© 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Analysis of Box Girder Bridges Using Haunches

Prof. Sonal T. Pawar
Department of Civil Engineering, K.J. College of Engineering & Research, Pune University, Pune, Maharashtra, India

ABSTRACT

A bridge is a structure providing passage over an obstacle without closing the way beneath. Recent developments in the field of Bridge engineering, Box Girder Bridges have heightened the need for improving the ability to carry the live load and undertaken as a result of code provisions .In this project deals with response of haunches in box girder bridges when subjected to standard moving load. Analysis of box girder bridges can be accurately done by finite element method. Maximum bending moment occurs at the junctions of box girder, therefore provision of haunches at junctions may lead to economic solution.

In this study it is proposed to develop finite element method for analysis of box girder with haunches. Parametric investigations will be performed for box type of bridges with and without haunches Span range is more for box bridge girder as compare to T-beam Girder Bridge resulting in comparatively lesser number of piers for the same valley width and hence results in economy. Effect of haunches on the performance of bridge girder will be studied and optimum size of haunches for various spans will be evaluated.
Keywords: Finite Element Method, concrete box girder bridge T -Beam bridge using civil software Etabs.

I. INTRODUCTION

A bridge is an arrangement made to cross obstacle in the form of low ground or a stream or river or over gap without closing the way beneath. Bridges required for passage of railways, roadway, and footpath even over carriages of fluids. in short bridge is a structure built to a span physical obstacle such as body of water , valley ,or road , for providing passage over a obstacle .design of bridge of vary , on the function of the bridge nature of terrain where bridge is constructed ,the material used in construction. Box girders are quite common in highway and bridge systems due to their structural efficiency, better stability, serviceability, economy of construction and pleasing aesthetics. Box girder bridges are commonly used for highway flyovers and for modern elevated structures of light rail transport. A box girder is particularly well suited for use in curved bridge systems due to its high torsional rigidity. High torsional rigidity enables box girders to effectively resist the torsional deformations encountered in curved thin-walled beams. The Box-Girders can be of different forms and geometry. Box girder decks are cast-in-place units that can be constructed to follow any desired alignment in plan, so that straight, skew and curved bridges of various shapes are common in the highway system .Box girders can be classified in so many ways according to their method of construction, use, and shapes. The reinforced concrete bridges are of following types.

1) Slab bridges
2) Girder and slab (T-slab) bridges
3) Hollow girder bridges
4) Rigid frame bridges
5) Arch bridges
6) Bow string girder bridges
7) Box girder bridges

The bridge type is related to providing maximum efficiency of use of material and construction technique, for particular span, and applications. As Span increases, dead load is an important increasing factor. To reduce the dead load, unnecessary material, which is not utilized to its full capacity, is removed out of section, which results in the shape of box girder or cellular structures. Span range is more for box bridge girder as compare to T-beam Girder Bridge resulting in comparatively lesser number of piers for the same valley width and hence results in economy.

II. METHODS AND MATERIAL

A. Literature Review

Box girder bridges can be analyzed by following methods
1) Finite element method
2) Finite strip method,
3) Spline finite strip method

Finite strip method employs the minimum total potential energy theorem to develop relationship between unknown nodal displacement parameters and the applied loads. In this method displacement function of finite strips are assumed as a combination of harmonics variation longitudinally and polynomial variation in the transverse direction. Harmonic functions are chosen to satisfy the two end support conditions.

Cheung (1968) first published the finite strip method which prospects as a method of analysis for simply supported box type structure in terms of accuracy and efficiency. Cheung and Cheung (1971) applied Finite strip method for curved box girder bridges. Cusens and Loo (1974) presented a general finite strip technique to single and multispan box bridges with an extension to analysis of prestressed girders, Kabir and Scordetis (1974) developed the finite strip computer program to analyze curved continuous span cellular bridges with interior radial diaphragm on supporting planar frame belt.

Alexander Hrennikoff (1941) and Richard Courant (1942) the finite element analysis can traced back to the wor. These pioneers share one essential characteristic: mesh discretization of a continuous domain into a set of discrete sub-domains, usually called elements. In 1950s, solution of large number of simultaneous equations became possible because of the digital computer. In 1960, Ray W. Clough first published a paper using term “Finite Element Method”.In 1965, First conference on “finite elements” was held. In 1967, the first book on the “Finite Element Method” was published by Zienkiewicz and Chung.In the late 1960s and early 1970s, the FEM was applied to a wide variety of engineering problems.Zdenek P. Bazant, Qiang Yu, Guang-Hua Li [4] studied the excessive long-time deflections of pre stressed box girders and came to the conclusion that the box girders are thick-walled shells for which the beam type analysis is inadequate.

