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A Review Article of Design and Deflection Analysis of Deck Slab using Staad Pro Software

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Abstract – **A review of Designed highly curved concrete ramp bridge, which presented a challenge to bridge engineers due to the problems imposed by the complex environmental and geometric constraints. They maintain the stability of the structure by balancing the dead, pre-stressing and live loads with the reactive forces at supports which is of particular important. They proved that these bridges could be designed and constructed economically. By respecting the geometry of the curved road and the constraints of the underlying elements, these bridges provided both functionality as well as balance of visual elements.**

Keywords– **GUI, Simple Span Bridges, Solid Deck Slab Bridge, T-Beam Deck Slab Bridge, Finite element method.**

I. INTRODUCTION

A **Deck Slab** bridge is a structure having a total length above 6m between the inner face of the dirt walls to carry the traffic loads above the natural obstruction (streams, rivers etc.) or artificial obstructions. The superstructure of the bridge comprises of the deck slab and supports. On the simple span bridge, the deck slab lay specifically on bearings through which forces and moments are transferred to the sub-structure. The deck slab bridge comprises superstructure as deck slab and supports as abutments. Fig. 1.1 shows the typical sections of the solid deck Slab Bridge which contains components such as deck slab wearing coat, abutment and footing. The solid deck slab casting is up-front with simple, and the concrete moulds are extremely easy to build. Solid volumes might be expanded. The T-beam deck Slab Bridge include deck slab sections supported by longitudinal girders are supported by abutments. The girders give the stiffness and strength essential for the length, and empower the section to be moderately thin and inexpensive to build. The details are required for the design of the abutment and substructure is span of bridge.

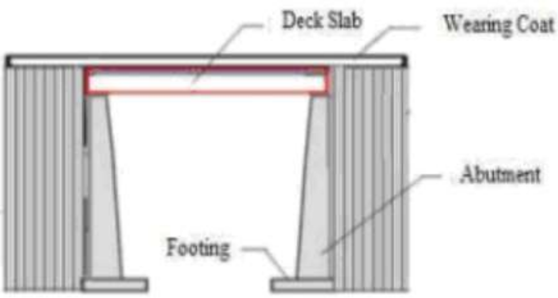

Fig.(1.1) Longitudinal section of Solid Deck Slab.

Fig-1.1 shows the typical sections of the T-beam deck slab bridge, which contains components such as, deck, slab, three longitudinal girder, wearing coat, abutment and footing. The required number of girders used is needy upon a few aspects, for example, the depth of the slab deck and the slenderness of the girder. Modulus for cast in-situ girder and section of slab deck are more convoluted than that essential for solid concrete slab decks. The requirements for the analysis and design of the superstructure and substructure are span, carriageway width and reduced levels etc.

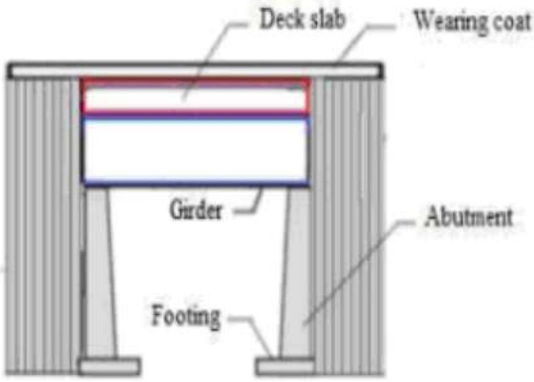

Fig. (1.2) Longitudinal section of Solid Deck Slab Bridge.

