Analysis of Integral Abutment Bridge

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Abstract- **Integral abutment bridges are those where the superstructure and substructure are continuous or integral with each other. Solid slab bridges are common for short span up to 25m and an efficient system for short skewed crossings. There is a need for more research to study the skewed integral abutment bridge behavior. Eventhough there are different methods of bridge deck analysis, grillage method is very popular among bridge engineers due to its simplicity. But finite element method is becoming better due to its capability to represent complex geometry of the structure more realistically. In this paper, the effect of skew angle on different span of reinforced concrete integral abutment slab bridge using grillage method is discussed.**

Keywords— Grillage analysis, skew slab bridge, twisting moment

I. INTRODUCTION

Skew bridges are not willingly chosen but necessitated due to site considerations such as alignment constrains, land acquisition problems, etc. The skew angle can be defined as the angle between the normal to the centre line of the bridge and the centre line of pier cap or abutment. The behavior of such skew slab is complicated, hence also the analysis, design and detailing. Many methods are used in analyzing bridges such as grillage and finite element methods.

Normally a rectangular slab bridge deck behaves in flexure orthogonally in the longitudinal and transverse direction. The principal moments are also in the traffic direction and also in the direction normal to the traffic. In case of skew slabs the force flow between the support lines is through the strip of area connecting the obtuse angled corners and the slabs primarily bends along the line joining obtuse angled corners.

Grillage analysis is the most common method used in bridge analysis. In this method the deck is represented by an equivalent grillage of beams. The other method used in modelling the bridges is the finite element method. In this method, the actual continuum is replaced by an equivalent idealized structure composed of discrete elements, referred to as finite elements, connected together at a number of nodes. There has been a lack of research studying the effects of the disproportionate distribution of dead loads on the superstructure during construction. The reactions at the obtuse angled end of slab support are larger than the other end. The bearing reactions tend to change to uplift in the acute angle corners with increase in skew angle.

II. DECK SLAB BRIDGE

A two span, two lane integral abutment skew slab bridge is considered. The span is varied from 3m to 12m with an increment of 3m and skew angle is varied from 0^0 to 60^0 with an interval of 15^0 . 0ne twelfth of the span is considered as depth of the deck slab. A width of 7.5m is provided. The height of abutment is 3m.

III. LOAD ON BRIDGE DECK MODELS

The deck of the bridge subjected to dead loads comprising of its self weights due to wearing coat, parapet, kerb etc which are permanently stationary in nature. The dead load act on the deck is the form of distributed load. These dead loads are customarily considered to be done by the longitudinal grid members only giving rise to the distributed loads on them.

The main live loading on highway bridges is of the vehicles moving on it. Indian Road Congress (IRC) recommends different types of standard hypothetical vehicular loading system, for which a bridge is to be designed.

The vehicular live load consists of a set of wheel loads. These are distributed over small areas of contacts of wheels and form patch loads. These patch loads are treated as concentrated loads acting at the centre of contact areas. This is a conservative assumption and is made to facilitate the analysis. IRC Class A two lane, 70R tracked and 70R Wheeled are considered in this study.

IV. GRILLAGE ANALYSIS

The method of grillage analysis involves the idealization of the bridge deck as a plane grillage of discrete inter-connected beams. This is the first important step to be taken by the designer and needs utmost care and understanding of the structural behaviour of the bridge decks.

Deck with skew angles less than 15^o can usually be handled as right decks. However, bridges having skew more than 15^o pose problems in regards to the positioning and orientation of the longitudinal and transverse grid lines. When skew region is small and right region is large. the main spanning will follow the direction normal to support and the longitudinal grid lines will be taken normal to the support lines and transverse grid lines will be perpendicular to them. But in the case of skew region is large and right is small, the main spanning will follow skew direction and hence longitudinal grid lines will be taken parallel to bridge axis and transverse grid lines will be perpendicular to these.

If grillage is chosen in the direction of principal trajectories then grillage will be representing truly the behaviour of a skew slab. But in the grillage analysis the grillage beams are choosen

a) Parallel to free edges and

b) Parallel to supports or orthogonal to line, joining the supports

In both cases they are not representing the prime bending behavior of the skew slab. If any other line is chosen for grillage other than the primary bending direction, the torsional behavior is not properly reflected.