B. Problem Definition

In this study three dimensional models of T-beam Girder Bridge ,box girders bridge with and without haunch for 15 M span are analysed to carry out the comparison of reaction, maximum bending moment ,bending stress, shear stress and mid span deflection response of box girder bridge using parametric study by varying span.

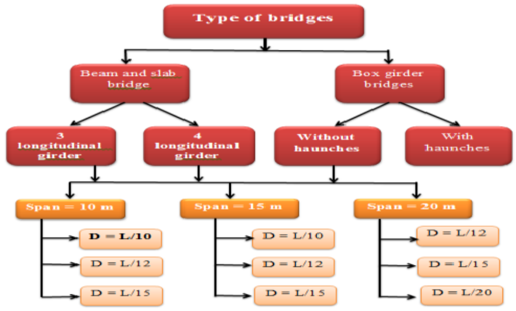


Figure 1 : Chart showing Parametric variation cases

The aim of this study is to better understand the behavior of concrete box Girders Bridge with and without haunch and T-beam Girder Bridge by using finite element software ETAB. The main objectives of this study are

- To carry out the analysis of three-dimensional finite element models of box girder and T-beam Girder Bridge using the finite element computer program “ETAB”.
- To compare the variation of bending stress, shear stress and force mid span deflection due to variation in lording.

For analysis of beam and Slab Bridge certain assumption are made which are as follows.

- Spacing of longitudinal girder :3 m
- Width of rib : 300 mm
- Thickness o slab : 200 mm
- Thickness of wearing cote : 80 mm
- Footpath 200 mm above wearing cote
- Spacing of cross girder : 3.33 c/c
- Loading type : Class AA track loading
- fck =20 Mpa , Fy =500 Mpa

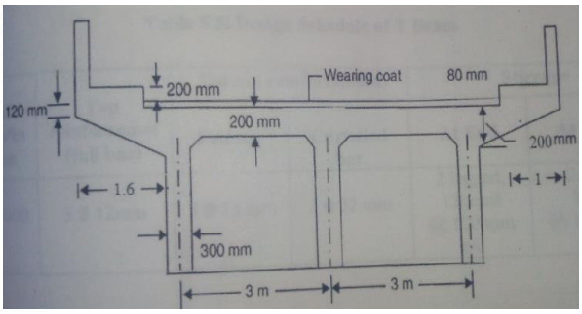


Figure 2 : Cross-sectional dimensions of T beam Girder Bridge

A) Loading

The loads that are considered on the superstructure of a typical box girder bridges and T - beam are listed below.

1) **Dead Load:** The self-weight of the structure is applied to the structure as dead load.
2) **Live Load:** The live load is considered as per IRC: 6-2000. The maximum wheel load in IRC Class AA loading is considered for analysis of box girders. The impact factor for IRC Class AA loading is also considered.

TABLE: IMPACT FACTORS FOR DIFFERENT SPANS

Span(m)	20	30	40
Impact factor	0.173	0.125	0.098

Wind loading: Wind force on a structure shall be assumed as a horizontal force of intensity specified in clause 212.3 of IRC 6-2000.

Tractive Effort, Breaking Force for Axle and Train : With this dynamic effect there are some forces which are applied on rails. Those are Tractive effort, breaking force coming to the structure when the sudden breaks are applied and when the train ready to start.
Tractive effort = 510KN
Breaking force for Axle = 25% of Axle load (245.2KN)
Breaking Force for Train = 13.5% of Train Weight (91.5 KN/m).

