Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 3, March-2016

Performance of Prestressed Slab type Bridge Superstructure on Curved Alignment

Ramparia Mohit[1], Pokar Narendra[2], Gandhi Dipesh[3]

[1]*HJD Institute of Technical Education and Research*
[2]*Civil Engineering Department, HJD ITER, Kera-Kutch*
[3]*Applied Mechanics Department, Government Engineering College, Bhuj*

Abstract - The object of the paper is to analyze prestressed horizontal curved solid slab for 20m and 25m bridge span using grillage analogy method. The analysis presented illustrates the behavior of bending moments, Shear Force, displacement due to change in Span and curvature for various load conditions of solid deck slab. Slab analyzed under various loading conditions as per IRC and results has been compared to know the effect of the curvature on bridge deck. Width of the deck slab keep constant (12m) for various degree of curvature (15°, 30°, 45°, 60°) and analysis has been done in STAAD Pro. In each analysis, the behavior of deck slabs was investigated, and maximum bending moment, max shear forces and displacement developed in members were observed.

Keywords – Prestressed Slab Type Bridge Superstructure, Solid Slab, Curved Alignment, STAAD Pro

I. INTRODUCTION

Bridge is life line of road network, both in urban and rural areas. Horizontally curved bridges are the most feasible options at complicated interchanges or river crossings where geometric restrictions and constraint of limited site space, make difficult the adoption of standard straight superstructures. Contrary to straight bridges, a very limited documentation on the study of horizontally curved bridges has been available.

Bridge design is an important as well as complex approach of structural engineer. As in case of bridge design, span length and live load are always important factor. Bridge design is an important as well as complex approach of structural engineer. As in case of bridge design, span length and live load are always important factor. These factors affect the conceptualization stage of design. The effect of live load for various span are varied. In shorter spans track load govern whereas on larger span wheel load govern. Many methods are used in analyzing bridges such as grillage and finite element methods. Generally, grillage analysis is the most common method used in bridge analysis. In this method the deck is represented by an equivalent grillage of beams.

There is a very limited knowledge available about curved bridges, both in standard specifications and literature. In this paper, analytical results of curved bridges are show in charts and tabular form for a various parameters such as shear, bending and displacement for curved bridges. This type of work can be also useful for preliminary design of horizontally curved bridge.

Hence to fill in the void for the realistic analysis, the work on the parametric study of curved bridges is performed. Various behaviors like bending, shear, displacement of horizontally curved prestressed bridges is presented. In this study for analyzing of bridge grillage analogy method is used using STAAD Pro. Eight models are prepared for different span lengths (20m, 25m) keeping the same material properties with varying degree of curvature from 15° to 60° at 15° increment for different load conditions and load combinations. Charts & tables for various parameters of curved bridges are presented in this paper.

II. GRILLAGE ANALOGY METHOD

The grillage analogy method is a computer-oriented technique and is being used in the analysis and design of bridges. With the use of computer facilitates, the investigation of several load cases can be done in very short time as compared to manual methods. The method consists of rigidly connected beams at discrete nodes i.e. idealizing the slab by an equivalent grillage. The deformations at the two ends of a beam element are related to the bending and torsional moments through their bending and torsional stiffness.

Idealization, as number of longitudinal and transverse beam elements in a single horizontal plane, rigidly interconnected at nodes. Transverse beams may be orthogonal or skewed with respect to the longitudinal beams, so that skew, curved, tapering or irregular slabs can be analyzed by this method.

In a simple grillage analysis, each beam is allotted a flexural stiffness in the vertical plane and a torsional stiffness. Vertical loads are applied only at the nodes. Computer software is used to determine the displacements (rotations about the two horizontal axes and the vertical displacement) at each node and the forces (bending moments, torsional moments and vertical shear forces) in the beams connected to each node.

Software's like STAAD Pro or SAP2000 can be used for grillage analogy modeling method.

Following points give a summary of the guidelines to convert an actual bridge deck into a grid for grillage analysis:

- Grid lines are placed along the center line of the existing beams, if any and along the center line of left over slab, as in the case of T-girder decking.
- Longitudinal grid lines at either edge be placed at 0.3D from the edge for slab bridges, where D is the depth of the deck.
- Grid lines should be placed along lines joining bearings.
- A minimum of five grid lines are generally adopted in each direction.
- Grid lines are ordinarily taken at right angles.
- Grid lines in general should coincide with the CG of the section. Some shift, if it simplifies the idealization, can be made.
- Over continuous supports, closer transverse grids may be adopted. This is so because the change is more depending upon the bending moment profile.
- For better results, the side ratios i.e. the ratio of the grid spacing in the longitudinal and transverse directions should preferably lie between 1.0 to 2.0.