Here the analysis is carried out using STAAD Pro software. For 0^0 models, grillage is provided normally that is parallel and perpendicular to supports. For 15^0 models, parallelogram meshing is followed. For skew greater than 15^0 , longitudinal grid lines are laid normal to supports.

V. RESULTS AND DISCUSSIONS

A. Analysis of 3m bridge deck

Analysis of 3m bridge deck is carried out and the depth of the slab is 0.25m. The dead load bending moment values are plotted below.

It is observed that the maximum longitudinal dead load bending moment (Mz) is obtained for 45º skew angle and then a decrease can be seen in the bending moment value. The difference in variation of longitudinal dead load bending moment is small. The twisting moment (Mx) and transverse bending moment are in same pattern.

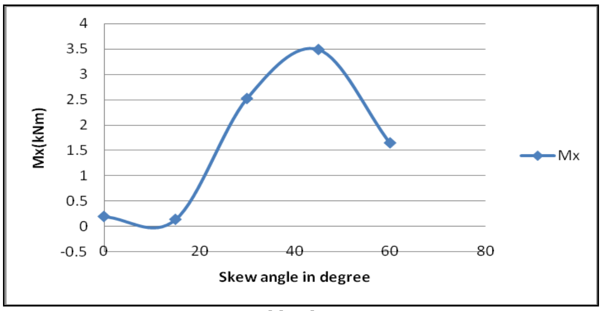

Fig.1. Dead load twisting moment

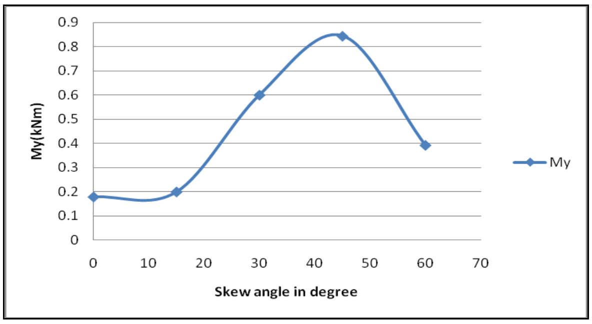

Fig.2. Dead load transverse bending moment

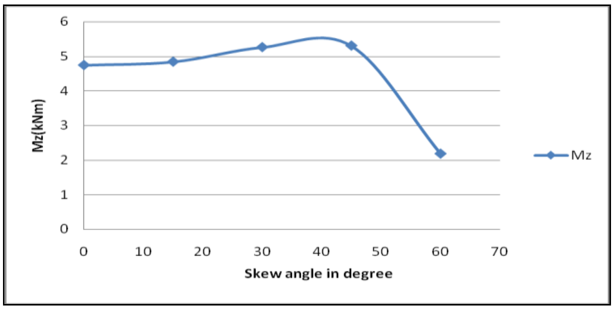

Fig.3. Longitudinal dead load bending moment

The bending moment values for different class of vehicles are also plotted. The bending moments for 70R wheeled is more than the other two. Here the peak value for bending moment is obtained for 45º.

