International Journal of Scientific Research in Civil Engineering
© 2022 | IJSRCE | Volume 6 | Issue 2 | ISSN : 2456-6667

Analysis of Rubberized Concrete Deck Slab for Different Bridge Structures as Per IRC Loadings

Ankit Patel[1], Murlidhar Chourasiya[2]
P.G. Scholar[1], Assistant Professor[2]
Department of Civil Engineering, Infinity Management and Engineering College, Sagar Madhya Pradesh, India

Article Info
March-April-2022

Publication Issue :
Volume 6, Issue 2
Page Number : 113-121

Article History
Accepted : 05 March 2022
Published : 20 March 2022

ABSTRACT

In this research work the finite element method is used for the analysis of three different type of bridges i.e. cable stayed, cable suspension and deck bridge with rubberized and NaOH treated rubberized concrete of constant width and length is considered.

In this study analyze different bridge sections for same loading conditions and sections. The loading class considered is CLASS 70R from IRC 006-2014. A Finite Element model is formulated for this study using Staad beava software package. This model is then analyzed, for parameters like deflection, stress under the influence of moving vehicle load also to discuss the cost effectiveness of each type of bridge.

The basis aim for this study is to give the best output for implementation of these results in future working conditions. In this study it is concluded that cable suspension bridge is comparatively more stable whereas cable stayed bridge is economical of all the types of bridge considered and deck bridge shows worst results overall.

Keywords: F.E.M, Structural analysis, Bridge, Deck slab, Hydraulic design, Vehicular loading, I.R.C., Staad beava, Forces, rubberized concrete.

I. INTRODUCTION

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 Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system.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.

Vehicle load capacity analysis of a bridge superstructure is required as per I.R.C. and manual for standards and specifications for Indian road congress norms. Its main purpose is to assure, that bridge is safe for the user or public. By the load capacity analysis, a bridge might be found to be incapable of securely conveying some legal loads. Furthermore, when the loads are beyond the range of permit loads need to be utilizing a particular structure, load limit analysis can give answer about which loads are securely satisfactory. STAAD. Pro is efficient and accurate software used for concrete and steel bridge analysis and design. The advantage of the software is that it incorporates this provision of Indian Road Congress (IRC) bridge design specifications and railway specifications. STAAD. Pro is a general purpose structural analysis and design tool with applications chiefly in the building industry - commercial buildings, bridges and highway constructions, industrial constructions, chemical plant structures, dams, retaining walls, foundations, culverts and other embedded structures, etc. STAAD. Pro is basically based on Finite Element Analysis for carrying out the computations for Analysis and Design of a Structure.

A bridge is a structure, by which a road, railway or other service is carried over an obstacle such as a river, valley other road or railway line. The superstructure of a bridge is the part directly responsible for carrying the road or other service. Its layout is determined largely by the disposition of the service to be carried. Supports at convenient locations. A typical configuration of a truss bridge is a ‗through truss' configuration. There is a pair of truss girders connected at bottom chord level by a deck that also carries the traffic, spanning between the two trusses.

In this dissertation, different bridge types are analyzed for vehicular load as per I.R.C. specifications, to determine the most stable and economical section which can design as per Indian standards,

For this study most importantly comparing rubberized concrete and NAOH treated rubberized concrete for three different bridge types they are Deck slab bridge, Cable stayed bridge, and Cable suspension bridge sections are considered with 200 meter length supports at the end of the geometry. This has been considered to analyze the bridge for critical load and after analyzing these critical loads, the results will be compared in terms of forces, weight and most importantly cost of each type to determine the most economical section.

Bridge structures

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.

Figure 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.

Figure 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:-

- To determine finite element analysis on different types (Deck, Suspension and Cable stayed) of bridges.
- To determine most effective and stable bridge type.
- To determine the most economical type of bridge In cost comparison.
- To find out the implementation of STAAD. Beava for IRC specification.
- To study the effect of rubberized and NaOH treated rubberized concrete in different types of bridges.