General steps for grillage analogy method:

1. Idealization of physical slab into equivalent grillage.
2. Evaluation of equivalent elastic inertias of members of grillage.
3. Application and transfer of loads to various nodes of grillage.
4. Determination of force responses and design envelopes and
5. Interpretation of results.

III. DESCRIPTION OF BRIDGE SUPER STRUCTURE

A simply supported two lane span of 20m and 25m solid is considered. Railing, footpath, crash barrier, lane dimensions are considered as per IRC: 5-1998. The bridge superstructure with 2 lane carriageway of 7.5 m width with footpath with prestressed solid slab is taken. On two side of carriage way crash-barrier with 0.45 m width and footpath with 1.5m width and parapet with 0.3m width provided.

- **CROSS SECTION OF SLAB**

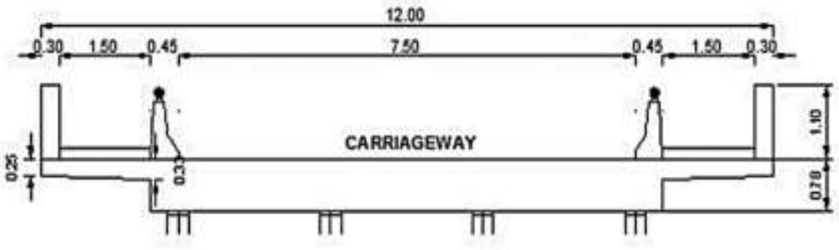

Figure 1. Cross Section of 20m Solid Slab

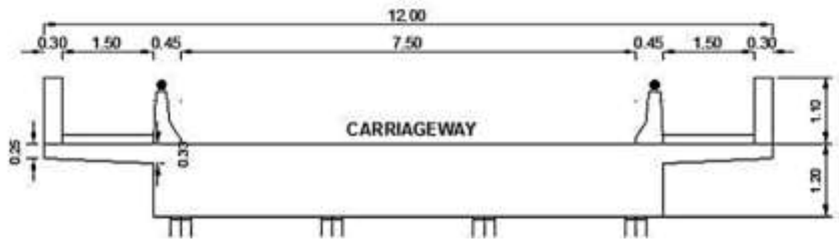

Figure 2. Cross Section of 25m Solid Slab

- **ELEVATION OF SLAB**

Figure 3. Elevation of Solid Slab

Table 1. Dimension of Slab Type Superstructure

	SOLID SLAB	
SPAN (m)	20m	25m
DEPTH (m)	0.78	1.2
WIDTH (m)	8.4	8.4
AREA (m^2)	6.552	10.08

- **LOADS**

The following loads are considered:

1) Dead load: The dead load includes self-weight of the slab type superstructure.
2) SIDL: Weight of crash barrier, parapet and wearing coat is considered in SIDL.
3) Live Load: IRC loading for two lane bridges are considered, which are as follows:
    - One lane of Class-70R wheel loading
    - Two lane of class-A loading
4) Load Combination: Following load combinations are carried out and worst effect is considered in the analysis.
    - DL + SIDL + LL (Maximum of Class 70R, Class A)

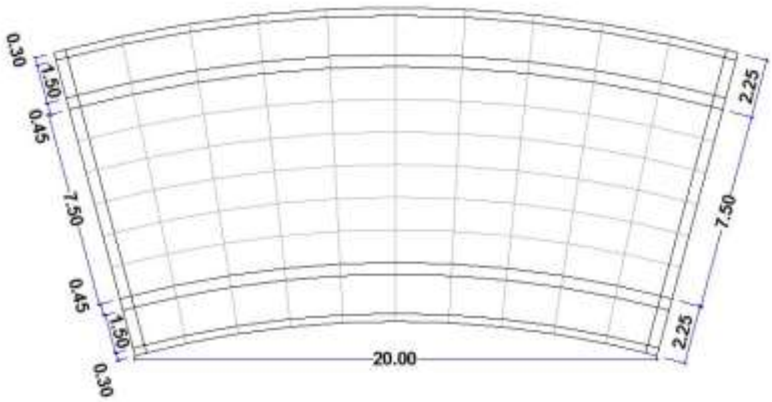

Figure 4. Grid Mesh (20m Span, 30 ° Degree Curvature)