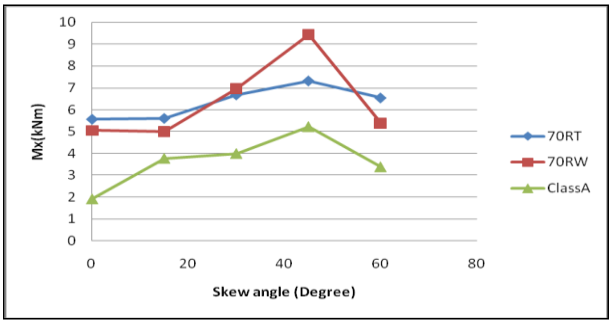

Fig.4. Twisting moment for different class of vehicles

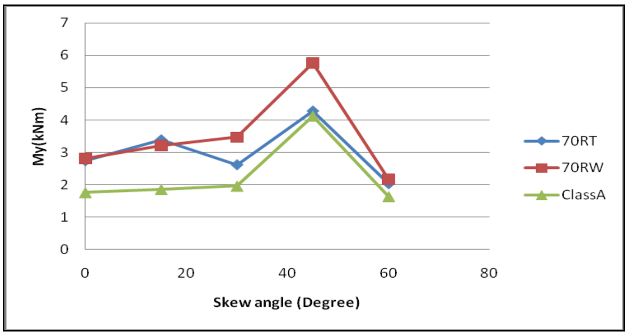

Fig.5. Transverse DL BM for different class of vehicles

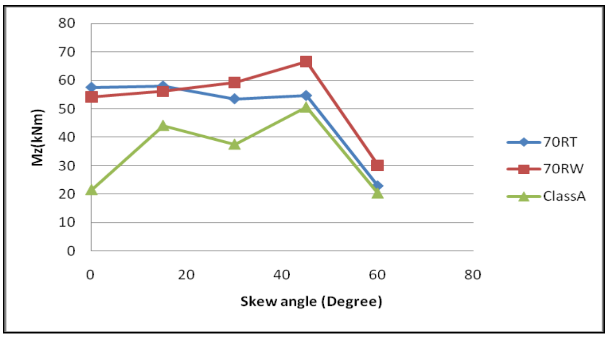

Fig.6. Longitudinal DL BM for different class of vehicles

B. Analysis of 6m bridge deck

Analysis of 6m bridge deck is carried out and the depth of the slab is 0.5m. The dead load bending moment values are plotted below.

