Analysis of Bridges With Unequal Pier Height And Varying Span Length

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Abstract- *The pre-stressed concrete bridges have excellent riding characteristics that minimize traffic vibrations, torsional rigidity, less likely to crack prematurely continuous span, strength and the most noteworthy characteristic is natural frequency of vibration hardly matches with vehicle frequency therefore attained spacious acceptance in freeway, highway flyovers, and in modern metro rail systems. As bridges are the important structures should be capable to withstand static as well as dynamic loads specially, earthquake-induced load to achieve a structure that behave at the level of life safety under enormous earthquakes. The present article shows the linear dynamic behavior of T-beam girder and Trapezoidal box girder bridge deck and compares static as well as dynamic behavior. Response spectrum analysis has been performed by using FEM based software in order to check the resonance criteria of bridge and to determine most favorable option from above two.*

Keywords- Bridges, Pier, T-beam girder, Box girder.

I. INTRODUCTION

1.1 GENERAL

Bridges are the life line of road network, both in urban and country zones. With fast innovation development, the commonplace bridge has been supplanted by creative practical structural system. One of these courses of action presents basic RCC framework that is T-Beam and Box Girder.

Bridge design is a goal and what's more personalities boggling approach for an structural design. Just as there should rise an occasion of Bridge design, span length and live loads are consistently fundamental variables. These parts affect the conceptualization time of plan. The impacts of live load for different extents are moving. Choice of structural system for a cross is continually a range in which investigate should be possible.

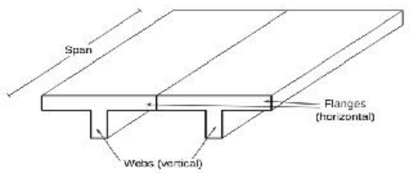


Fig 1. T-Beams

1.1.2 Girder

Girder is a term used in construction to refer to a supporting, horizontal beam that can be made from a variety of construction materials such as stainless steel, concrete, or a combination of these materials. A girder bridge is a basic, common type of bridge where the bridge deck is built on top of such supporting beams, that have in turn been placed on piers and abutments that support the span of the bridge.

1.1.3 Box Girder

A Box Girder Bridge is a Bridge in which the primary Beam involve girder in the shape of a hollow box. The box girder typically involves either pre-stressed concrete, structural steel, or a composite of steel and reinforced cement. The box is ordinarily rectangular or trapezoidal in cross-area. Box Girder Bridge is generally utilized for highway flyovers and for present day elevated structures of light rail transport. Although regularly the crate box girder bridge is a type of beam bridge, box girder may likewise be utilized on cable stayed bridges and different structures.

Fig 2. Box girder

In this case we considered three codes of vehicles loads in bridge analysis:-

- Indian Standard, Indian Road Congress (IRC codes) – Class AA and Class A
- AASHTO-LRFD Bridge Design Specifications – HL-93K and HL-93M

1.2 COMPUTERS AND STRUCTURES:

ANSYS develops and markets finite element analysis software used to simulate engineering problems. The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes.

1.3 ADVANTAGES OF T-BEAM AND BOX-GIRDER

1.3.1 ADVANTAGES

- Beam bridges are helpful for short spans.
- Long distances are normally covered by placing the beams on piers.

Box-Girder

- Reduces the slab thickness and self-weight of bridge
- Cost effective
- Greater strength per unit area of concrete

1.3 OBJECTIVES

- To study the deck slab interaction with the loading considered as IRC Codes.
- To evaluate the suitability of the bridges for short as well as long spans
- To evaluate code expressions for live-load distribution factors for concrete girder bridges.

1.4 PARAMETERS

The design parameters are check and verify by the structural analysis program (ANSYS).The structural design is a very important part of the bridge which defines safety in overall context and the major cost of the project. Therefore, the choice of the correct and appropriate code will save a high value of the cost of construction, in addition to the safe and successful design. To decide the size (dimension) of the member and the amount of reinforcement required. To check the weather adopted section will perform safely and satisfactorily during the life time of the structure. Design Philosophy, Loading and pattern of loading, Safety factors.

II. LITERATURE REVIEW

2.1 B.Paval "Analysis of Multi-Cell Pre-stressed Concrete Box-Girder Bridge" International Journal of Engineering Technology ISSN 2394 – 3386 Volume 3, Issue

The aim of this thesis is to study a basic design of a pre-stressed concrete box girder bridge and to describe the linear, non-linear and time history analysis of this concrete spread box girder superstructure when subjected to different loads simulating the effect of traffics. The pre-stressed concrete box girder bridge superstructure analyzed in the base case consists of two concrete box girders with simple span.

2.2 PragyaSoni, Dr. P.S. Bokare "Review of Design Procedure for Box Girder Bridges" International Journal for Research Volume 5 Issue IX, September 2017

Due to population growth and rapid urbanization, there has been an enormous growth in traffic volume on highways over the last few decades. In order to ensure smooth flow of traffic, numerous new highways and flyovers are being constructed. The use of box-girders has proven to be a very efficient structural solution for highway bridges and flyovers due to its high tensional rigidity, serviceability, economy, aesthetics and the ability to efficiently distribute the eccentric vehicular live load among the webs of the box-girder.