Centrifugal forces: Centrifugal force is produced where box girder is situated on a curve IRC 6 -2000.
Group Loading Combinations: The combination considered as

- DL+SLL
- DL+USLL 1+USLL 2

C. Structural Analysis

ETAB is a highly sophisticated, general purpose finite element program, designed primarily to model the behaviour of solids and structures under externally applied loading. Its slab is monolithically constructed with the concrete box girder. The girder is a four cell box girder having rectangular cross-section and three, four longitudinal girder in T Beam Bridge. The models created with ETAB are shown in figure given below

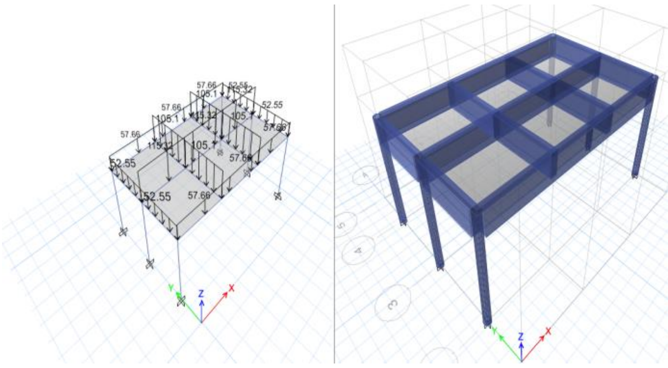


Figure 3 : 3D view of 3 longitudinal girder T beam and loading

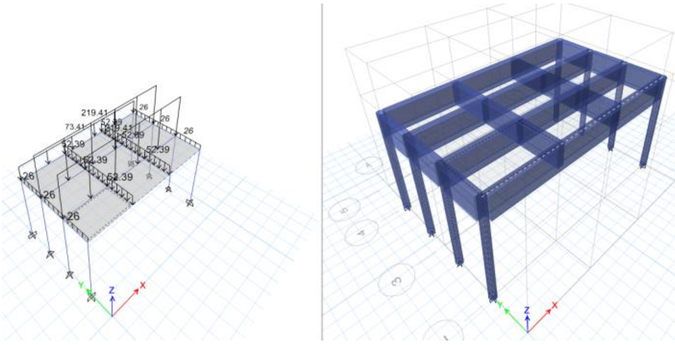


Figure 4 : 3D view of 4 longitudinal girder T beam and loading.

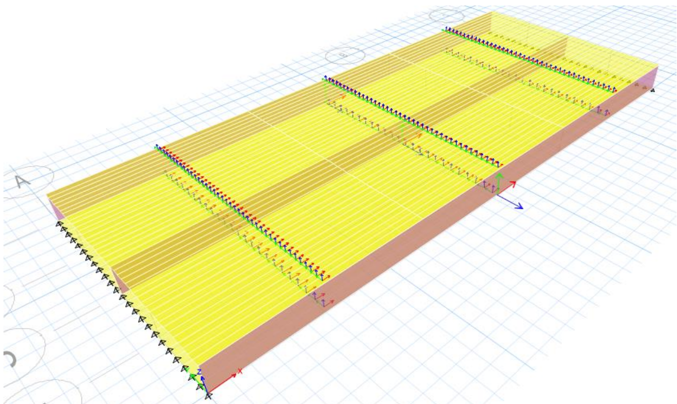


Figure 5 : 3D view of Box girder bridge without haunch

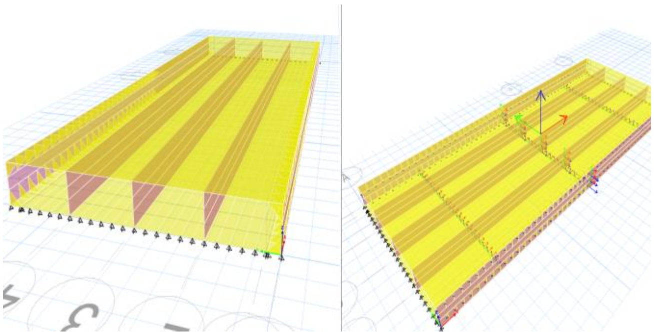


Figure 6 : 3D view of Box Girder Bridge with haunch

III. RESULTS AND DISCUSSION

The box girder bridge and T -beam type bridge of span 15 m with loading combination are analysed and diagram obtained for the stress ,defection for various load combination span of 15 m as show below