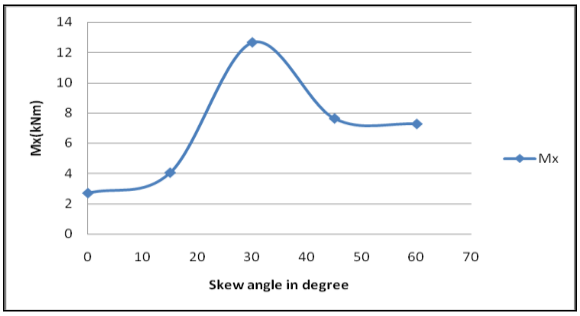

Fig.7. Dead load twisting moment

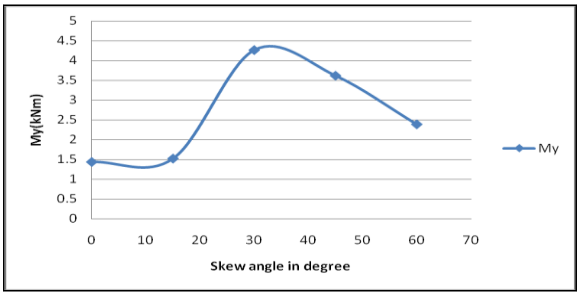

Fig.8. Dead load transverse bending moment

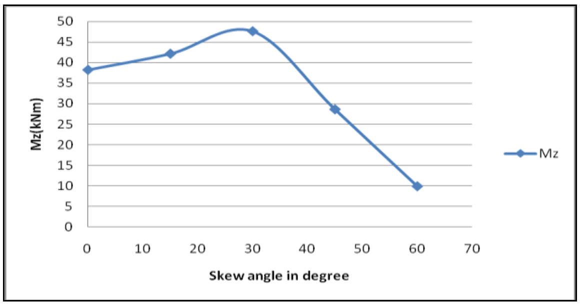

Fig.9. Longitudinal dead load bending moment

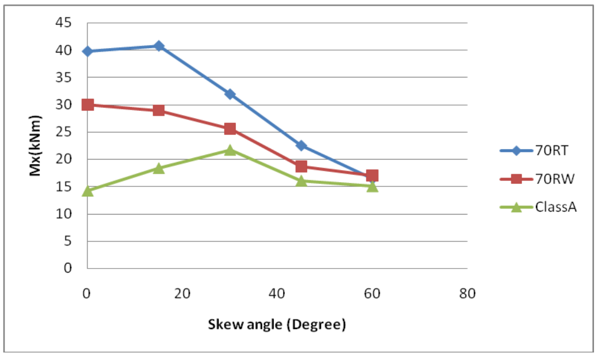

Fig.10. Twisting moment for different class of vehicles

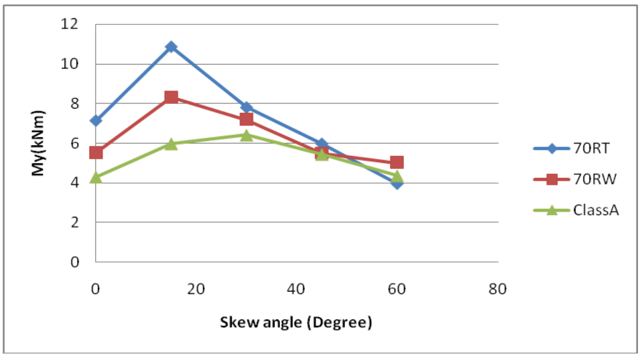

Fig.11. Transverse DL BM for different class of vehicles

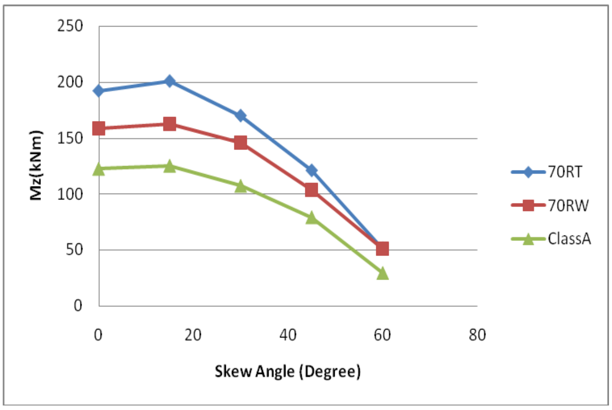

Fig.12. Longitudinal DL BM for different class of vehicles

C. Analysis of 9m bridge deck

Analysis of 9m bridge deck is carried out and the depth of the slab is 0.75m. The dead load bending moment values are plotted below.