II. LITERATURE REVIEW

Basanagouda Timmanagudar, Sanjay Raj A, Shijina K, "Analysis of RC Bridge Decks for National and International Standard Loadings Using Graphical user interfaces Method''[2016]: Conducted a work on the culverts, which are built under an earth mound for passage of a watercourse, like the watercourses through the ridge as road banks cannot be allowed to block the waterway. The structural design of the box culvert is carried out. The structural design includes the concern of load cases (box with empty, full, surcharge loads, etc.). The components of the structure are required to be designed to resist the extreme bending moment and shear force and specified a full conversation on the requirements in the Codes, considerations and validation of all the above aspects of design. C.V. Alkunte et al. [2] presented the project on the piers, exposed to different loads in along directed and horizontal direction, like wind load, topical water power, seismic force, etc. I.R.C code regulations were used for the assessment and the effect of different forces on the bridge pier. A parametric study is explained for the effectiveness by IRC living load for different heights of the pier and spans of the bridge for the different shape of the pier. In the end, effect of IRC the living load is studied for different heights of the pier and spans of the bridge for the different shape of the pier.

DESIGN METHODE: Presented the comparison of the effect of different standard loadings on a set of reinforced concrete bridge decks using the finite-element method was attempted. The parameters investigated include the feature ratio (span/width) and IRC vehicle loading. The outcomes show that two IRC standard loading were 5 to 15% maximum difference in deflection and longitudinal bending moment. The maximum vehicle axle-load of IRC standards found to be 0.45 times lower than that of Euro standards. Hence, 0.58 to 0.55 times decreases the numerical value of response parameters of the structure.

S.N.krishna kanth, Dr.V.anjaneya Prasad, "Design and analysis of bridge design using staad pro"[2016]: Bridge is a structure having a total length of above 6 meters between the inner faces of the dirt walls for carrying traffic on road or railway. The bridges shall be classified as minor bridge and major bridge. Minor bridge – Bridge having a total length up to 60 meters. Clause 101.1 of IRC 5:1998 Major bridge – Bridge having a total length above 60 meters.

DESIGN METHODE: The bridges are designed and constructed adopting the following IRC specifications. • IRC 5:1998 Standard specification and code of practice for road bridges- Section I general features of design • IRC 6:1966 Standard specification and code of practice for road bridges – Section II load and stress • IRC 21:1987 Standard specification and code of practice for road bridges- Section III cement concrete • IRC 40 : 1995 Standard specification and code of practice for road bridges- Section IV (bricks, stones and masonry) • IRC 22:1986 Standard specification and code of practice for road bridges- Section VI composite construction • IRC 78:1983 Standard specification and code of practice for road bridges- Section VII formation and sub structure • IRC 83:1987 Standard specification and code of practice for road bridges- Section IX bearings • IRC SP:20 2002 Rural Road Manual • IRC SP 13:2001 Guideline for the design of small bridges and culvert.

Vikash Khatri "Skew bridges analysis using grillage analogy'' [2012]: In this paper describes Grillage analysis is the most common method used in the bridge analysis. In this method the deck is represented by an equivalent grillage of beams. The finer grillage mesh, provide more accurate results. It was found that the results obtained from grillage analysis compared with experiments and more rigorous methods are accurate enough for design purpose.

DESIGN METHODE: The finite element method is a well-known tool for the solution of complicated structural engineering problems, as it is capable of accommodating many complexities in the solution. In this method, the actual continuum is replaced by an equivalent idealized structure composed of discrete elements, referred to as finite element, connected together at a number of nodes. Behaviour of a skew bridge.

Dr. Maher Qaqish "Behaviour of a skew bridge" [2008]: This method is usually used for analysis of bridges based on the consideration of the bridge deck as an elastic continuum in the form of an orthogonally anisotropic plate. Using the stiffness method of structural analysis, it became possible to analyse the bridge deck structure as an assembly of elastic structural members connected together at discrete nodes.

DESIGN METHODE: There are four distinct techniques which have been found useful by bridge engineers: grillage and space frame analysis, folded plate method, finite element method and finite strip method .The grillage analogy method involves a plane grillage of discrete interconnected beams.

William A. Litle [1966]: Established a reliable small scale ultimate strength modeling technique for wide-flange steel frameworks and presented the results of the first phase of his study. Five techniques have been considered for fabrication of small scale wideflange steel beams. At the one-eighth to one-fifteenth scales envisioned for the model work, minimum thicknesses down to about 0.025-in would be required. Although the process produced reliable welds, test specimens showed occasional weld skips or incomplete welds due to imperfect alignment of the plates or due to "wandering" of the electron beam. These occurrences, coupled with the physical size limitations of existing vacuum chambers which house the electron beam equipment, caused rejection of this technique. Resistance welding of flange and web plates was also investigated.