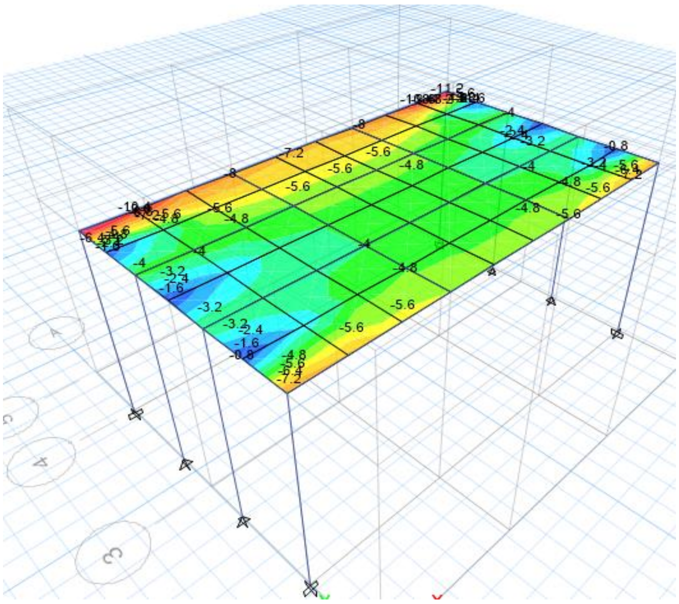


Figure 7 : 3D view of T beam bridge with stress distribution

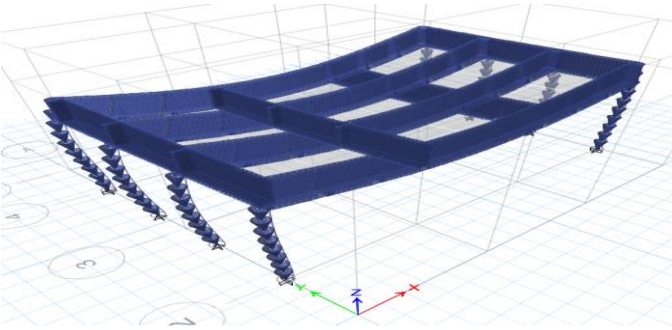


Figure 8 : 3D view of T beam bridge defection

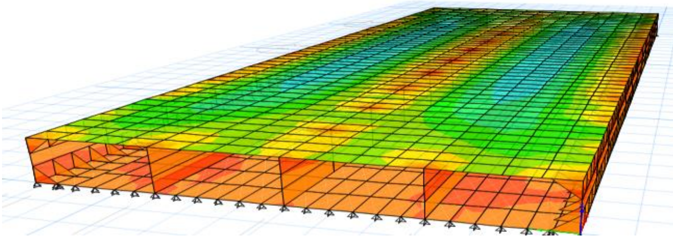


Figure 9 : 3D view of Box girder bridge with haunch stresses/forces

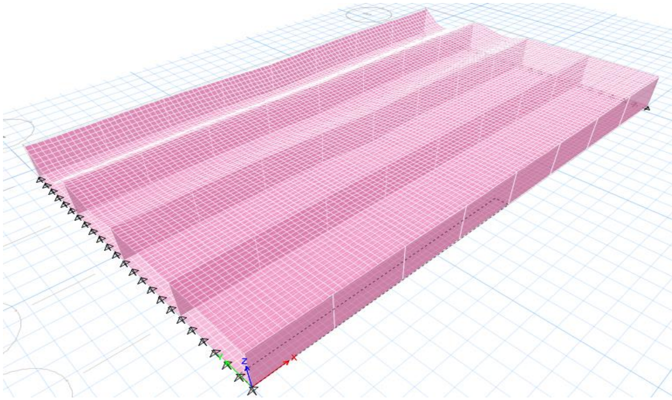
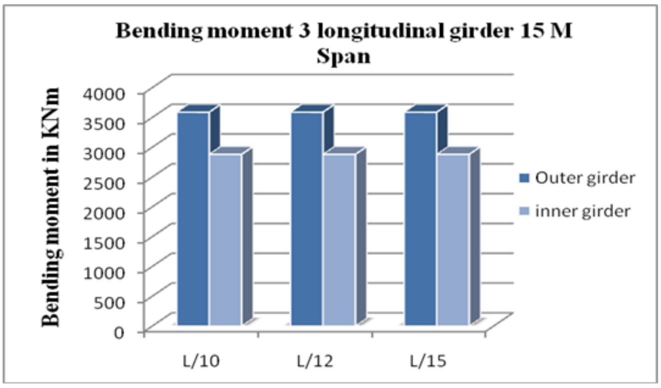
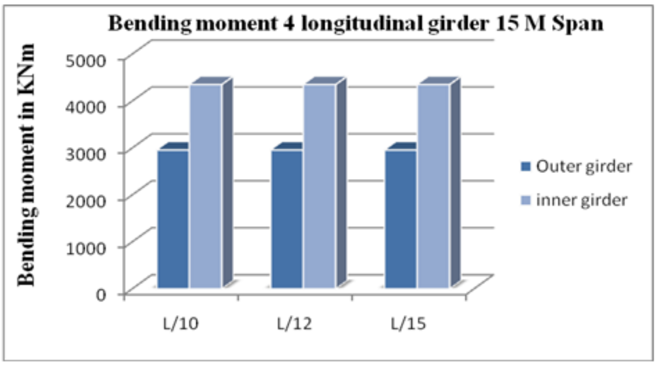


