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Influence of Skew Angles on Box Type Bridge

Nasir Ali, Himanshu Guleria, Himanshu Sharma

***Abstract:** In the present study, modeling and analysis of a three-lane three-span box bridge has been carried out by using finite element software STAAD pro.v8i. The study has been execute to find the effect of skew angle on all bride slabs (top slab, bottom slab, outer walls, inner walls) under various loads (dead load, live load, surfacing load, earth pressure, temperature and live load surcharge) and their combinations using IRC 6:2016. Skew angles taken for study ranges from 0^0 to 70^0 with an interval of 10^0. Parameters that are mainly examined are longitudinal moments, transverse moments, torsional moments, shear forces and displacements. It has been observed that with the increase of skew angle all the parameters increases with the increase of skew angles in all slabs.*

***Keywords:** Skew bridge, skew angle, moments, force, displacement*

I. INTRODUCTION

In the present era, bridges can be attributed as life line of any country. With the availability of new techniques, there is a growing demand for skew bridges. The reason behind this surge are less availability of space especially in the urban areas, complex intersections at the places where roads cross obstructions like rivers, railway crossings, etc. at an angle other than 90^0. Skew bridges are useful at the places where road alignment changes are not feasible and at the places where roads are constructed in the areas having different terrains [3]. Skew bridges help to maintain the alignment of the modern highways by negotiating the sharp curves which in turn makes the road construction economical and increases safety to the fast-moving vehicles. The skew angle can be defined as the angle between the centerline of the traffic and abutments. Due to the presence of skew angle, both longitudinal, as well as transverse length increases in proportion to cosec ϴ where ϴ, is the skew angle [3] (Figure.1).

Skew bridges up to an angle of 20^0 show somehow same behavior as that of normal bridges but the problem arises when the skew angle is more than 20^0 various parameters like longitudinal moments, transverse moments, torsional moments, shear forces, etc. show different behavior. In the present study, behavior of three-lane box type skew bridge having skew angle ranging from 0^0 to 70^0 under different loads and combinations (dead load, superimposed dead load, surfacing, earth pressure, temperature load, live load, live load surcharge) as per IRC 6:2016 has been studied.

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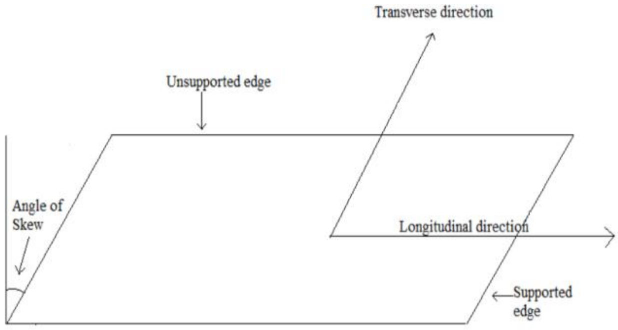

Figure 1 Plan of skew bridge

II. II. MODELLING ON STAAD PRO

2.1 Software and its features

STAAD pro is a software developed by the research engineers international in 1997 and later brought by Bentley. For modeling, STAAD pro v8i version has been used. The software is worldwide used for the design and analysis of structures like buildings, bridges, towers, and water plants for materials like concrete, steel, timber, and aluminum as it supports various codes of design. Both 2D and 3D structures can be analyzed and designed. It provides parameters like bending moment, shear force, torsional moment, deflection of any structure and variation of such parameters can show in post-processing**.**

2.2 Geometric dimensions of a bridge

For present study, the span of each box is 8 m and the width of the bridge is decided as per IRC 6:2016. Final plan and data of bridge model is shown in figure 2 and Table 1.2 respectively.

