FINITE ELEMENT MODELING OF REINFORCEMENTED CEMENT CONCRETE SKEW BRIDGE AND DYNAMIC ANALYSIS

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ABSTRACT

This study was focused to compare and analyses the normal and skew bridge with different angles (30°, 45°, and 60°) for IRC Class A loading to determine the deflection, bending moment and shear force. The normal and skew bridge was modeled to evaluate the effectiveness of skew angles. The result clearly show that the skew bridge with 60° reduced deflection up to 40% to 50% compared to normal bridge. The skew bridge with 60° exhibited similar trend in the reduction of both bending moment and shear force up to 30% to 35% for wheel load. Since the load carrying capacity of skew slab significantly depends on the skew angle, from this study it was found that skew angle with 60° will improve overall behavior of the bridge compared to normal bridge.

INTRODUCTION

Bridges are great symbols of mankind's conquest of space. They are the enduring expressions of mankind's determination to remove all barriers in its pursuit of a better and freer world. Bridges are life lines to humanity to connect two communities which are separated by streams, valleys, railroads, etc. All the physical forces of the nature and gravity must be understood with mathematical precision and such forces have to be resisted by manipulating the right materials in the right pattern. Hence the design and building of bridges requires both the inspiration of an artist and skill of an artisan. Scientific knowledge about materials and structural Behaviour has expanded tremendously, and computing techniques are now widely available to manipulate complex theories in innumerable ways very quickly.

The Indian Railways is known to be one of the largest railway networks in the world with about 116000 bridges in its network. Research Development Standards Organization (RDSO) has standardized designs for commonly adopted spans. However these designs are for right bridges and not for skew bridges. Thus there is a need for detailed analysis of skew slab railway bridges so that their design may be standardized. Skew bridges are inevitable in urban areas due to limited land availability and due to alignment constraints.

LITERATURE REVIEW

Mahmoud Sayed-Ahmed, Khaled Sennah

In 2013, Mahmoud Sayed-Ahmed, Khaled Sennah has done a project on Finite Element and Modal Analysis of 3D Joint less Skewed RC Box Girder Bridge. In this paper Modal analysis reveals that skewed bridge deck will not deform constantly through the deck's diagonal corners, leading to 3D in-plane and out-plane rotation and translation that could dramatically increase with the addition of different types of loading. In converting the conventional simply-supported bridge to joint less semi-continuous bridge, designer should consider the 3D effect for all connections.

Shervin Maleki

In 2007, Shervin Maleki has done a project on Deck Modelling for Seismic Analysis of Skewed Slab-Girder Bridges. In this paper Analytical study of single-span skewed slab-girder bridges, with spans ranging from 10 to 30 meters. In all cases considered, the deck stresses found to be very small and far below the allowable tensile steel stress or compressive concrete stress. Therefore, it is concluded that the assumption of rigid deck can be used safely for skewed slab-girder bridges with elastomeric or pinned bearings with spans up to 20m and skews up to 30 degrees.

Kanhaiya LalPandey

In 2010, Kanhaiya LalPandey has done a project on Behavior of Reinforced Concrete Skew Slab under Different Loading Conditions. In this paper the same aspect ratio and skew angle, the ultimate (total) load carrying capacity of skew slabs are higher in case when the loads are distributed across the width. Cracks are limited within a small bandwidth parallel to support line along centre span for multiple point loads placed across the centre span.