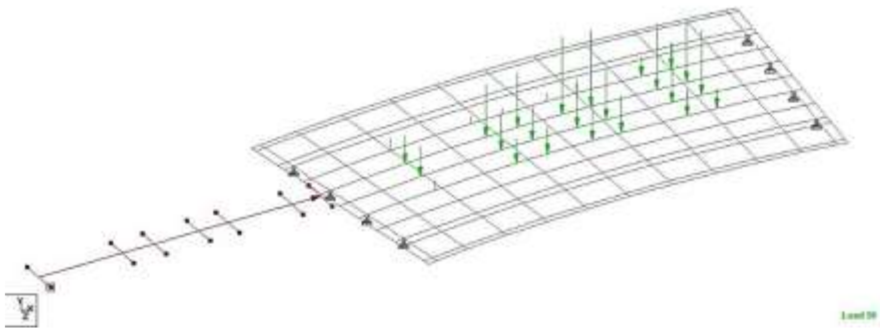

Figure 5. Live Load (Class 70R)

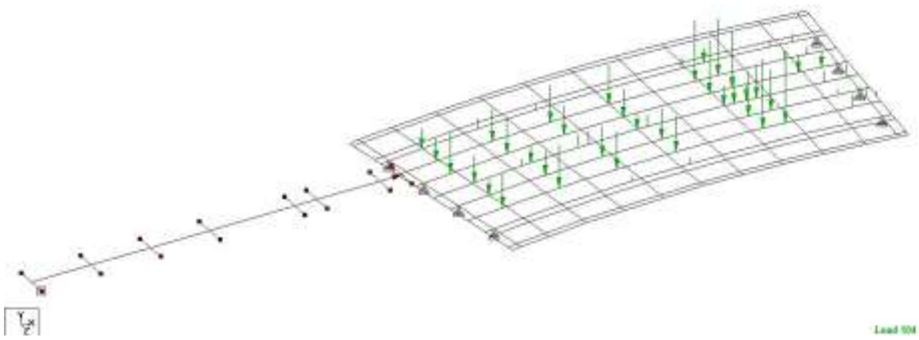

Figure 6. Live Load (Class A)

IV. ANALYSIS RESULTS

The results are collected for a particular span (20m and 25m) with varying degree of curvature (15° to 60° at 15° increment). Results are taken for DL + SIDL + LL (Max.). The values of maximum B.M., S.F., and displacement are collected for entire Section of which maximum B.M. and displacement occurs at mid span, maximum S.F. at edge near supports.

Table 2. Max. Bending Moment (20m Span)

	Degree Of Curvature			
	15° Degree	30° Degree	45° Degree	60° Degree
Max. Bending Moment (T.M)	1351.283	1622.377	1970.748	2424.047

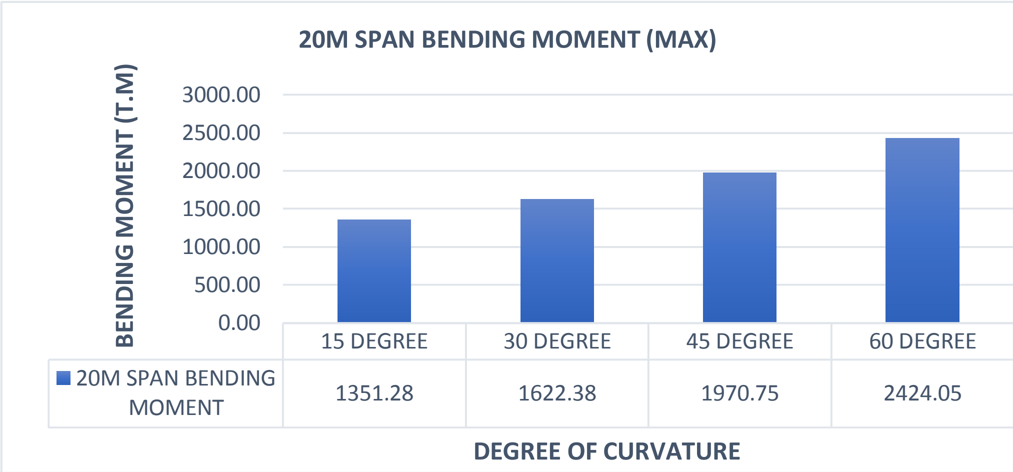

Figure 7. 20m Span Bending Moment (Max)

Table 3. Max. Bending Moment (25m Span)

	Degree Of Curvature			
	15° Degree	30° Degree	45° Degree	60° Degree
Max. Bending Moment (T.M)	2652.605	3097.362	3673.151	4432.665