Table 1.1 Carriage way widths for number of lanes

S.No	Carriageway Width (CW)	Number of Lanes for Design Purposes	Load Combination (Refer Table 6A for diagrammatic representation)
1)	Less than 5.3 m	1	One lane of Class A considered to occupy 2.3 m. The remaining width of carriageway shall be loaded with 500 kg/m^2
2)	5.3 m and above but less than 9.6 m	2	One lane of Class 70R OR two lanes for Class A
3)	9.6 m and above but less than 13.1 m	3	One lane of Class 70R for every two lanes with one lanes of Class A on the remaining lane OR 3 lanes of Class A
4)	13.1 m and above but less than 16.6 m	4	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, OR one lane of Class A for each lane.
5)	16.6 m and above but less than 20.1 m	5	
6)	20.1 m and above but less than 23.6 m	6	

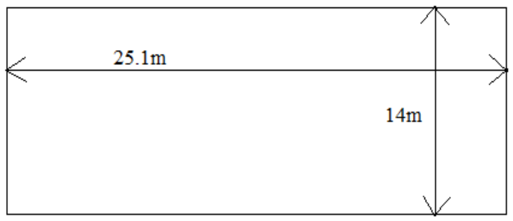

Figure 2(a) Final plan of bridge

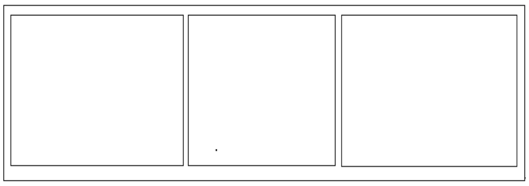

Figure 2(b) Transverse section of bridge

III. Table 1.2 Dimensions of bridge model

S.NO	Parameters	Dimensions	Quantity
1	Thickness of top slab	0.7m	1
2	Thickness of bottom slab	0.75m	1
3	Thickness of outer walls	0.4m	2
4	Thickness of inner walls	0.35m	2
5	Clear span of boxes	8m	
6	Number of boxes		3
7	Clear height	5.025m	

2.3 Stepwise procedure to prepare model on Staadpro.v8i

- Double click on STAADpro.v8i icon
- A window will appear select new project
- Select space (as it is a 3D modal)
- Give file name and location of folder where you want to save
- Select length unit (m) and force unit (kN) and then click next
- New window will appear click add beam or add plate option and then click finish
- A window with data bar, tool bar, menu bar, text bar etc. will appear
- Select a node and then go to translational repeat, select the axis and give dimensions according to your modal and then ok repeat the process till your model is completed as shown in Figure 3 and 4.

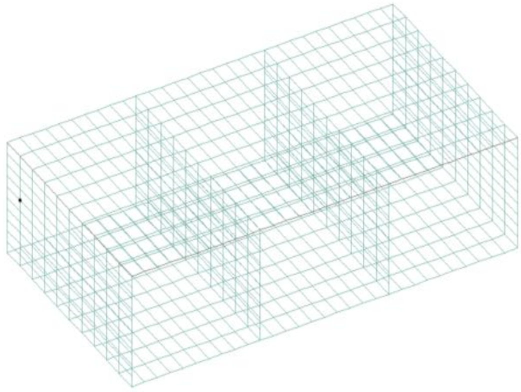

Figure 3 Final modal on Staadpro.v8i

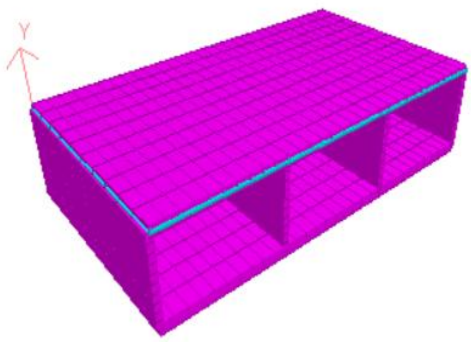

Figure 4 Rendered 3-D modal of box type bridge

IV. STUDY OF LOADING

Code of practice for roads and bridges IRC 6:2016 provides following values for various loads [15]:

3.1 Dead load

Density of concrete for bridge members is taken as 25kN/m^3

Density of bitumen is taken as 22kN/m^3

Dead load calculations

Self-weight of structure is assumed as 1with the density of 25 kN/m^3

Weight of bitumen layer on bridge

= density of bitumen X thickness of bitumen layer

=22 X 0.070

=1.534kN/m^2

3.2 Earth pressure load

E.P=$K_0 \gamma Z$

Where

K_0 = coefficient of earth pressure at rest

γ = density of soil

Z = height of wall

E.P= 0.5 X 20 X 6.75

E.P= 6.45 kN/m^2

3.3 Live load surcharge

$\Delta P = K_a \gamma h_{eq}$

Where

k = Coefficient of lateral earth pressure

γ = Density of soil

h_{eq} = Equivalent height of soil for vehicular loading 1.2 m

ΔP= 0.5 X 20 X 1.2

ΔP = 12kN/m^2

3.4 Live loads

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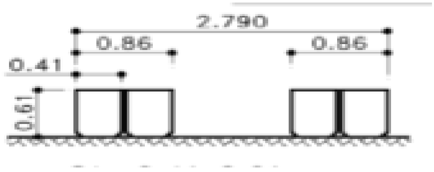

Figure 5 Wheel spacing for 70R wheeled vehicle

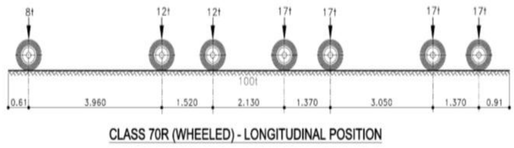

Figure 6 70R wheeled vehicle

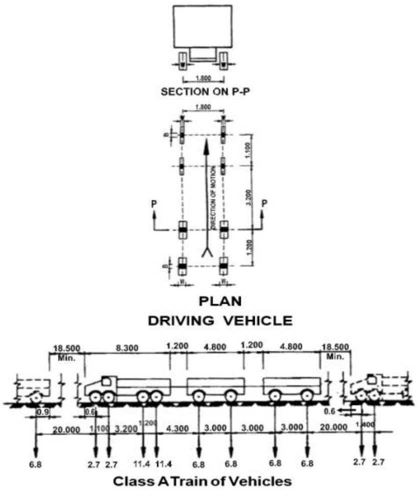

Figure 7 Class A train of vehicles

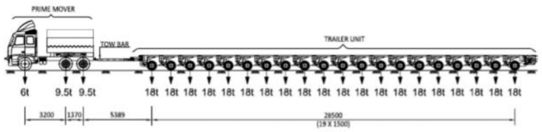

Figure 8 SV class vehicle with typical axle arrangement

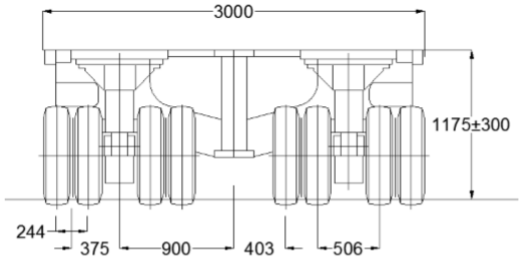

Figure 9 Transverse wheel spacing of special vehicle

V. RESULTS

In the present work, 8 models of three lane box type skew bridge are prepared on STAAD PRO V8i with skew angle ranging from 0^0 to 70^0 with an increment of 10^0. Under different loads dead load, superimposed dead load, surfacing, earth pressure, temperature, surcharge and live load and their combinations, results are obtained for longitudinal moments, transverse moments, torsional moments and shear force.

