformly distributed load which produces the BM at one-sixth of the span equal to the BM developed at that section under the standard loads. EUDL for Shear Force (SF) is that uniformly distributed load which produces SF at the end of the span equal to the maximum SF developed under the standard loads at that section.

Step 6: After apply the EUDL Load, now the next step to be considered for the Moving Live Load (LL) in which include the Breaking Load and Vehicle Load are as follow:-

1) DFC (*Dedicated Freight Corridor*) LOADING FOR BENDING MOMENT [Eccentric & Concentric]

2) DFC LOADING FOR SHEAR FORCE [Eccentric & Concentric]
3) Coefficient of Dynamic Augment (CDA) *Coefficient of Dynamic Augment* FOR PROVIDED DECK LENGTH.

Step 7: After applied all the boundary condition and forces, now the model has to be "Analyze" for getting the results i.e. Axial force, shear force, deflection and support reactions etc.

Step 8: after analysis results designing is followed as per Indian Standard 456:2000 R.C.C. design and optimization of each case is done to provide its economical section for same loading and geometry in all the cases.

Step 9: After optimization process comparative results are drawn in all cases to determine the best one with the help of graph using M.S. Excel.

Table 1 : Description of Structure

S NO.	DESCRIPTION	UNIT
1	LENGTH	60 m
2	CARRIAGEWAY	12 m
3	PIER (ABUTMENT)	2 X 1.5 m
4	HEIGHT OF DECK	10 m
5	DECK DEPTH	0.3 m
6	GIRDER	2.3 X 1.2
7	BEARING PLATE	0.6 X .45 m

Table 2 : Property of material

S.NO	Description	Value
1	Sections	Standard
2	Young's modulus of steel, Es	2.17x10^4 N/mm^2
3	Poisson ratio	0.17
4	Tensile Strength, Ultimate Steel	505 MPa
5	Tensile Strength, Yeild Steel	215 MPa
6	Elongation at Break Steel	70 %
7	Modulus of Elasticity Steel	193-200 GPa
8	Concrete	M60

The Bridge is of structural plan in X direction is 60 m and in Z it is 12 m & Y direction is 4 meter respectively.

IV. ANALYSIS RESULT

Shear Force:

Table 3. Shear force in Deck Bridge

Shear Force kN	
Deck Bridge	Deck Bridge (UHPC)
1418.779	758.233

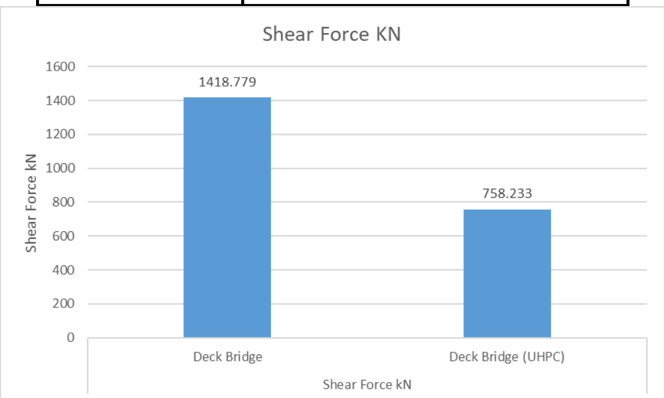

Fig 6. Shear Force in Deck Bridge

Axial Force:

Table 4 : Axial force in Deck Bridge

Axial Force kN	
Deck Bridge	Deck Bridge (UHPC)
353.42	176.172

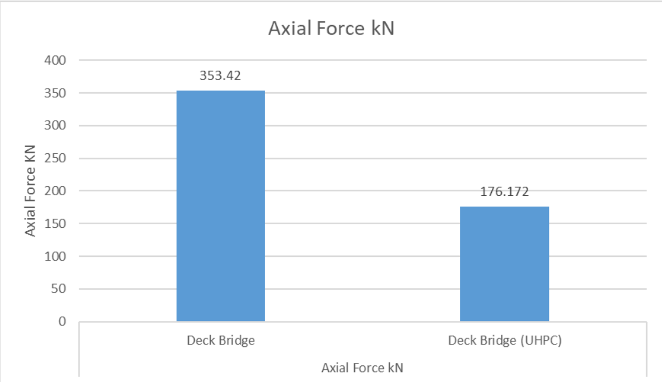

Fig : 7 Axial Force in Deck Bridge

Bending Moment

Table 5. Bending moment in Deck Bridge

Bending moment kN-m	
Deck Bridge	Deck Bridge (UHPC)
4082.252	2396.54

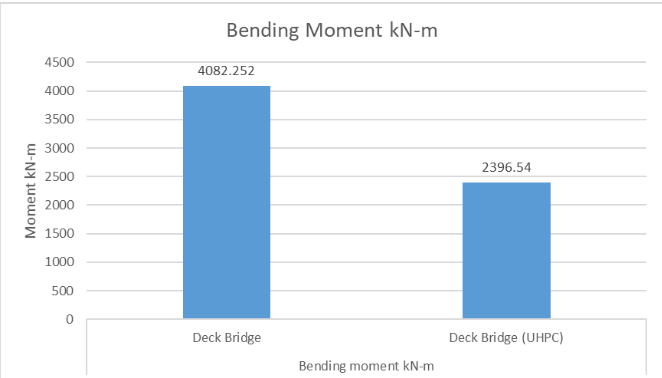

Fig: 8 Bending moment in Deck Bridge

5.5 Deflection:

Table 6. Deflection in Deck Bridge

Deflection mm	
Deck Bridge	**Deck Bridge (UHPC)**
2.119	**3.281**

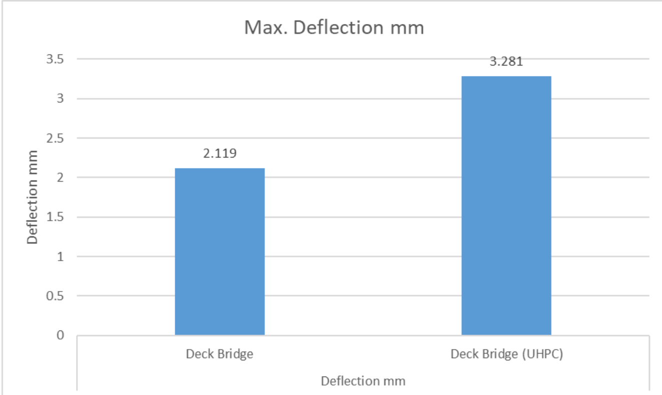

Fig : 9. Deflection in Deck Bridge

Cost Analysis

Magnitude of maximum stress for various forms of sections of bridge has been plotted

Table 7. Cost Analysis

Cost Analysis (Rupees)			
S.no.	concrete volume in cu.m	S.O.R rates	Total cost of concrete
Deck slab	1531.7	4500	6892650
Deck slab (UHPC)	793.9	4500	3572550

V. CONCLUSION

Shear Force

Shear force in known as the unbalance force observed due to transmission of load from beam to column, in our study it is observed that with UHPC concrete it can be minimized in all the cases considered for study.

Axial Force

Axial force is known as the vertical force observe in piers, this force is meant to distribute load from pier to earth. It is observed in the results that with UHPC concrete Distribution of vertical forces can be processed easily.

Bending Moment

In terms of bending moment it is observed that minimum bending is in UHPC, which is resulting in comparatively most economical in comparison as bending moment is directly proportional to reinforcement requirement.

Deflection

In case of deflection we observed in above chapter that maximum deflection is obtained in UHPC concrete Bridge as compared to general bridge as we minimized the sectional data by 50 mm but structure is stable.

Cost Analysis:

In this study it is observed that utilizing UHPC concrete we can minimize the section as bending moment is decreased which results in minimizing sectional data. Here the reduction in cost is due to reduction in Ast. Requirement.

Future Scope

1. In this study precast girder has been considered however in future suspension type bridge can be consider.
2. In this study Analysis tool staad has been adopted whereas in future any other tool can be consider.
3. In this study IRC vehicular loading is considered whereas in future AASHTO specified loading can be taken.

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