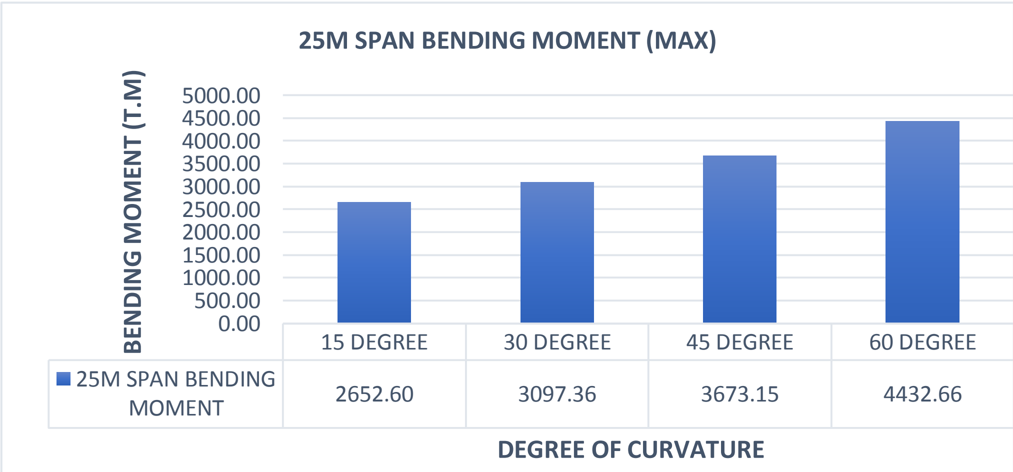

Figure 8. Max. Bending Moment (25m Span)

Table 4. Max. Shear Force (20m Span)

	Degree Of Curvature			
	15° Degree	**30° Degree**	**45° Degree**	**60° Degree**
Max. Shear Force (T/M width)	52.84	62.27	72.16	87.14

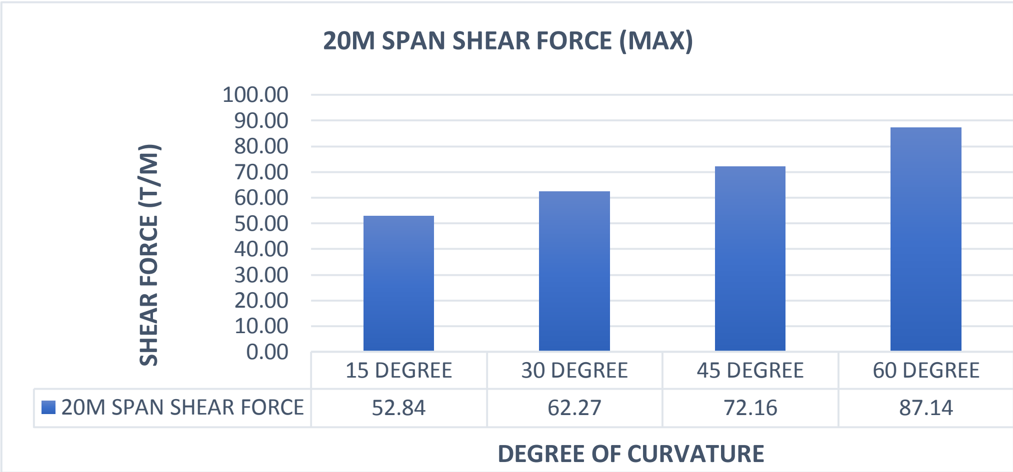

Figure 9. Max. Shear Force (20m Span)

Table 5. Max. Shear Force (25m Span)

	Degree Of Curvature			
	15° Degree	**30° Degree**	**45° Degree**	**60° Degree**
Max. Shear Force (T/M width)	79.31	97.93	119.57	149.68