4.1 Contours of maximum torsion in top slabs for all skew angles.

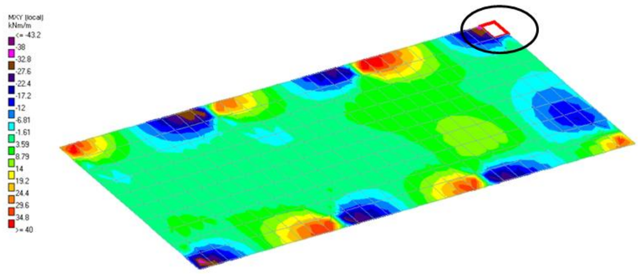

Figure 10 Typical top slab contour of max torsion for 0^0 skew

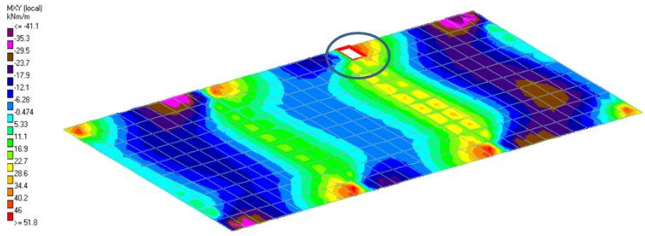

Figure 11 Typical top slab contour of max torsion for 10^0 skew

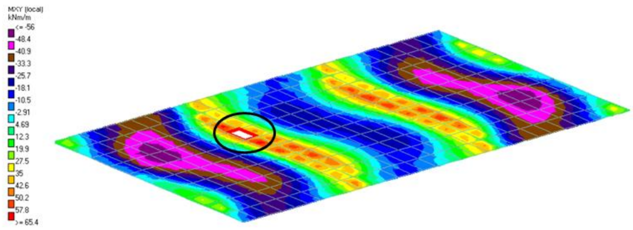

Figure 12 Typical top slab contour of max torsion for 20^0 skew

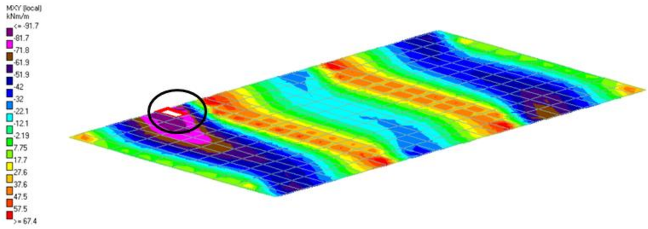

Figure 13 Typical top slab contour of max torsion for 30^0 skew

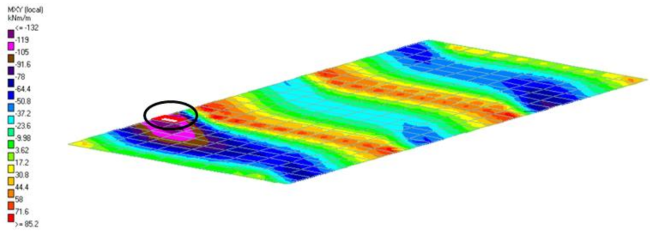

Figure 14 Typical top slab contour of max torsion for 40^0 skew

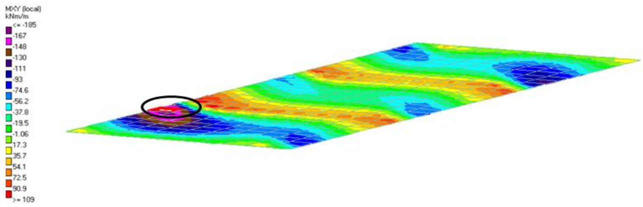

Figure 15 Typical top slab contour of max torsion for 50^0 skew

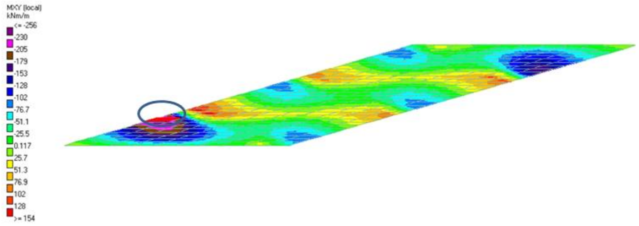

Figure 16 Typical top slab contour of max torsion for 60^{0} skew

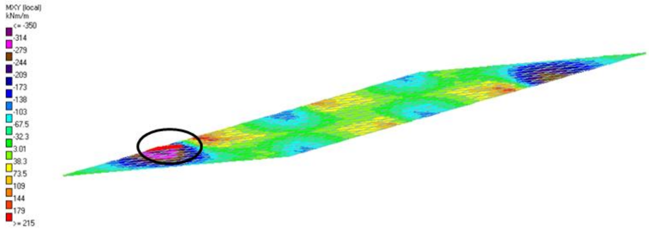

Figure 17 Typical top slab contour of max torsion for 70^{0} skew

4.2 Results of models for all slabs and their variation with skew angle

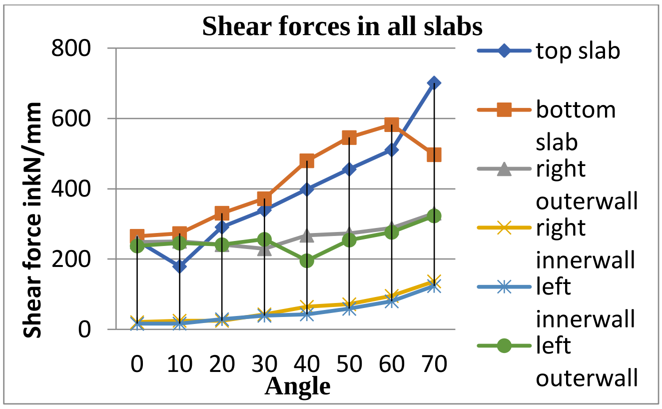

Chart-1: Shear force v/s skew angle

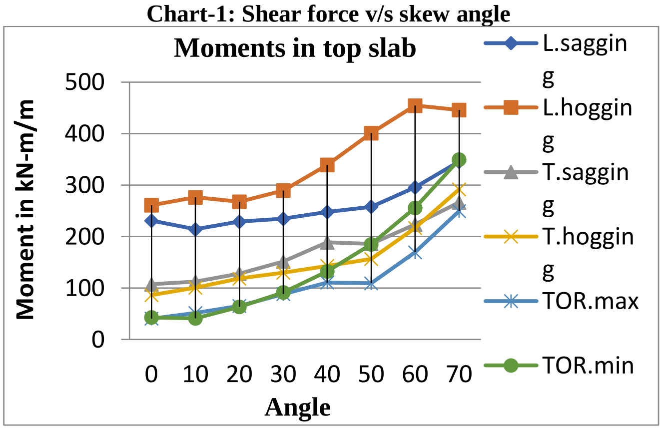

Chart-2: Top slab moments v/s skew angle