Figure 10 : 3D view of Box girder bridge with haunch deflection

It can observed from graph 5. 1 and 2 bending moment of T beam with 4 longitudinal girder are more by 52 % for inner girder as compared to 3 longitudinal girder.

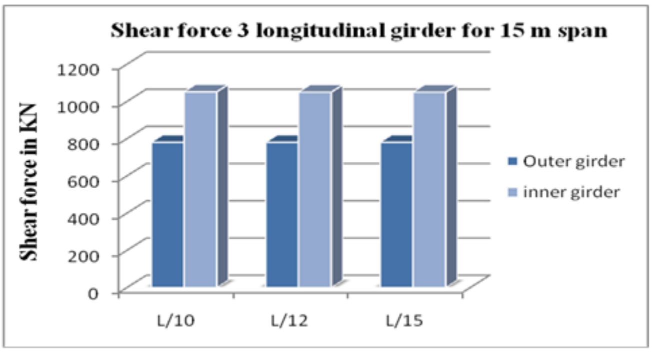


Graph 1: Bending moment for 3 longitudinal girder

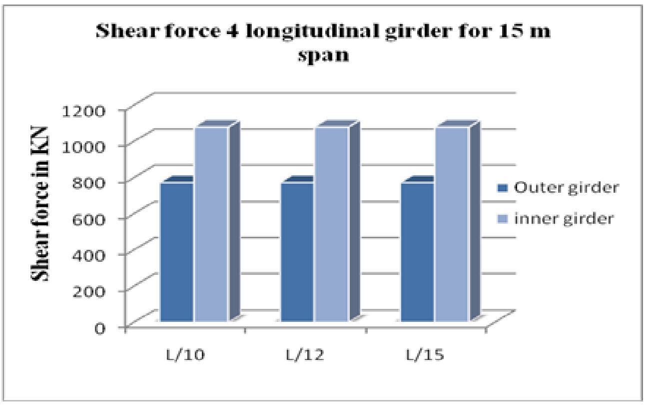


Graph 2: Bending moment for 4 longitudinal girder

It can be observed from graph 3 and 4 that shear force for the 4 longitudinal girder are decreased by 3 % for outer and increased by 2 % for inner girder as compared to 3 longitudinal girder.

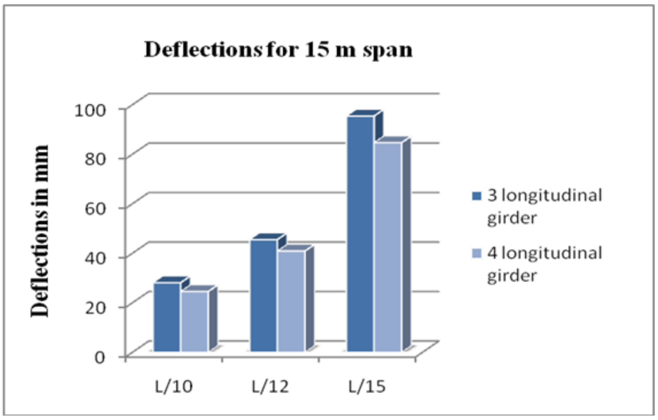


Graph 3: Shear force for 3 longitudinal girder



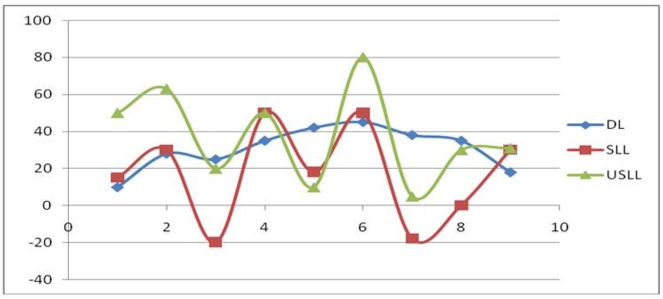
Graph 4: Shear force 4 longitudinal girder