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.

Hussain et. al. (2017) Studied that In this project, the structural analysis of suspension bridge is conducted using the computer program named as (CSi Bridge). The analysis is based on adopting AASHTO and Iraqi specifications standard for loading in bridges. The 14th – July suspension bridge built in Baghdad in 1963 was taken as a case study. The actual data (Bridge geometry in material properties) was input to the program with standard loading mentioned above. The results indicate that the max tensile stress in the main cable was 0.36 Fu. The maximum compressive stress in the tower was 0.51 Fy, while the maximum normal and shear stresses in the plate of the main girder were 0.8 Fy and 0.33 Fu respectively. It is a type of bridges in which a continuous deck (the load-bearing portion) is hung below the suspension cables on vertical suspenders that connect the deck with the main cable.

Lukeet. al. (2017) The Sunni berg Bridge in Switzerland, designed by Christian Menn, is a tall cable-stayed bridge with low pylons. It is an excellent example of the way that structural members, shaped in response to engineering considerations can be both functional and have high aesthetically qualities. This paper examines the close link between the aesthetics and the form of the structural elements; compares the loading used for the design with loading from the British Standards; uses simplified structural elements to analyse the stresses in the bridge; and examines the construction process. The Sunniberg Bridge is a harp arrangement cablestayed bridge with 3 main spans (the longest measures 140m) and 2 side spans. The reinforced concrete deck is 526m long and follows a tight of curve of radius 503m at an inclination of 3.2%. The deck is 12.37m wide in total, 9m wide curb to curb, and it carries 2 lanes. The piers/pylons are also constructed from reinforced concrete, the tallest of which rises a total of 75m above the valley floor, 62m up to the roadway and 15m above it.

III. Methodology

Step 1: Selection the geometry of superstructure by using coordinate system in STAAD Pro or plot over the AUTO CAD, which can beimport 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.

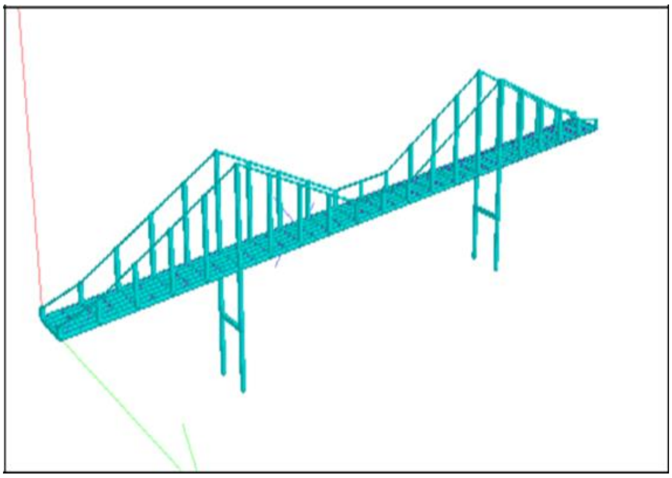


Figure 3 R.C.C Bridge Type

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. It is considered that R.C.C. Bridge of different types such as Deck Slab, Cable Stayed and Cable Suspension bridge types of superstructure define the dimensions like 200 length, 10 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

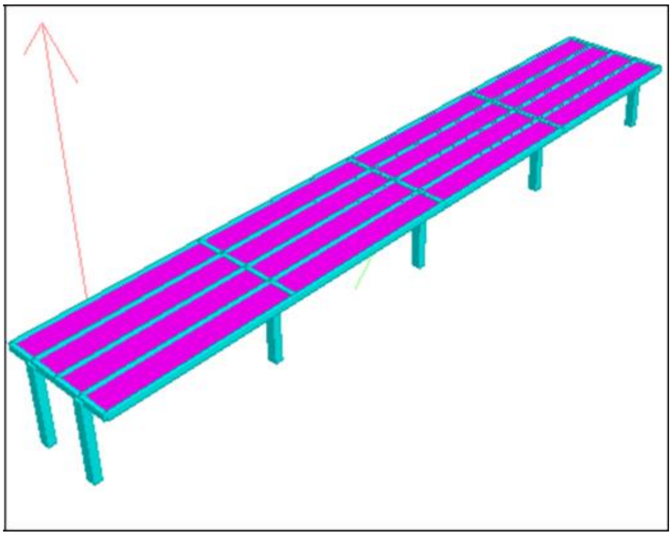


Figure 4 Deck Bridge

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.

