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

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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 paper we are presenting review of literatures related to analysis of bridge tructure with material variations.

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 Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system.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

II. LITERATURE REVIEW

Guohui et. al. (2018)[1] 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)[2] 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)[4] 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) [3] 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.

Kumar andPhani (2015)[26] This research‘s objective was to estimate the economic importance of the railway cum road bridge. This paper was carried out to find out the reduction in cost of construction by providing single bridge for both road as well as railways. The analysis and design phase of the project was done utilizing STAAD PRO V8i. It was observed that the construction of a single bridge reduced the cost of two separate bridges for road and railways, also land acquisition problem is reduced to some extent.

Kale et. al. (2014)[27] Studied the cost efficient approach of reinforce cement concrete T-beam girder. His main objective function was to reduce the total cost in the design process of the bridge system considering the cost of materials. The cost of each structural component such as material, man power, cost for reinforcement, concrete and formwork. For each and every bridge its girder length, width of bridge, deck slab depth, width of web of girder and girder depth are considered for the cost minimization of the bridge system, the structure is modeled and analyzed using the direct design methods. Cost efficient problem is formulated in NLPP (non-linear programming problem) by Sequential Unconstrained Minimization Technique. The model is analyzed and designed for an optimization purpose by using Mathematical lab (Matlab) Software with SUMT, and it is capable of indicating precisely with high probability of minimum design variables. Optimization for reinforced cement concrete T-beam girder system is illustrated and the results of the optimum and conventional design procedures are compared.

Pathak (2014)[28] Studies various behaviors like bending, shear, axial & torsion for horizontally curved reinforce cement concrete box bridges considering three dimension FEM using SAP software. This approach simplifies analysis & the preliminary design of curved bridge section. The increase in the torsion for any set of graph is comparatively increases than that of bending moments, shear forces and axial forces which indicate that box section is having high torsional stiffness and is nonlinearly vary with degree of curvature. From the study it is observed that various span, the multiplication factor for variable degree of curvature is varying linearly for axial force & bending moment, which is about 1.20 to 1.30 for 90° curvature. Multiplication factor for torsion moment is varying nonlinearly having
1.80 to 1.90 for 90° curvature, while there is not necessary to apply multiplication factor for shear force.

Rajamoori and Vamsi (2014)[29] The precast pre-stressed bridge system offered two principal advantages: it is economical and it provides minimum downtime for construction. Pre-stressing is the application of an initial load on the structure so as to enable the structure to counteract the stresses arising during its service period. In this present project I am going to know the behavior of pre-stressed concrete beam, how they stressed, percentage of elongation, pressure applied to make beam stressed. This thesis completely going to do in a practical approach that on a major bridge having 299 mts span, 36 no‘s of PSC Beams & 8 no‘s of RCC Beams. My attempt is on PSC Beams, where the Beam post tensioning values, rate of elongation & behavior can be defined after stressing.

Chan et. al. (2013)[30] Simplified methods for bridge designs have been allowed to use for many years by various North American bridge design codes. However such methods have not yet been permited to use in Hong Kong. The use of simplified methods will not only shorten the time spent on analysis, but will also permit the designer to retain a ―feel‖ of behaviour of the bridge which is usually lost in traditional analyses. This paper constitutes the first report on the development of simplified methods of bridge analysis for use in Hong Kong. It presents the simplified method for the analysis of girder bridges with two lanes with the objective of generating discussion from practising designers which may lead to the enhancement of the proposed method and other methods currently under development.

Saxena and Maru (2013) [31] discussed the variation and cost difference in T beam girder and two cell box girder in terms of concrete quantity and conclude that cost of concrete for T-Beam Girder is not as much of two cell Box Girder as quantity required by T-beam Girder, Quantity of steel for T-beam Girder is less so budget of steel in T-Beam is less as compared to two cells Box Girder Bridge T-Beam Girder is economical for span length is not more than 25m but if span is more than 25 m, so Box Girder is always suitable. This type of bridge structure lies in the high torsional rigidity because of closed box section.

Pengzhen et. al. (2012)[32] The structural behavior of T-frame bridges is particularly complicated and it is difficult using a general analytical method to directly acquire the internal forces in the structure. This paper presents a spatial grillage model for analysis of such bridges. The proposed model is validated by comparison with results obtained from field testing. It is shown that analysis of T-frame bridges may be conveniently performed using the

spatial grillage model. They concluded that The static and dynamic behaviors of a rigid T-frame bridge were investigated analytically and experimentally. Based on the comparison study on analysis results obtained from the conventional and proposed analysis methods, one may obtain more economical designs using the spatial grillage model. Main contents of the grillage model include the grillage mesh and the grillage member section properties.

Fernando et. al. (2012)[33] Steel and composite (steel-concrete) highway bridges are currently subjected to dynamic actions of variable magnitude due to convoy of vehicles crossing on the deck pavement. These dynamic actions can generate the nucleation of fractures or even their propagation on the bridge deck structure. Proper consideration of all of the aspects mentioned pointed our team to develop an analysis methodology with emphasis to evaluate the stresses through a dynamic analysis of highway bridge decks including the action of vehicles. The design codes recommend the application of the curves S-N associated to the Miner‘s damage rule to evaluate the fatigue and service life of steel and composite (steel-concrete) bridges. In this work, the developed computational model adopted the usual mesh refinement techniques present in finite element method simulations implemented in the ANSYS program. The investigated highway bridge is constituted by four longitudinal composite girders and a concrete deck, spanning 40.0m by 13.5m.