DESIGN METHODE: In order to establish proper techniques, a one- by two-bay three-story space framework was fabricated using one fifteenth scale 14WF103 members as columns and one fifteenth scale 21WF62 members as beams. He conclude that the mechanical properties and weld ability of SAE C1020 hot rolled steel permit its use as an ultimate strength model material for ASTM A36 steel structures, Milling wide-flange sections from hot rolled bar stock is a reliable and accurate process for fabricating small scale sections with element thicknesses down to 0.025-in, The machining process used to fabricate the wide flange 12 sections destroys the sharp break at the yield plateau but does not significantly influence the yield or ultimate strength, Tension and joint tests show that the Heliarc welding process (TIG) with Industrial Stainless 410 filler wires provides joints with more than adequate strength and ductility, Due to an unpredictable strength increase in the heat affected zones of non-annealed welded joints it is desirable to anneal whole frameworks before testing.

Corley[2004]: Constructed and tested 1/10 scale micro-concrete model of new Potomac river crossing 1-266 at Washington D.C., Since the construction of this bridge would set several precedents, it was decided that structural model tests should be used to supplement the design calculations. The tests were carried out to study performance of the model bridge under application of dead load and design live load. In addition, behavior of the model under extreme overload was determined. The model was constructed of 3-ft.-long precast concrete segments that were sequentially grouted in position and post tensioned together. The use of precast segments was strictly for convenience in the laboratory. The results showed that, under the application of service load representing the dead load of the prototype and one live load plus impact under (HS 2044) loading, no structural cracking occurred and the model bridge remained essentially "elastic".

Sritharan[2001]: Tested five-story precast concrete building by PRESSS Precast Seismic Structural Systems) program, under simulated seismic loading. It was determined that, for seismic testing purposes, it would be only necessary to model 50 x 50 sq. ft plan area of the prototype buildings with 2 bays in each direction. The test building was then modeled at 60% scale of the resized prototype buildings in order to accommodate it inside the Charles Lee Powell Structural Laboratory at the University of California at San Diego (UCSD).

DESIGN METHODE: This resulted in the test building having 30 x 30 sq. ft in plan, 7 ft 6 in. story height and 15 ft bay length and modeling all critical connections of a real building. They were expected that the different levels of pseudo dynamic testing together with stiffness measurement and inverse triangular tests, will sufficiently quantify the performance of the PRESSS building at different limit states.

Kapil Kushwah, Anshuman Nimade, Mahesh Patidar , Vikas joshi"ANALYSIS OF RC DECK SLAB BRIDGE FOR VARYING SPAN [2008]: The bridge is a structure imparting passage over an impediment without remaining the way under. The desired passage may be for a road, a railway, pedestrians, a canal or a pipeline. T-beam bridge decks are one of the predominant sorts of forged-in vicinity concrete decks and consist of main girders, cross girders which imparts lateral tension to the deck slab and deck slab which runs among T-beams constantly. Bridges are exceedingly investment systems and vital landmarks in any country. Besides being crucial links in transportation device. Strength, protection and economy are the Three key capabilities that cannot be left out before the finalization of kinds of bridges.

DESIGN METHODE: While deciding the forms of bridge, spans and other parameters are to be studied cautiously to fulfil out the need of suitability to site situations. the analysis of a three span two lane T-beam bridge is carried out by varying the span of 10m, 15m, 18m, and number of longitudinal & cross girders using software Staad Pro v8i. In order to obtain maximum bending moment and shear force in girder, maximum Stresses in slab and maximum reaction and moment at the support, the bridge models are subjected to the IRC class AA Tracked loading system and concluded that with the increase in shear force, bending moment and deflection in the girder and variation of stresses in slab.