B. Cable Stayed Bridge:

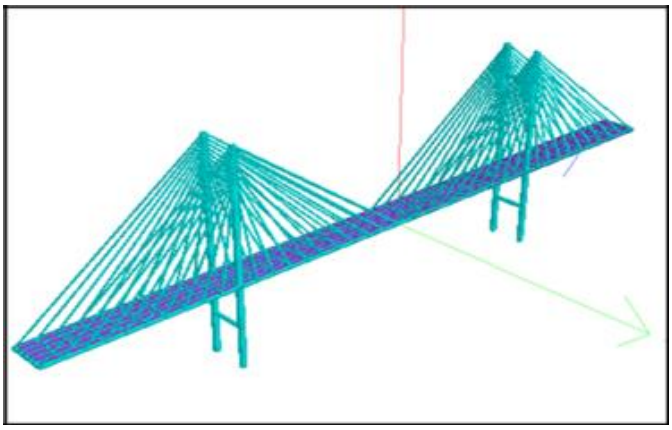


Figure 5. Cable Stayed Bridge

A Cable Stayed Bridge (fig 5) has one or more towers, from which cables support the bridge deck. A distinctive feature are the cables which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines.

C. Cable Suspension Bridge:

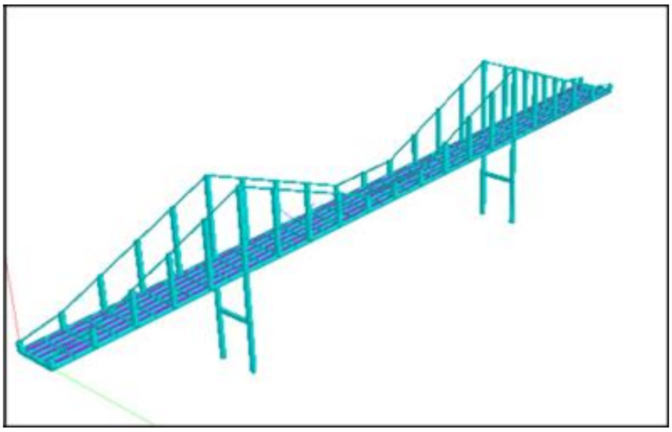


Figure 6 Cable Suspension Bridge

Cable Suspension Bridge (fig 6) is a type of bridge in which the deck (the load-bearing portion) is hung below suspension cables on vertical suspenders. The first modern examples of this type of bridge were built in the early 19th century Simple suspension bridges, which lack vertical suspenders, have a long history in many mountainous parts of the world.

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.

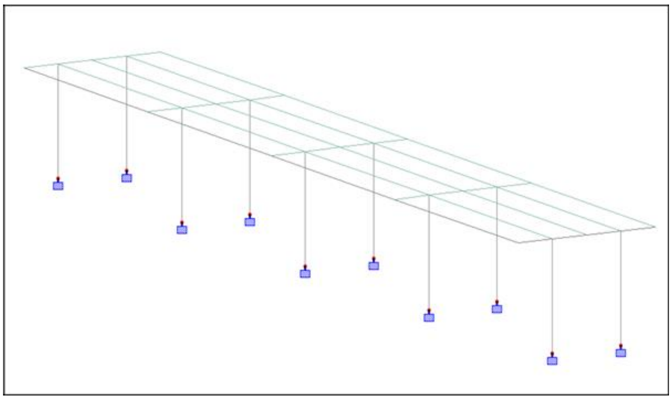


Figure 7 Support condition

Step 4: After apply the support condition, now the next step to be considered for the Deal Load of the superstructure i.e. ―self weight.