Deflection of 4 longitudinal girder are less by 10 % as compared to 3 longitudinal girder shown in graph

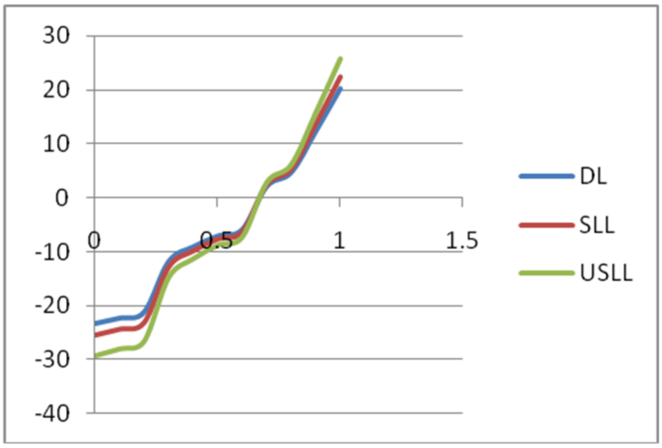


Graph 5: Defection of 3 and 4 longitudinal girder

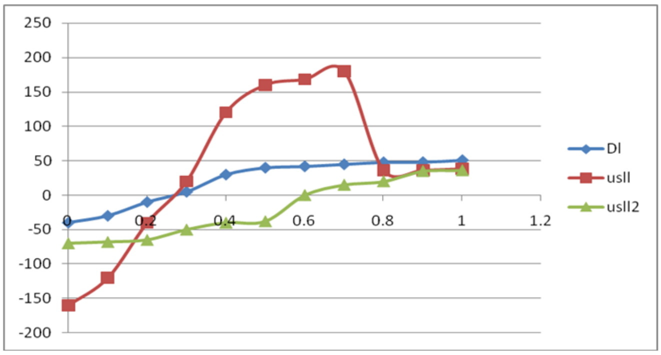
Analysis result of box girder bridge without haunch for 15 m span are presented and transverse stress x , and longitudinal stress y for top slab ,bottom slab and vertical wall presented in graph 6 to 8.



Graph 6: Variation of x direction L/10 top slab



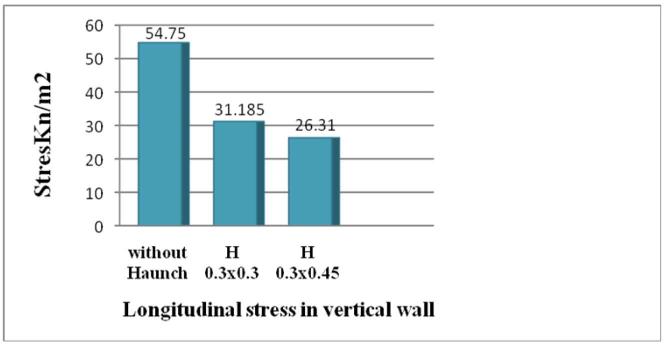
Graph 7: Variation of y Bottom Slab for L/10 depth



Graph 8: Variation of x outer vertical Wall for L/15 Depth

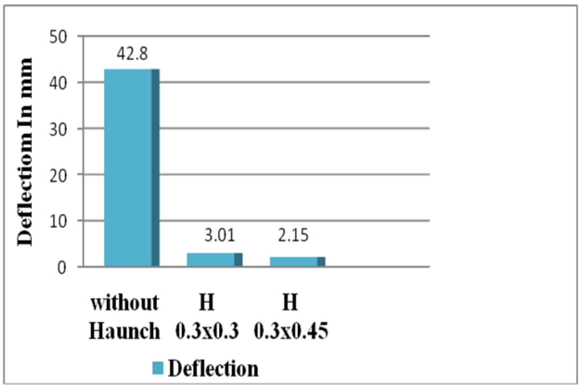
Comparison of box Girder Bridge with and without haunch for 15 m span is shown in following graphs.