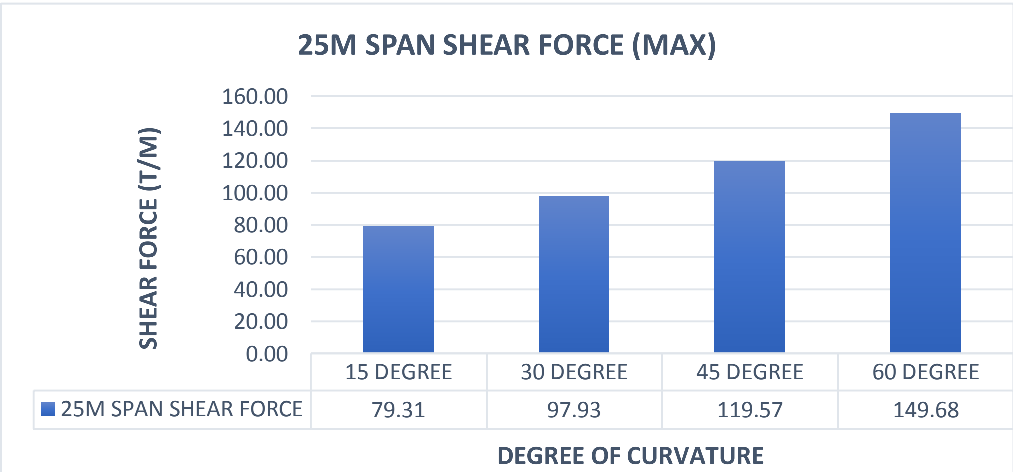

Figure 10. Max. Shear Force (25m Span)

Table 6. Max. Displacement (20m Span)

	Degree Of Curvature			
	15° Degree	**30° Degree**	**45° Degree**	**60° Degree**
Max. Displacement (M)	0.109	0.167	0.259	0.411

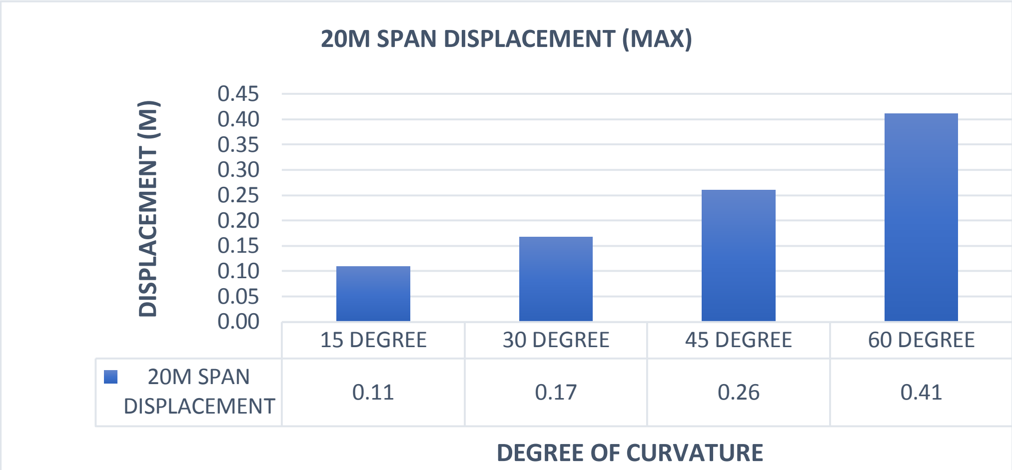

Figure 11. Max. Displacement (20m Span)

Table 7. Max. Displacement (25m Span)

	Degree Of Curvature			
	15° Degree	**30° Degree**	**45° Degree**	**60° Degree**
Max. Displacement (M)	0.089	0.129	0.192	0.294

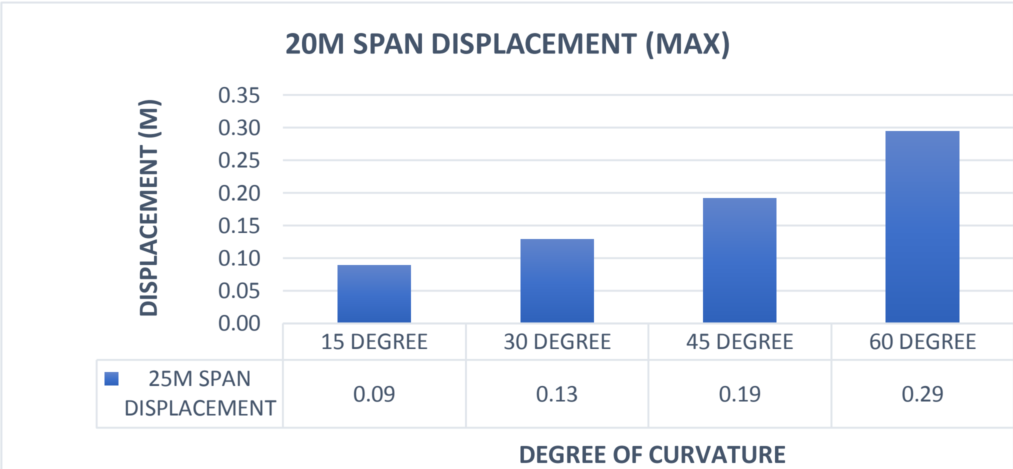

Figure 12. Max. Displacement (25m Span)

V. CONCLUSION

Eight Models were prepared for two different span lengths (20m and 25m) keeping the same material properties with varying degree of curvature from 15° to 60° at 15° increment for different load conditions and load combinations. Loads, load combinations and end conditions were applied to the models as per IRC specifications. STAAD Pro. Software was used for the analysis. The conclusions obtained from the present study are shown in tables and graphs above and can be described as below.