Sarno et. al. (2012)[34] The ―Retro‖ TA project funded by the European commission within the Series-project aims at studying numerically and experimentally the seismic behaviour of an old existing reinforced concrete bridge with portal frame piers and the effectiveness of different isolation systems. In particular, an experimental test campaign will be performed at ELSA Laboratory of JRC (Ispra, Italy). Two piers (scale 1:2.5) will be built and tested using the PsD technique with sub-structuring; the modelling of the entire viaduct is considered along with the non-linear behaviour of each pier, due to bending, shear on the transverse beams and strain penetration effect at the column bases. The comprehensive numerical investigations have shown the high vulnerability of the sample bridge. Consequently two isolation systems (yielding-based and friction-based bearings) have been currently designed and characterized. Because the test will start after the summer 2012, in this research relates the relevant issues will be here addressed and discussed.

Mamadapur et. al. (2012)[35] Analysed a simple span T-beam bridge by using I.R.C. specifications and Loading (dead load and live load) as a 1-D (one dimensional) structure. Finite Element Method analysis of a three-dimensional structure was carried out using STAAD. Pro software Both models were subjected to I.R.C. Loadings to produce maximum bending moment. The results were analyzed and it was found that the results obtained from the finite element model are lesser than the results carried from 1-D (one dimensional) analysis, which states that the results obtained from I.R.C. loadings are conservative and FEM gives economical design.

Michas et. al. (2012)[36] Discussed various non-ballasted concepts and some considerations are made in relation to life cycle cost for high speed track. It is concluded that slab track is in a long-term perspective, more economically efficient as observed. Even though the slab track construction costs are 30 % to 50 % higher than the standard ballasted track, the maintenance costs for slab track are one-fourth of those for ballasted track.

Yousif et. al. (2011)[37] This paper discussed the design and analysis of bridge foundation subjected to load of train with four codes, namely AASHTO code, British Standard BS Code 8004 (1986), The Chinese National Standard (CNS, 2002) and Chinese code (TB10002.5-2005). The study focused on the design and analysis of bridge‘s foundation manually with the four codes and found which code is better for design and controls the problem of high settlement due to the applied loads. The results showed the Chinese codes are costly that the number of reinforcement bars in the pile cap and piles is more than those with AASHTO code and BS code with the same dimensions. Settlement of the bridge was calculated depending on the data collected from the project site. The vertical ultimate bearing capacity of single pile for three codes was also discussed. Another analysis by using the three-dimensional Plaxis program of finite elements and many parameters were calculated. The maximum values of the vertical displacement were close to the calculated ones. The results indicate that the AASHTO code was economics and safer in the bearing capacity of single pile, while the Chinese code (CNS, 2002) gave a good indicator of the risk to foundation settlement.

Wen-Liang et. al. (2010) [39] This paper presents a stability investigation of a special-shape arch bridge with a span of 180 m. Its structure and mechanics are significantly different from normal arch bridges because of its single arch rib skewing across the girder, its hangers hanging unevenly along the arch rib with different aslant angle, and its arch rib being subjected to massive axial compression force, bending moment, torque, and shear stress. In this paper, the eigenvalue method is used to analyze some of the main influencing factors, such as different loads, restraint conditions of arch spring, stiffness of arch rib, stiffness of main girder and rise-span ratio of arch rib. The study results showed that the slant hangers at both sides of the girder reduced the tendency of arch instability, which is obviously helpful to maintain overall structural stability. Increasing the height of the main girder can improve the structural stability, but the effect is limited.

Qaqish et. al. (2008)[39] A simple span T-beam bridge was analyzed by using AASHTO specifications and Loadings as a one dimensional structure, then a three-dimensional structure was carried out by using finite element plate for the deck slab and beam elements for the main beam. Both models were subjected to 1.5 AASHTO Loadings and at certain locations to produce maximum bending moment and maximum shear. The results were analyzed and it was found that the results obtained from the finite element model are smaller than the results obtained from one dimensional analysis, which means that the results obtained from AASHTO loadings are conservative.

Thomas et al. (2007)[40] Simulates the response of 6 and 20-story steel movement- resisting frame buildings (US 1994. UBC) for ground motions recorded in the 2003 Tokachi-oki earthquake. They consider building with both perfect welds and also with brittle welds similar to those observed in 1994 Northridge earthquake. Their simulations show that the long- period ground motions recorded in the near-source regions of the 2003 Tokachi-oki earthquake would have caused large inter-story drifts in flexible steel moment – resisting frame buildings designed according to the US 1994, UBC.

Krishnan et. al. (2006) [41] Studied the responses of tall steel movement frame buildings in scenario magnitude 7.9 earthquakes on the southern San Andreas fault. This work used three-dimensional, nonlinear finite elements models of an existing eighteen-story moments frame building as it, and redesigned to satisfy the 1997 uniform building code. The authors found that the simulated responses of the original buildings indicate the potential for significant damage throughout the San Fernando and Los Angeles basins. The redesigned building fared better, but still showed significant deformation in some areas. The rupture on the southern San Andreas that propagated north-to-south induced much larger building responses that the rupture that propagated south-to-north.

Vaibhav B. Chavan et. al. (1990)[42] This research‘s objective was to estimate the economic importance of the Hollow Sections in contrast with conventional sections. This paper was carried out to find out the percentage economy accomplished using Hollow Sections so as to understand the importance of cost efficiency. The technique used in order to reach the objective involves the comparison of various profiles for different combinations of height and material cross -section for given span and loading conditions. The analysis and design phase of the project was done utilizing STAAD PRO V8i. The results of STAAD analysis were validated with the results of Manual analysis.

III. CONCLUSION

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.

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