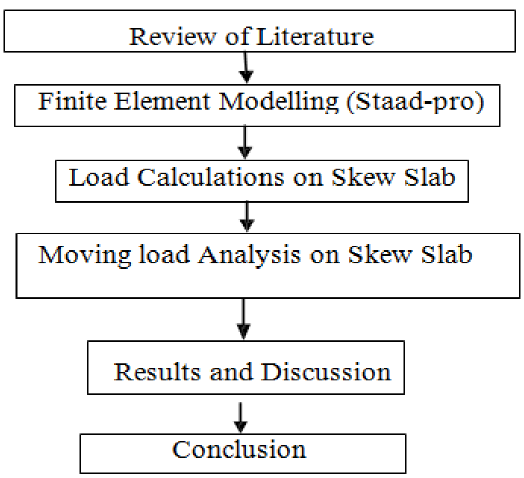
Sk.Md.Nizamud-Doulah and Ahsanul Kabir, In 2009, Sk.Md.Nizamud-Doulah and Ahsanul Kabir has done a project on Non linear Finite Element Analysis Of Reinforced Concrete Rectangular and Skew Slabs. In this paper, The maximum deflection for skewed deck slabs decreases with the increase in skew angle for all aspect ratios. At 60° the reduction is around 75% in slab Bridge without edge beam and about 90% reduction in seen for slabs with edge beam when compared to right bridge without edge beam for all aspect ratio for dead load. A similar trend is observed in case of wheel load but the order of reduction is comparatively less i.e. about 40 % to 50% compared to the case of dead load.

The effect of a skew angle on single-span reinforced concrete bridges is analyzed using the finite-element method and the results are presented in this paper. Investigations are carried out on RC slab bridge decks with and without edge beams to study the influence of aspect ratio, skew angle and type of load. The finite-element analysis results for skewed bridges are compared to the reference straight bridges for dead load, IRC Class A loading and IRC 70R loading for with and without edge beam. A total of 90 bridge models are analyzed. The variation of maximum deflection, maximum longitudinal sagging bending moment, maximum torsional moment, and maximum support reaction with skew angle is studied for all 90 bridge deck models. The FEA results of Dead load and Live load bending moments and deflections decreases with increase in skew angle, where as maximum support reactions increases with increase in skew angle and the maximum torsional moment increases with skew angle up to 45 degrees and there after decreases. The benefit of providing edge beam is reflected in significant decrease in deflection, longitudinal bending moment and torsional moment.

In this paper seismic response analysis of a simple span concrete deck girder skewed bridge is carried out for a wide range of skew angles. In this regard, a 3-D model bridge using the finite element method is considered in linear time history analysis. A standard direct time integration approach is employed in the time history analysis. An earthquake ground motion record complying with the design acceleration response spectrum obtained from low to moderate magnitude earthquakes is applied in the longitudinal direction of the bridge. The analytical results have indicated that the skewed bridge responses are quite different from the non-skewed bridge and varying with the skew angles and also on ground motion characteristics.

METHODOLOGY

The detailed methodology adopted for this research is as follows:

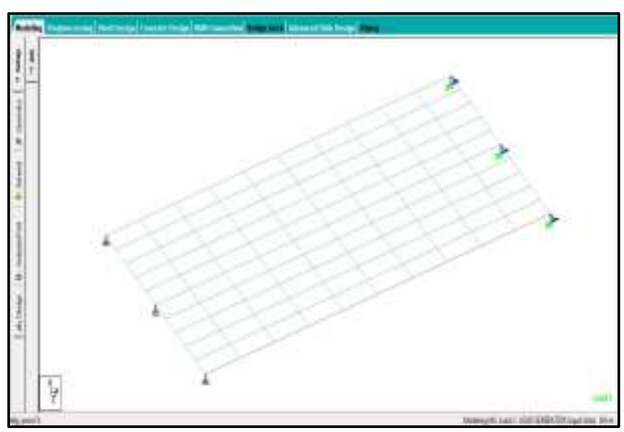


ANALYTICAL PROCEDURE

Staad pro

STAAD.Pro V8*i* is a comprehensive and integrated finite element analysis and design offering, including a state-of-the-art user interface, visualization tools, and international design codes. It is capable of analyzing any structure exposed to static loading, a dynamic response, wind, earthquake, and moving loads. STAAD.Pro V8*i* is the premier FEM analysis and design tool for any type of project including towers, culverts, plants, bridges, stadiums, and marine structures. With an array of advanced analysis capabilities including linear static, response spectra, time history, cable, imperfection, pushover and non-linear analyses, STAAD.Pro V8*i* provides your engineering team with a scalable solution that will meet the demands of your project every time. STAAD.Pro V8*i* will eliminate the countless man-hours required to properly load your structure by automating the forces caused by wind, earthquakes, snow, or vehicles. In addition, no matter what material you are using or what country you are designing your structure for, STAAD.Pro V8*i* can easily accommodate your design and loading requirements, including U.S., European (including the Eurocodes), Nordic, Indian, and Asian codes.