Maher Shaker Qaqish [2006]: Studied the effect of skew angles distribution of bending moment in bridge slabs. He subjected 1.8 AASHTO truck loading, 1.8 AASHTO equivalent distributed loading and abnormal loading to the structural model. He compared the results for transverse and longitudinal moments with the results obtained from AASHTO specifications. This comparison shows that applying AASHTO specification for slab bridge deck is safe and economical.

Ozgur and White [2008]: Studied the behavior and design of horizontally curved and skewed I-girder bridges predicted by 3D FEA and 3D Grid models. They observed that major-axes of bending stresses and deflection are not affected significantly by the 18 geometric nonlinearity whereas the influence of geometric nonlinearity is noticeably high for the flange lateral bending stresses and radial deflections. Research work has been done to model a structure, and for testing the behavior of skewed slabs. December (2008) and January (2009) Field instrumentation and live load testing were performed in by Inspectech, a division of Kabbani Construction Group to predict the behavior of Al- Awali bridge. November (2009) and March (2010) Azad, Baluch, and Kalemu from KFUPM made a finite element analysis (FEM) testing model using STAAD.Pro program to analyze and study the behavior of Al- Awali bridge.

Cheung[2005]: studied analytically and experimentally the behavior of simply supported curved bridge decks with intermediate column supports. His analytical study was based on the finite-strip method, the results of which compared favorably with experimental values obtained from testing thirty 1:60 scale asbestos cement curved slab 13 decks. He conducted a static analysis of orthotropic curved bridge decks with two radial edges simply supported and the other two curved edges free, using a

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combination of Fourier series and the finite-difference technique. The governing fourth-order partial differential equation of orthotropic plates was converted to an ordinary differential equation and solved by the finite-difference method.

Harik and Pashanasangi[2005]: presented a solution for the analysis of orthotropic curved decks subjected to uniform, partial uniform and patch loads, line and partial line loads in the radial and tangential directions, and point loads. The analysis is based upon an approach similar to that of the finite strip, but does not require the polynomial representation and minimization procedure often associated with the finite strip. The deck was divided into radially supported curved strips, whose deflections and loads were expressed in a Levy Fourier series. Convergence was achieved by increasing the number of modes instead of the number of elements.

Sato, Vecchio, and Andre[2005]: tested the scale model to study the behavior of reinforced concrete elements. Two important aspects of model construction and response analysis are the requirements of geometric similitude and material similitude, both must be satisfied in order for a proper model to exist. Geometric similitude requires that all linear dimensions of both the specimen and the load application system be scaled down from the corresponding dimensions of a prototype by a constant ratio, (1/S1), where S1 is the scale factor. Material similitude requires that, at any given load, the stress and strain in the model and prototype must be related by a constant stress factor Ss, and a constant strain factor Se. The experimental results which they made indicate that reinforced 14 concrete scale models, when fabricated and tested to the requirements of replica scaling, can be used to accurately predict many aspects of prototype behavior under loading conditions.

Iqra Zaffar and Priyanka Singh"Analysis and Design of Deck Slab Bridge"[2001]: Bridges are the lifelines and supporters for the improvisation of the road network. Not only do the bridges help in traffic flow without any interference but also maintain the safety of roads. Due to this reason the bridges design has gained much importance. This paper is basically concerned about the analysis and design of Deck Slab Bridge by STAAD Pro using IRC Loading. Which contains a span of 100m X 16m and has a 4-girder system. The objective is to check the result for particular input design, properties and parameters and the approach has been taken from AASHTO standard design. The nodal displacement, beam property, vehicle loading details, concrete design can be easily found out performing the analysis and design method.

RITTIK BHOWMIK,S. MUKHERJEE,SULAGNO BANERJEE "Review on bubble deck with spherical hollow balls"[2011]: The aim of this paper is to discuss about various significance of Bubble Deck Slab against Conventional Slab based on the various studies. Reinforced concrete slabs are one of the most common components in modern building construction consuming most of the concrete. Due to the sheer amount of concrete required to produce these slabs, the dead weight of them tend to be very large. Heavier structures are less desirable than lighter structures in seismically active regions because a larger dead load for a building increases the magnitude of inertia forces which the structure must resist, as large dead load contributes to higher seismic weight. Bubble Deck is a revolutionary method which was developed in the 1990s in Europe and is gaining popularity and acceptance worldwide. This method virtually eliminates concrete from the middle of the conventional slab, thereby dramatically reducing structural dead weight. Bubble Deck slab uses hollow spherical or elliptical balls made by recycled plastic. Plastic voided slabs are capable of reducing the amount of concrete necessary to construct a building by 30 percent or more. Voids in the middle of a flat slab eliminate up to 35% of a slab's self-weight removing constraints of high dead loads and short spans. This provides a wide range of cost and construction benefits.