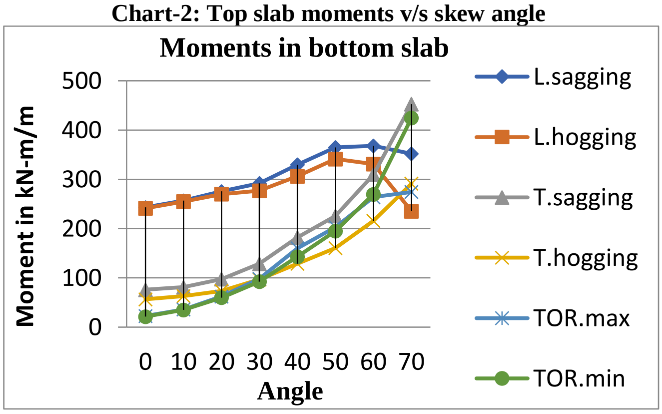

Chart-3: Bottom slab moments v/s skew angle

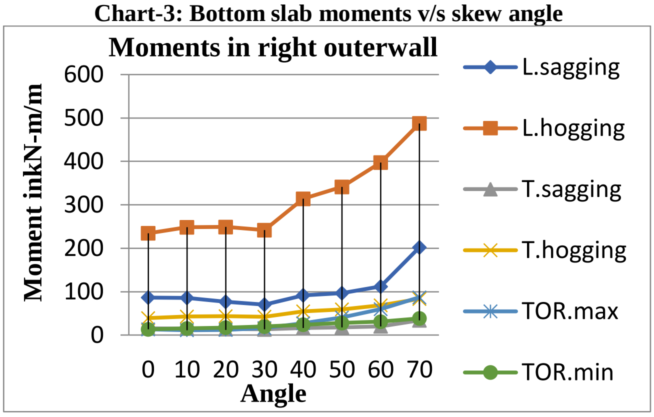

Chart-4 Right outer wall moments v/s skew angle

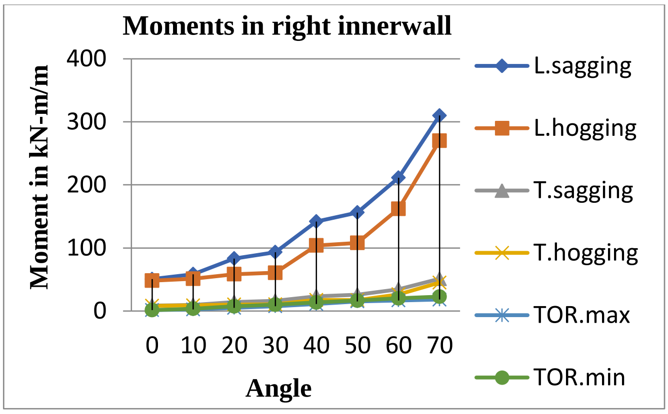

Chart-5: Right inner wall moments v/s skew angle

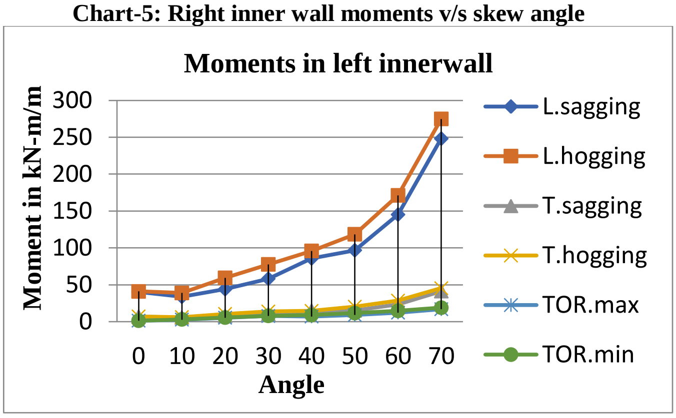

Chart-6: Left inner wall moments v/s skew angle

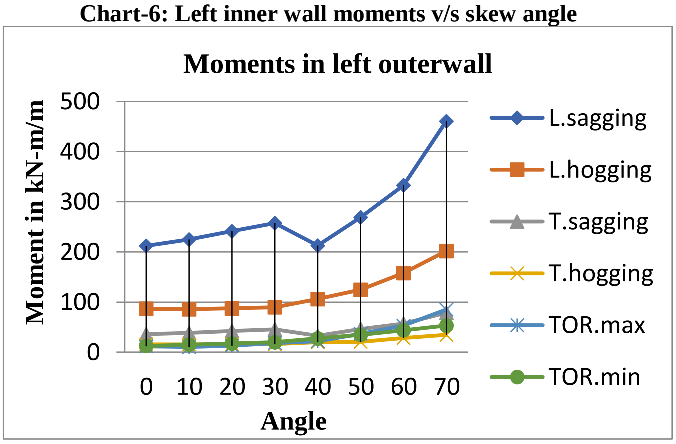

Chart-7: Left outer wall moments v/s skew angle

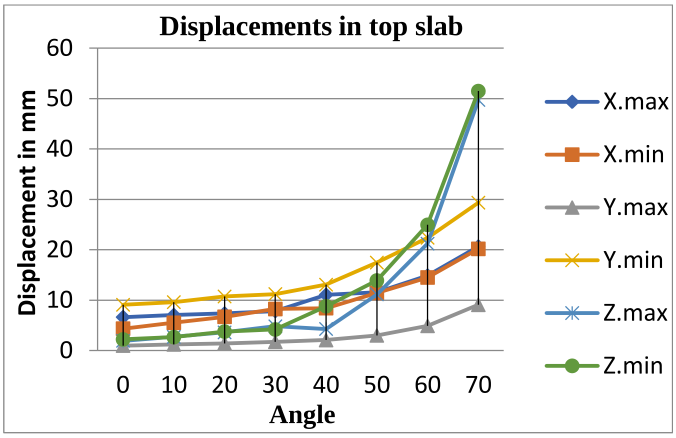

Chart-8: Top slab displacements v/s skew angle

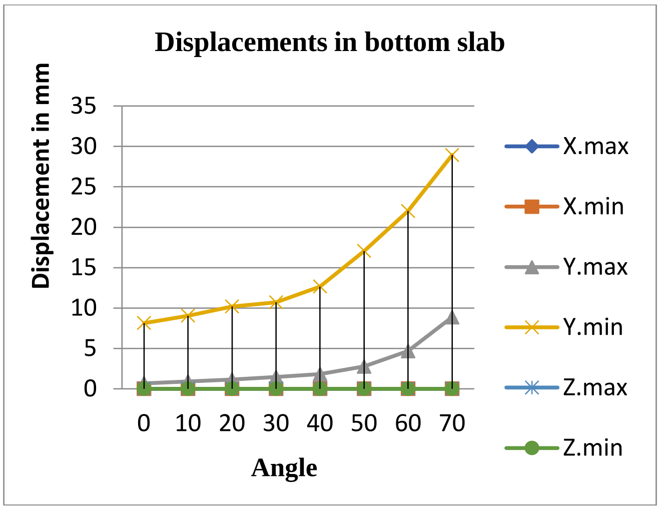

Chart-9: Bottom slab displacements v/s skew angle

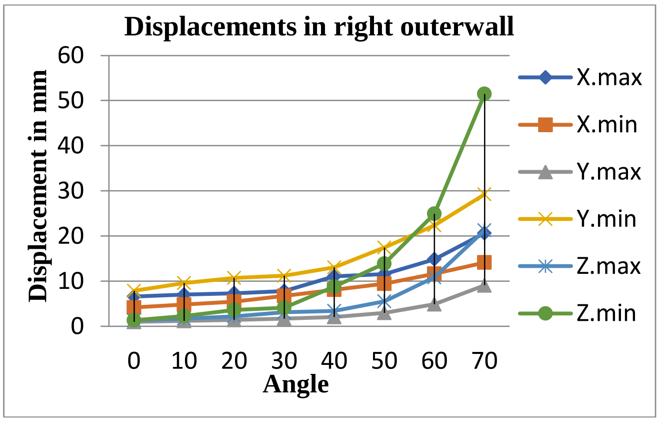

Chart-10: Right outer wall displacements v/s skew angle

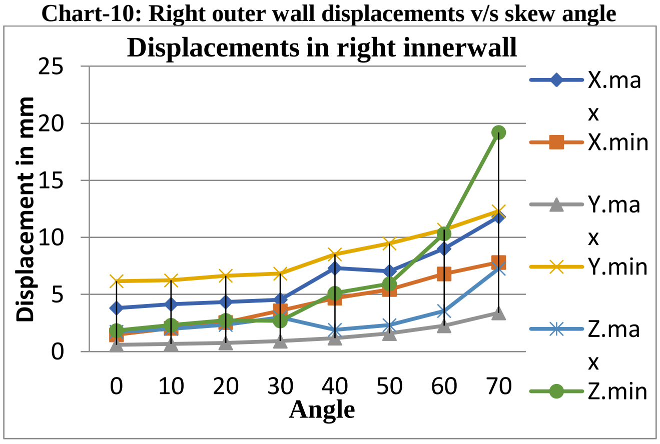

Chart-11: Right inner wall displacements v/s skew angle

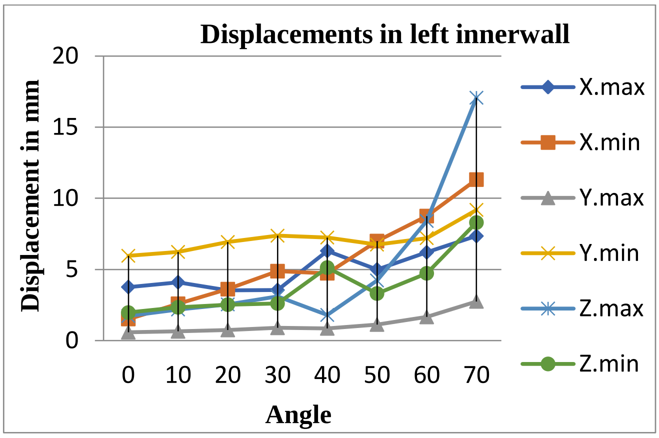

Chart-12: Left inner wall displacements v/s skew angle

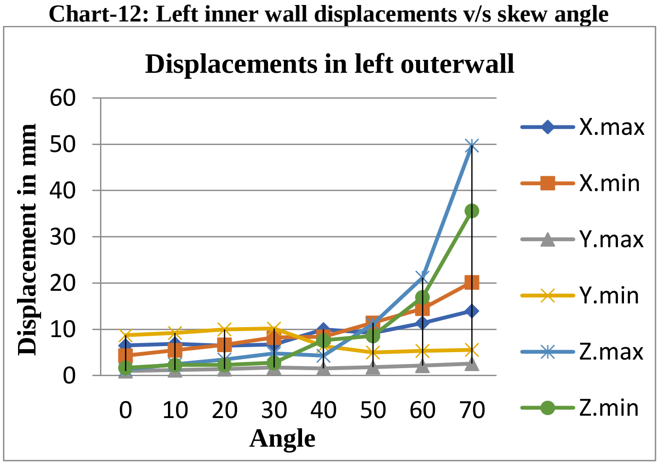

Chart-13: Left outer wall displacements v/s skew angle

- From the charts (Chart 1), it is observed that shear force in all the slabs increases with the increase of skew angle.