From graph 9 it can be observed that stresses for box girder with haunches are reduced by almost 45 % for 0.3 x 0.3 haunch whereas it reduced by 50 % for 0.3 x 0.45 haunches .As the stress are reduced load carrying capacity of box will increased.



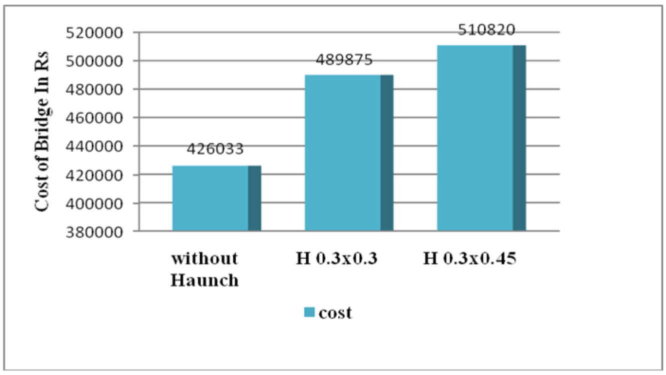
Graph 9: Comparison of longitudinal stresses x for 15 m span

From graph 10 observed that deflection for box girder with haunch are reduced 87 % for 0.3 x 0.3 haunch and 0.3 x 0.45 haunches respectively.



Graph 10: Comparison of deflection for 15 m span bridge

From graph 11 The percentage increase in cost for 0.3 x 0.3 haunch is 18 % and for 0.3 x 0.45 haunches 21 % .Even through the cost is increased for haunches stresses and deflection are very less for box girder with haunch .Economy in box girder with haunches can be achieved by reduced the thickness of top slab, bottom slab, and vertical wall.



Graph 11: Comparison of cost for 15 m span bridge

IV. CONCLUSION

Analysis and design of T beam and Multicell Box Girder Bridge is performed in this paper. Analysis of Box girder bridges with and without haunches and T Beam Bridge is done by using finite element method software Etab.

Following prominent conclusion are drawn from parametric investigations.

Provision of haunches in box girder leads to reduction in stresses by 50 percents as compared to box girder without haunches .The stress value of box girder without haunches is close to the permissible tress value . on the other hand, for box girder with haunches the stress value are very less than permissible value.

Deflection for box girder bridges with haunches reduced substantially by 87 % as compared to box girder without haunch.
Comparing haunches with 0.3 x 0.3 m size and 0.3 x 0.45 size, it is observed that the haunch with size 0.3 x 0.3 m is effective enough for 15 m span.
Stresses for box girder with haunches are reduced by almost 45 percent for 0.3 x 0.3 haunch it reduced by 50 % for 0.3 x 0.45 haunches .As the stress are reduced load carrying capacity of box will increased.

Scope for future work is study can be done for span more than 20 m, continuously supported box girder and analysis of box girder with pressurised members of the box girder.

V. REFERENCES

[1] Fushun LIU, Haujan LI, Guangming YU "New Damage Location for Bridges subjected to a Moving oad", Journal of Ocean University of China, Vol. 6, No. 2, pp. 199-202, 2007.

[2] Adam C, Heuer R, Ziegler F "Reliable Dynamic Analysis of an Uncertain Compound Bridge under Traffic Loads", Springer-verlag, Acta mech 223, pp.1561-1581, 2012

[3] Gupta P. K, Singh K K and Mishra A. "Parametric study on behaviour of box-girder bridges using finite element method", Asian journal of civil engineering, Vol. 11, No. 1, 2010.

[4] Zdenek P. Bazant, Qiang Yu and Guang-Hua Li. "Excessive Long-Time Deflections of Pre stressed Box Girders. I: Record-Span Bridge in Palau and Other Paradigms", Journal of structural engineering, June 27, 2012.

[5] Chirag Garg & Siva Kumar M. V. N . "Study of basic design of a precast segmental box girder bridge", International journal of civil engineering, May 2014.

[6] IRC: 6-2000, Standard specification and code of practice for road bridges, section-III

[7] IRC: 21-2000, Standard specification and code of practice for road bridges, section-III