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:-

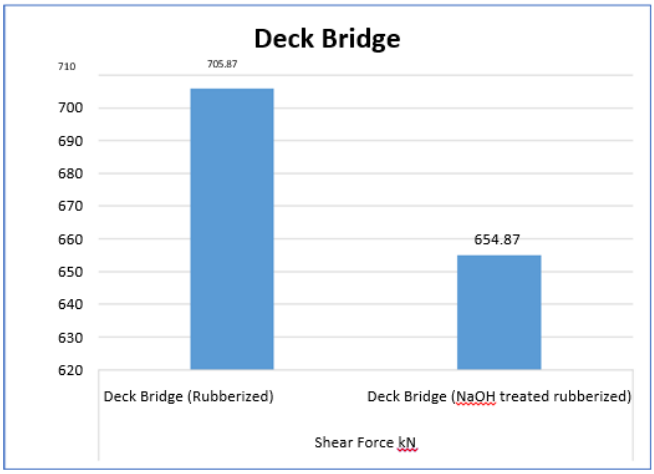
1) DFC (Dedicated Freight Corridor) LOADING FOR BENDING MOMENT [Eccentric & Concentric]
2) DFC LOADING FOR SHEAR FORCE [Eccentric & Concentric]
3) Coefficient of Dynamic Augment (CDA)Coefficient of Dynamic Augment FOR PROVIDED DECK LENGTH.

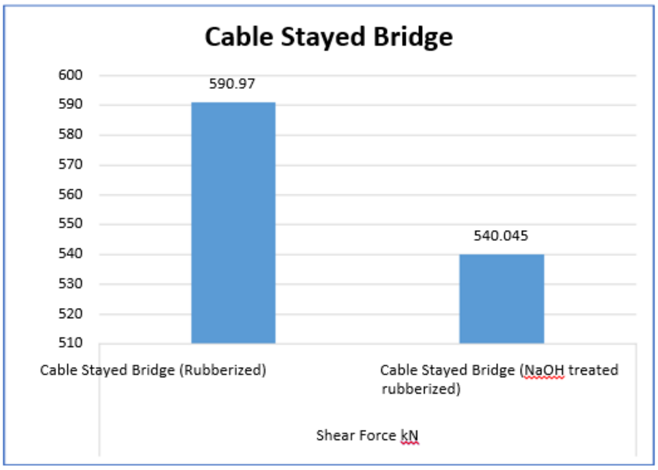
Step 7: After applied all the boundary condition and forces, now the model has to be ―Analyze‖ for getting the results i.e. Axial force, shear force, deflection andsupport reactions etc.

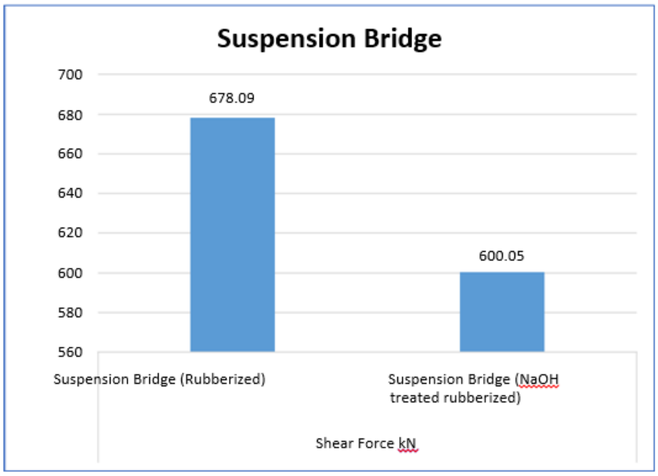
Step 8: after analysis results designing is followed as per Indian Standard 456:2000R.C.C. design and optimization of each case is done to provide its economical section for same loading and geometry in all the cases.