In this study a total of four models are modelled in staad-pro (shown in the table1) and the moving load analysis was performed to know the performance of the skew angled slab.



LIVE LOAD

The live loads are taken as per I.R.C. 6-2010. The types of vehicles are mentioned below:

(i) I.R.C. 70R Tracked Vehicle (70T)
(ii) I.R.C. 70R Wheeled Bogie (40T)
(iii)I.R.C. 70R Wheeled Train (100T)
(iv) I.R.C Class-A Train Vehicle

The critical live load combination 3- lane considered as per I.R.C. 6-2010

(i) One lane of 70R + One lane of Class A
(ii) 3-Lane of Class A

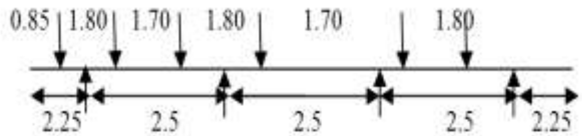


Fig. Three lanes of class A at minimum eccentricity

The live loads are applied as moving loads using STAAD-Pro. The load generation is taken as length of span+length of vehicle by 0.1. As shown below

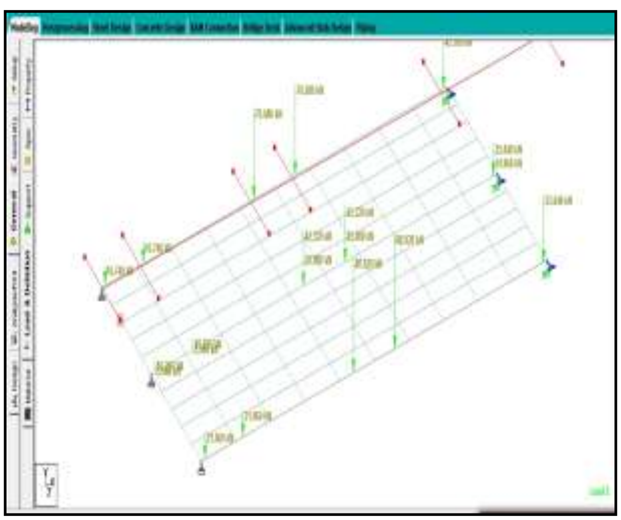


Fig. live load acting on model

Results and Discussions

Based on comparison and analysis of the normal and skew bridge for deflection, bending moment, and shear force and their behaviour when moving load is applied on them were discussed below.