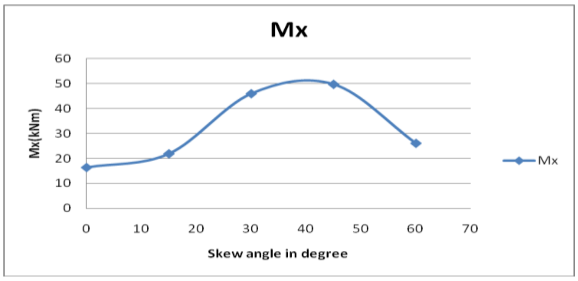

Fig.13. Dead load twisting moment

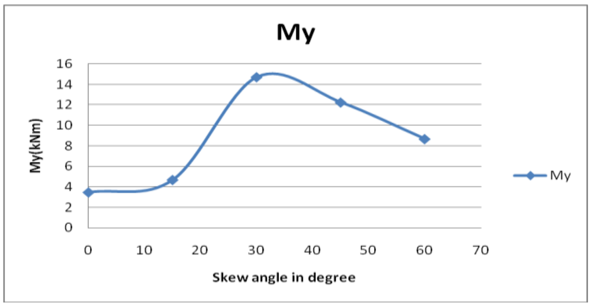

Fig.14. Dead load transverse bending moment

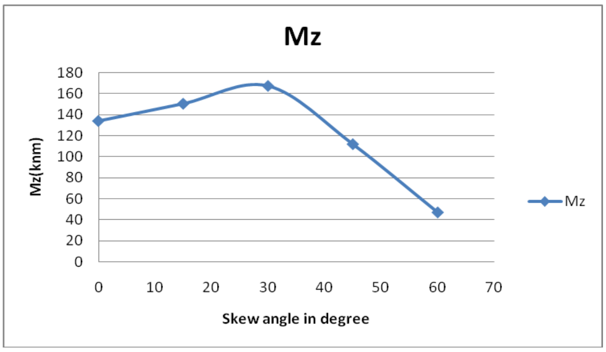

Fig.15. Longitudinal dead load bending moment

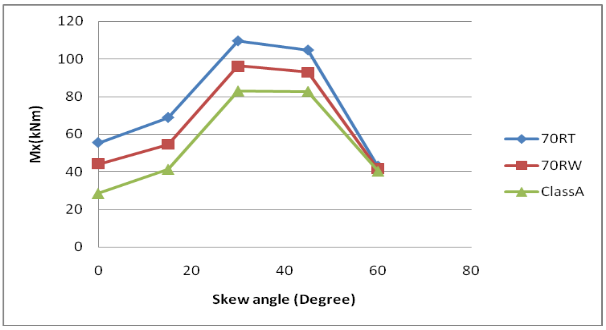

Fig.16. Twisting moment for different class of vehicles

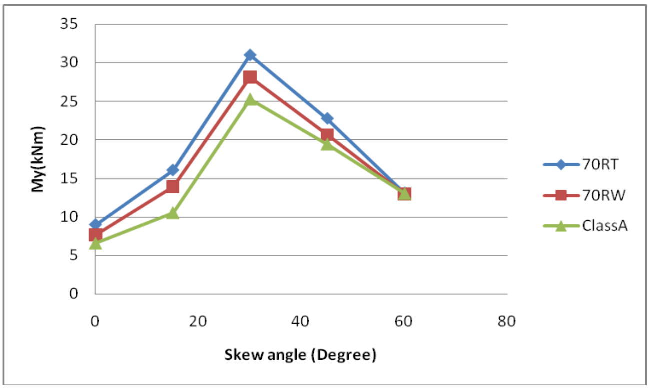

Fig.17. Transverse DL BM for different class of vehicles

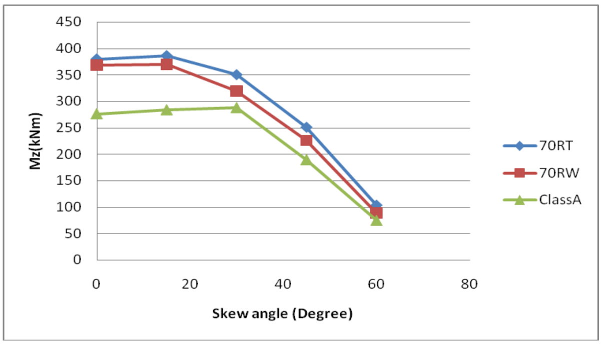

Fig.18. Longitudinal DL BM for different class of vehicles

D. Analysis of 12m bridge deck

Analysis of 12m bridge deck is carried out and the depth of the slab is 1m. The dead load bending moment values are plotted below.

From the graph it is observed that bending moment values for 12m span decrease after 15^0 .