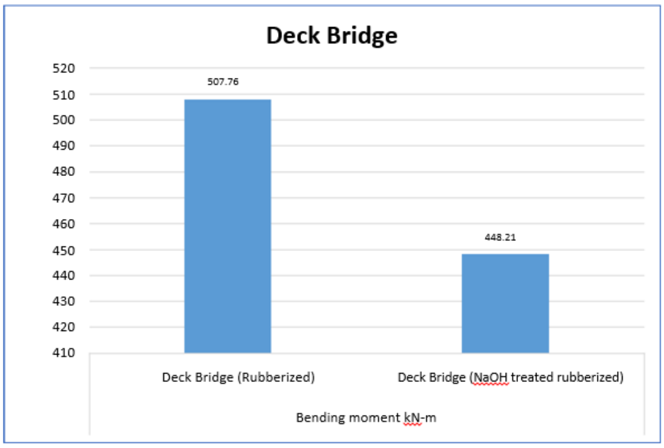
Step 9: After optimization process comparative results are drawn in all cases to determine the best one with the help of graph using M.S. Excel.

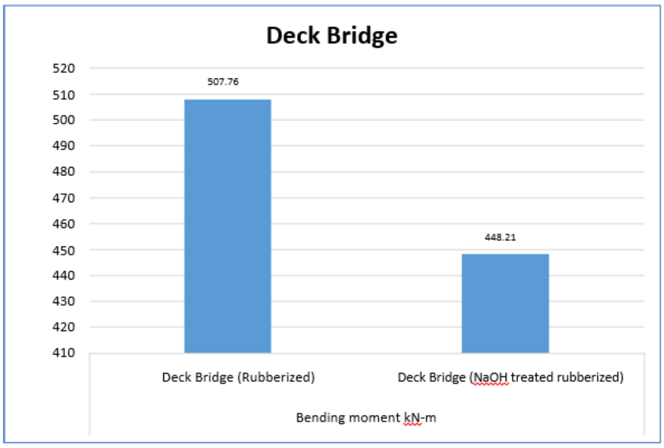
IV. ANALYSIS RESULT

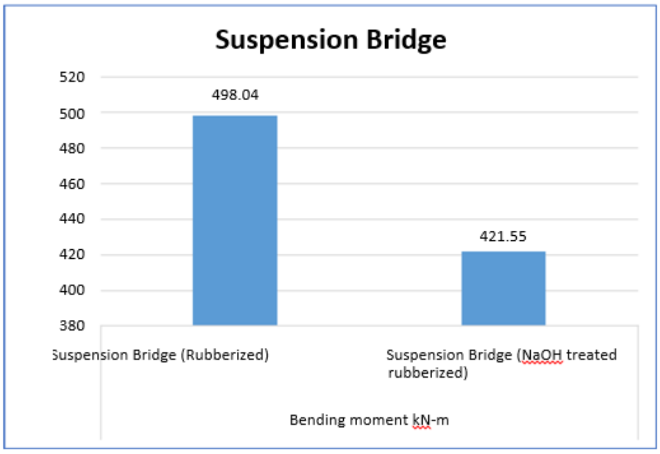


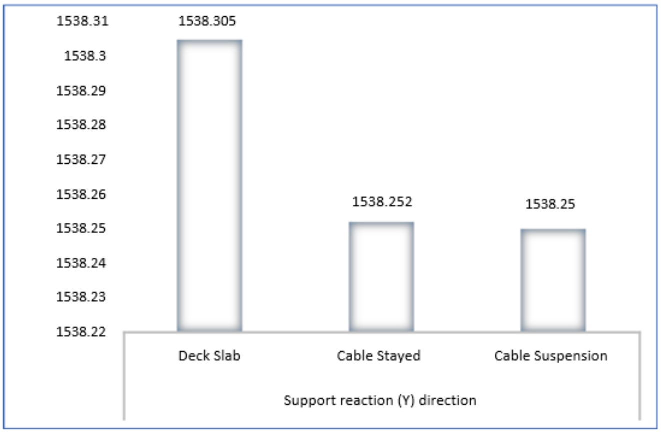












V. CONCLUSION

In case of deflection it is observed in above chapter that deflection is decreased in all types of bridge considering NaOH treated rubberised concrete with an average declination of 11.8% comparing to rubberised concrete.