Stresses

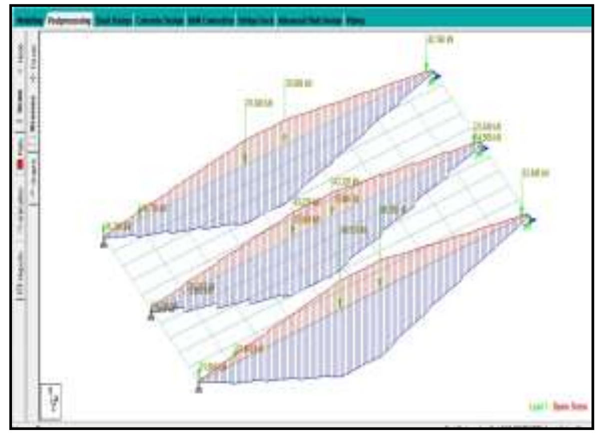


Fig.shows stress when skew angle is 0^0

Displacements

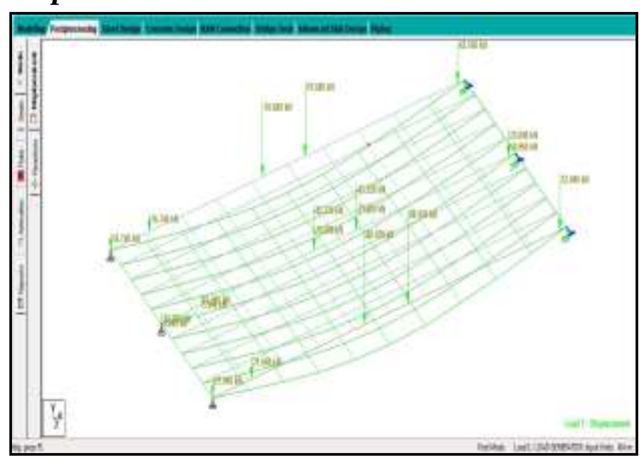


Fig. 4.2 shows displacements when skew angle is 0^0

End reactions

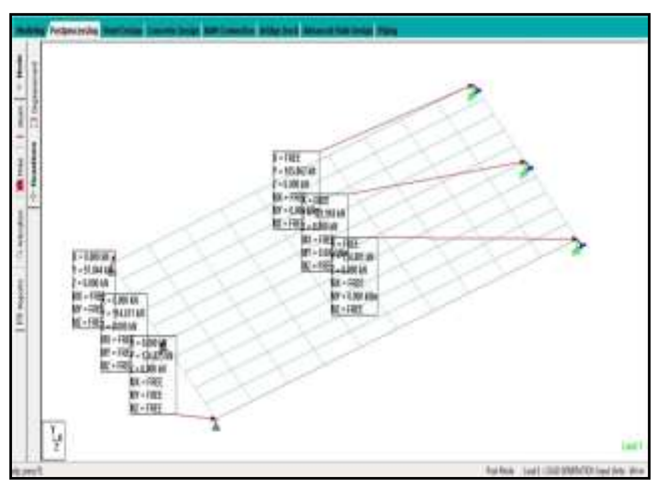


Fig. Shows end reactions when skew angle is 0^0

Stress contour

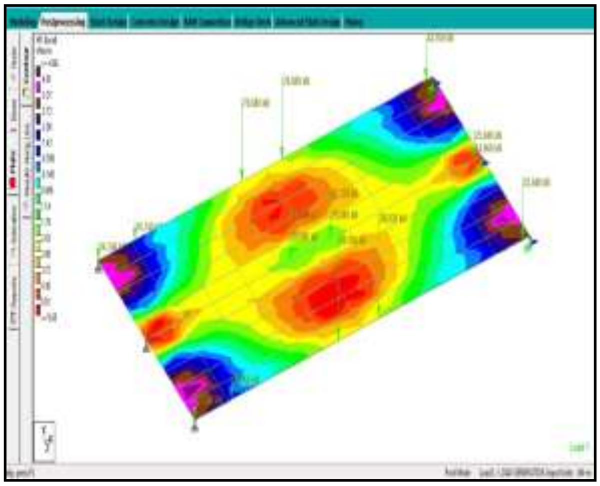


Fig. Shows stress contour when skew angle is 0^0

CONCLUSION

1. The maximum deflection for skewed deck slabs decreases with the increase in skew angle for all aspect ratios and at 60° there was a reduction of 75 % in slab bridge without edge beam and about 90 % reduction was observed for slabs with edge beam when compared to right bridge without edge beam for all aspect ratio for dead load. A similar trend was observed in case of wheel load but the order of reduction was comparatively less i.e. about 40 % to 50% in case the case of dead load.
2. Longitudinal bending moment shows similar pattern of reduction with increase in skew angle and maximum reduction due to dead load was found to be 70 % for a skew angle 60° compared to right bridge without edge beam for all aspect ratio when edge beam was provided it decreased up to 75% for a skew angle 60^0 compared right bridge without edge beam for all aspect ratio Maximum wheel load longitudinal bending moment decreases up to 35% for skew angle compared to right bridge for all aspect ratio.
3. As the skew angle increases maximum longitudinal moments gradually shifts towards obtuse angle
4. The load carrying capacity of skew slab significantly depends on the skew angle and based on this study the skew angle with 60° improved overall behavior of the bridge compared to normal bridge.

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