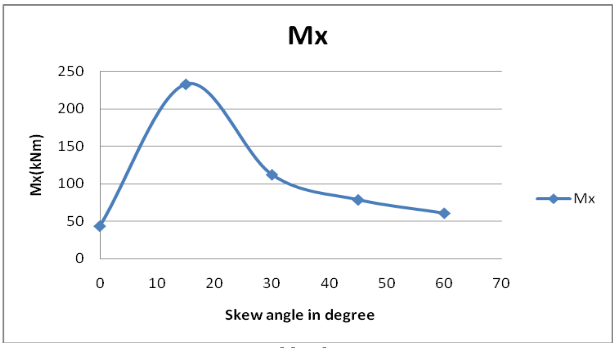

Fig.19. Dead load twisting moment

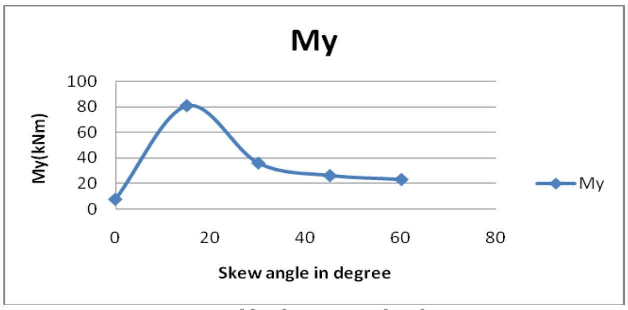

Fig.20. Dead load transverse bending moment

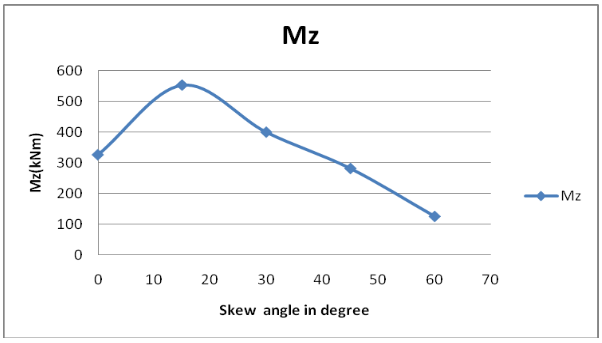

Fig.21. Longitudinal dead load bending moment

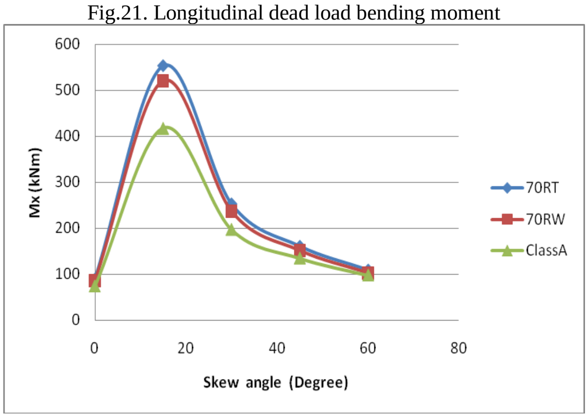

Fig.22. Twisting moment for different class of vehicles

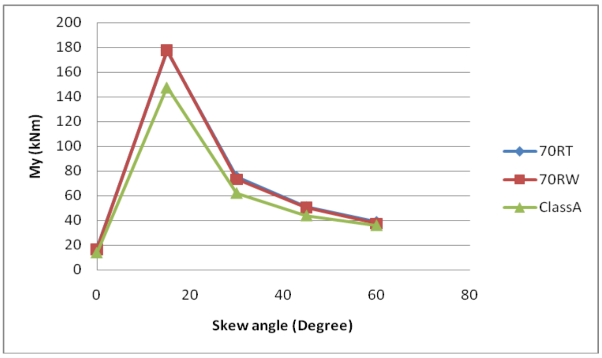

Fig.23. Transverse DL BM for different class of vehicles

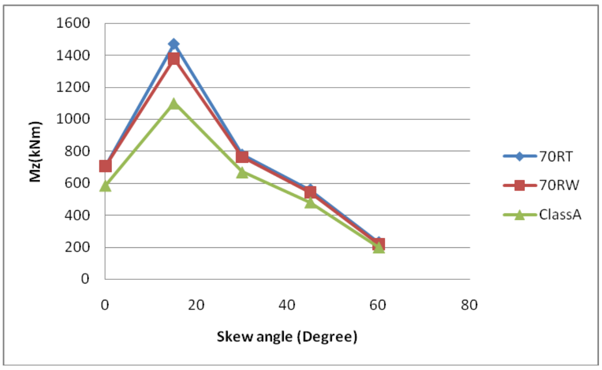

Fig.24. Longitudinal DL BM for different class of vehicles

VI. CONCLUSION

From this study, it is clear that for longer span the bending moment values are also high. The peak value of bending moment for 12m span is obtained for 15^{o} skew angle. Further increase in skew angle decreases the bending moment values. The bending moment values for 9m and 12m are approximately similar and there is only a slight variation. Here the twisting moment decreases with increase in skew angle after 15^{o} but its value increase with the span. In the case of skew slab the force flow between the support lines is through the strip of area connecting the obtuse angled corners. For the same span as skew increases the moment value decreases due to lower area of strip between the obtuse corners and it is due to lower skew width. 70R Wheeled is more critical in 3m span, while 70R tracked is critical in 6m span. The grillage analysis is easy to use and comprehend.

REFERENCES

[1] A text book on Bridge Deck Analysis by Eugene J O' Brein and Damien and L Keogh
[2] C. Menassa, M Mabsout, K. Tarhini and G. Frederick (2007),-Influence of Skew Angle on Reinforced Concrete Slab Bridges‖, Journal of Bridge Engineering, ASCE
[3] H. Zeng, J. Sun, H. Stalford,2000 " An Analysis Of Skewed Bridge/Vehicle Interaction Using The Grillage Method", University of Oklahoma
[4] Ibrahim S. I Harba, " Effect of Skew angle on Behaviour of Simply Supported R. C T-beam Bridge Decks" ‖, ARPN Journal of Bridge Engineering and Applied Sciences, Vol.6, No. 8,Aug 2011.
[5] Mahesh Shaker Qaqish, "Distribution of Bending Moments in the Longitudinal T-beams of Skew Deck Slab'‖, European Journal of Scientific Reasearch ISSN 1450-216X Vol. 13 No.3 (2006), pp. 374-380.