- It is clearly indicate from charts that longitudinal moments and transverse moments both sagging and hogging in all slabs increase with the increase of skew angle.
- From torsional charts (Chart 2 to Chart 7), it can be concluded that torsional moments in all slabs increases with the increase of skew angle.
- From displacement charts (Chart 8 to Chart 13), it is observed that displacement increases in all slabs with the increase of skew angle.

VI. CONCLUSION

- From the above results, it can be concluded that the behaviour of box type bridge changes at lower skew angles also which is not seen in other type of bridges.
- In box type bridges parameters like longitudinal moments, transverse moments, torsional moments, shear forces and displacements in all slabs of bridge increases with the increase of skew angle.

So, utmost care should be taken in the design of box type skew bridge even at lower skew angles.

REFERENCES

1. Harba, I.S., 2011. Effect of skew angle on behavior of simply supported RC T-beam bridge decks. ARPN Journal of Engineering and Applied Sciences, 6(8), pp.1-14.

2. Théoret, P., Massicotte, B. and Conciatori, D., 2012. Analysis and design of straight and skewed slab bridges. Journal of Bridge Engineering, 17(2), pp.289-301.
3. Kar, A., Khatri, V., Maiti, P.R. and Singh, P.K., 2012. Study on effect of skew angle in skew bridges.
4. Mohseni, I. and Rashid, A.K., 2012. Development of the applicability of simplified Henry's method for skewed multicell box-girder bridges under traffic loading conditions. Journal of Zhejiang University SCIENCE A, 13(12), pp.915-925.
5. Abdel-Mohti, A. and Pekcan, G., 2013. Assessment of seismic performance of skew reinforced concrete box girder bridges. International Journal of Advanced structural engineering, 5(1), p.1.
6. Deshmukh, N. and Waghe, D.U., 2015. Analysis and design of skew bridges. International Journal of Science and Research, ISSN, pp.2319-7064.
7. Singh, A., Kumar, A. and Khan, M.A., 2016. Effect of Skew Angle on Static Behavior Of Reinforced Concrete Slab Bridge Decks: A Review.
8. Deepak, C. and Sabeena, M.V., 2015. Effect of skew angle on uplift and deflection of RCC skew slab. International Journal of Research in Engineering and Technology, 4(5), pp.105-111.
9. Anusureebi S.K and Krishnachandran V.N., 2016, "Effect of reinforcement pattern on behaviour of skew slab", International journal of engineering and technology, Vol.3, P-ISSN 2395-0072.
10. Ajay D.Shahu, S.V.Joshi and P.D.Pachpor., 2016, "Analysis and behaviour of skew bridges with different skew angles", Indian technical research organisation, Vol.3, pp.
11. Yalcin, O.F., 2017. A comparative study of live load distribution in Skewed Integral and Simply Supported Bridges. KSCE Journal of Civil Engineering, 21(3), pp.937-949.
12. Anagha Manoharan and Glynez Joseph., 2016, "Analysis of skew bridge with varying skew angles", International journal of scientific and engineering research, Vol.7, ISSN 2229-5518.
13. Raj.KK and Phani R.G., 2017, "Design and study on behaviour of skew slab bridges with various skew angles", journal of applied science and innovations, Vol.1.
14. Naresh Reddy G.N and Muthu K.U., 2017, "Analysis of simply supported RCC skew slabs", International journal of civil engineering and technology, Vol.8, pp.121-128.
15. Indian Road congress IRC 6:2016 standard specification and code of practice for roads and bridges.

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