Support Reaction is the total amount of load of the superstructure transmitting to substructure. In our study it is observed that support reaction is approximately same in all condition 1538.25 KN due to same loading conditions.

In terms of bending moment it is observed that Bending moment is decreased by 10.5% due to NaOH treated rubberised concrete which results in cost effective design of the structure.

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 NaOH treated rubberized concrete in Deck bridge 7.82%, Cable stayed bridge 9.7% and Suspension bridge 12.2% declination is observed.

In terms of Axial force it is observed that values in rubberised concrete case is decreased by 7.3% due to proper distribution of vertical forces.

In terms of Cost Analysis in this study we prepared cost analysis table considering S.O.R rates. In this analysis we have observed that using NaOH treated rubberized concrete we can minimize the cost by 13.5% which results in economical design.

VI. REFERENCES

[1]. Guohui cao,karthiga p, elavenil s, kmp d. A comparison of road over bridge and rail over bridge. The iupjournal of structural engineering. 2018.

[2]. Neelandharan, shetty rs, prashanth mh, channappa tm, ravi kumar cm. Information vibration suppression of steeltruss railway bridge using tuned mass dampers.

[3]. Luke j. Xueyi l, pingrui z, feng dm. Advances in design theories of high-speed railway ballastless tracks. Keylaboratory of high-speed railway engineering, southwest jiaotong university, chengdu, china. 2017

[4]. Alaa hussain wakar s. Chee luo, progress in high-speed train technology around the world. Transport bureau, the ministryof railways of china, beijing, china. Traction power state key laboratory, southwest jiaotong university,chengdu 610031, chinaa. Astaneh a. Progressive collapse of steel truss bridges, the case of i-35w collapse, asla a university ofcalifornia, berkeley, usa 2017.

[5]. Bridge rules (railway board). Rules specifying the loads for design of super structure and substructure ofbridges and for assessment of the strength of existing bridges.

[6]. Indian railway standards-steel bridge code indian railway standard code of practice for the design of steelor wrought iron bridges carrying rail,road or pedestrian traffic.

[7]. Irc: 6-2014 section –ii (loads and stesses) standard specifications and code of practice for road bridges.

[8]. Irc: 21 section –iii cement concrete (plain and reinforced) standard specifications and code of practicefor road bridges.

[9]. Xiaoyan lei1 and bin zhang, analysis of dynamic behavior for slab track of high-speed railway based on vehicle and track element, journal of transportation engineering © asce / april 2011 / 227.

[10]. M.j.m.m. steenbergen_, a.v. metrikine, c. Esveld, assessment of design parameters of a slab track railway system, journal of sound and vibration 306 (2007) 361–371.

[11]. David n. Bilow, p.e., s.e. and gene m. Randich, p.e., slab track for the next 100 years, portland cement association, skokie, il. xueyi liu, pingrui zhao, feng dai, advances in design theories of high-speed railway ballastless tracks, volume 19, number 3, september 2011.

[12]. Coenraad esveld and valéri markine , slab track design for high-speed irs concrete bridge code : 1997 code of practice for plain, reinforced & prestressed concrete for general bridge construction.

Cite this article as :

Ankit Patel, Murlidhar Chourasiya, "Analysis of Rubberized Concrete Deck Slab for Different Bridge Structures as Per IRC Loadings ", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 6 Issue 2, pp. 113-121, March-April 2022.
URL : https://ijsrce.com/IJSRCE22629