III. SUMMARY OF LITERATURE SURVEY

The most common form of highway bridge construction in the United States is the slab-on-girders/beams. The concrete deck slab in such bridges is usually designed following the AASHTO's Load Factor Design Specification (Standard 1996) as a one-way slab with the main steel reinforcement being perpendicular to traffic. This approach is based on the work of Westergaard (1930), which considered the slab to be rigidly supported at the location of the girders.

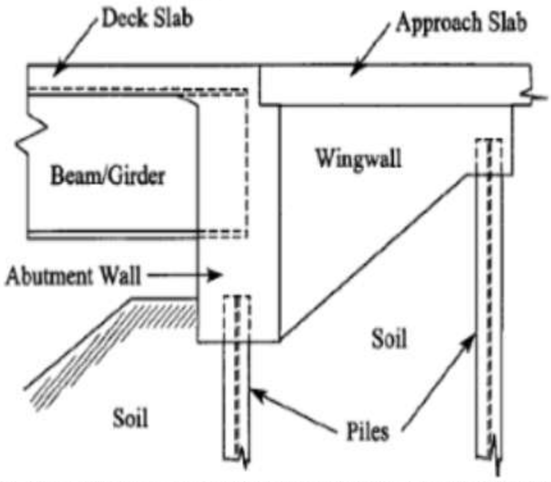

Fig. (3.1) Connection Detail for Composite Steel Integral Bridge.

Strip of a concrete slab on several I-girders, M (in kN/m), canbe taken as follows:

M=

Where S = effective span length of the slab (m), calculated as the clear distance between the edges of the top flange plusone-half the width of the flange; and P = weight of the heaviest wheel in the design truck (kN). The distribution reinforcement at the bottom of the slab along the direction of traffic, percentage of the primary reinforcement for positive moments obtained from

Where this reinforcement is to be placed in the middle one-half of the slab. In addition to the primary and distribution reinforcements, temperature and shrinkage reinforcement along the direction of traffic is placed on the top of the slabto control cracking.

Recently, AASHTO published its LRFD bridge design spec-incautions (LRFD 1994). The design of the concrete slab in this state-of-the-art document is accomplished by one of three methods. The first method is an approximate procedure, which is based on isolating a strip of the slab perpendicular to the centerline of the bridge at the location of the heavy axles and treating the strip as a continuous beam on unyielding supports. The second method is an empirical approach that utilizes the arching action in the slab and requires placing four layers of isotropic reinforcement in the slab. The third method involves analyzing the whole bridge using a detailed finite-element method.

IV.GAP IN RESEARCH REVIEW AND OBJECTIVE OF NEW RESEARCH

Based on the survey of available literature following gaps in the research are identifying.

- There is very limited research which focuses on varying Span/Depth ratio of RC deck slab bridge with different span.
- There is almost Nil research available for span/depth ratio with considering span/width ratio of deck slab bridge. Based on above-mentioned gaps following the objectives of the research are being investigated
- To evaluate the performance of the RC deck slab with varying depth/span ratio.
- To compare stresses on girders and piers of the bridge with varying the thickness of the deck slab to optimize the performance of the bridge with safe and economic aspects.

V. CONCLUSION

From the research we understand about the contribution of different researches in the field of the deck slab structure system, a gap in the research and objective of the research to be conducted. These contributions help to visualize the problem faced by RC deck sab from a new perspective. By evaluating the performance of deck slab bridge with different thicknesses its enhanced economic aspect may be achieved, which shall lead to the direction of the design of safe stronger and more economical bridge.

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