1. As per above graph it has been concluded that the bending moment, shear force and displacement of slab type superstructure is increase with increasing in degree of curvature.
2. Max. Bending moment and displacement obtain at center of span length.
3. Max. Shear force obtain at outer edge of curvature near the support.
4. Max. Displacement obtain at center span outer edge of curvature.
5. Due to increasing in span and degree of curvature bending moment shear force and displacement is increase.
6. The benefit for grillage analysis is that it is easy to use and comprehend.

REFERENCES

1. Saifee Bhagat and Dr. K. B. Parikh, "Comparative Study of Voided Flat Plate Slab and Solid Flat Plate Slab" International Journal of Innovative Research & Development (IJIRD) Vol. 3 Issue 3, March-2014.
2. Shaimaa Tariq Sakin, "Punching Shear in Voided Slab" International Institute for Science Technology and Education (IISTE) Vol. 6, No.10, 2014.
3. Saifee Bhagat and Dr. K. B. Parikh, "Parametric Study of R.C.C Voided and Solid Flat Plate Slab using SAP 2000" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Vol. 11, Issue 2 Ver. VI, Mar- Apr. 2014.
4. Mulesh K. Pathak, "Performance of RCC Box type Superstructure in Curved bridges" International Journal of Scientific & Engineering Research, Vol. 5, Issue 1, January-2014.
5. Amit Saxena and Dr. Savita Maru, "Comparative Study of the Analysis and Design of T-Beam Girder and Box Girder Superstructure" IJREAT International Journal of Research in Engineering & Advanced Technology, Vol. 1, Issue 2, April-May, 2013.
6. B.Vaignan and Dr. B.S.R.K Prasad, "Analysis Of Voided Deck Slab And Cellular Deck Slab Using Midas Civil" International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 9, September- 2014.
7. Singh Shailendra, Jain Utkarsh, Nimoriya Manish Kumar, Faraz Md. Islamuddin, "A Comparative Study Of Simply Supported And Continuous R.C.C. Slab Bridges" International Journal of Engineering Research and General Science, Volume 3, Issue 3, ISSN 2091-2730, May-June, 2015.
8. R.Shreedhar, Spurti Mamadapur, "Analysis of T-beam Bridge Using Finite Element Method" International Journal of Engineering and Innovative Technology (IJEIT), Volume 2, Issue 3, ISSN: 2277-3754, September 2012.
9. R.Shreedhar, Rashmi Kharde, "Comparative study of Grillage method and Finite Element Method of RCC Bridge Deck" International Journal of Scientific & Engineering Research Volume 4, Issue 2, ISSN 2229-5518, February-2013.
10. Baidarb Akht, Leslie G Jaege, M. S. Cheung, Aftab A. Muft, "The State Of The Art in Analysis of Cellular and Voided Slab Bridges" National Research Council of Canada.
11. Mohsen A. lssa and Rajan Sen, "Service, Post-cracking and Ultimate Response of Continuous Post-Tensioned Voided Slab Bridges" ACI Structural Journal.
12. C.S. Surana and R. Agrawal, "Griliage Analogy in Bridge Deck Analysis" Narosa Publishing House, New Delhi.
13. Edmund C.Hambly, "Bridge Deck behavior"
14. N. Krishna Raju (2002) "Prestressed Concrete", 8th edition, TATA McGraw-Hill Publishing Company Limited, New Delhi.
15. IRC: 6(2000). Standard Specification and Code of Practice for Road Bridge, Section II, Loads and Stresses, Indian Road Congress, New Delhi.
16. IRC: 21-2000, "Standard Specifications and Code of Practice for Road Bridges, Section III, Cement Concrete (Plain and Reinforced)", The Indian Roads Congress, New Delhi, India, 2000.
17. IRC-5:1998 - Standard Specifications and Code of Practice for Road Bridges, Section 1 General Features of Design, New Delhi.
18. IRC-38 – For Horizontal Curve, Indian Road Congress, New Delhi.