2.3 Mr. Praveen Naik, Dr. R. Shreedhar "Study on Behavior of Skew PSC Box Girder Bridge" (IJRASET) Volume 6 Issue V, May 2018

Skew bridges are built where geometry cannot accommodate straight bridge. The most common and basic type of bridge, that is widely used for roadways is Girder Bridge. The two most common types of girders that are used in practice are beam and Box Girders. Though box girder design is more complicated, it has wide acceptance due to their structural efficiency, aesthetic appearance, better stability and serviceability.

2.4PaldenHumagai, Pavan Kumar Peddineni "Manual Analysis And Design Of Post Tensioned Pre-Stressed Concrete T-Beam Segment Bridge Using Proto-Type Model" (IJCIET) Volume 8, Issue 4, April 2017

The report examines in detail the application of segmental precast T-Beam girder construction in achieving long spans in bridge structures. Numerous examples from throughout the world indicate that such construction can provide an effective means of achieving long span in the range of 100 to 500 ft. Used segmental pre-cast bridge structure member is manufactured in a number of short units which during erection are joined together, end to end, and post-tensioned to form the completed superstructure.

2.5 Vivek P. Joshi Ronak S. Gajjar "Literature Review in Analysis of Horizontally Curved Box-Girder Bridges" IJSRD Vol. 6, Issue 10, 2018

Bridge is life line of road network, both in urban and rural areas. With rapid technology growth the conventional bridge has been replaced by innovative cost effective structural system such as T-Beam Girder System and Box Girder Bridge System. In spite of difficult design procedure and complex form work requirement , box girders, have gained wide acceptance in freeway and bridge systems due to their structural efficiency, better stability, serviceability, economy of construction and aesthetic appearance.

2.6Punil Kumar M P, Shilpa B S "Dynamic analysis of box girder bridges" International Research Journal of Engineering and Technology, Volume: 03 Issue: 07 | July-2016

Now days the dynamic performance of structure is very much essential while designing any structure. Analyzing the PSC Box girder bridge, statically and dynamically is the basic aim of this dissertation. Here with and without application of dynamic loads, the performance of bridge is studied. The study of bridge with bearing between girder and top of pier are included. By applying moving load, vehicle (or) truck load, pre-stress and axial forces, the effects of bridge model is carefully studied.

III. METHODOLOGY

3.1.1 Dead LoadAnalysis

Dead load response can be physically figured by considering the dead load because of superstructure (Brace, Stomach and Deck piece). Longitudinal moments are figured similarly by duplicating responses with the longitudinal unconventionality which is the separation between the centerline of wharf and bearing.

3.1.2 Live Load Analysis

Road bridge decks have to be designed to withstand the live loads specified by Indian Roads Congress (I.R.C: 6-2010 Section II)

In India, highway bridges are designed in accordance with IRC bridge code. IRC: 6 - 2010 Section II gives the specifications for the various loads and stresses to be considered in bridge design.

3.1.3 Impact Load

The dynamic effect caused due to vertical oscillation and periodical shifting of the live load from one wheel to another when the locomotive is moving is known as impact load. The impact load is determined as a product of impact factor (i) and the live load.

Bridge	Loading	Span	Type of Vehicle	Impact factor (i)
Highway RC bridges according to IRC regulations	IRC class AA loading	(i) Spans less than 9 m	(a) Tracked vehicle	25% for spans up to 5m linearly reducing to 10% for span of 9m.
			(b) Wheeled vehicle	25%
		(ii) Spans 9 m or more	(a) Tracked vehicle	10% up to a span of 40m & in accordance with the curve in Fig 3.4 for spans in excess of 40m
			(b) Wheeled vehicle	25% for span up to 12m & in accordance with the curve in Fig 3.4 for spans in excess of 12m
	IRC class A loading and IRC class B loading	Spans between 3 m and 45 m	(a) Wheeled vehicle	$\frac{4.5}{6+L}$ L- Span in meters

3.1.4. Seismic Load

If a bridge is situated in an earthquake prone region, the earthquake or seismic forces are given due consideration in the analysis. An earthquake causes vertical and horizontal forces in the structure that will be proportional to the weight of the structure. IS: 1893 Part-3 may be referred for the actual design loads.

The following methods of seismic analysis can be employed for calculation of seismic forces in bridges.

1) Seismic Coefficient Method (SCM)
2) Response Spectrum Method (RSM)
3) Time History Method (THM)
4) Pushover Analysis (PA)

1. Seismic Coefficient Method (SCM)

The seismic force to be resisted by bridge component shall be computed as follows:

$$F = A_h W$$

Where,

F = Horizontal seismic force to be resisted
W = Weight under consideration ignoring reduction due to buoyancy or uplift.
A_h = Design horizontal seismic coefficient

2. Response Spectrum Method (RSM)

The following steps are required in RSM:

Formulation of an appropriate mathematical model consisting of lumped mass system using 2D/3D beam elements.

Horizontal Seismic Coefficient (Ah)

The design horizontal seismic coefficient, Ah shall be determined from following expression of 6.4.2 of IS1893 (Part

1): 2002.

$$A_h = \frac{Z}{2} \cdot \frac{I}{R} \cdot \frac{Sa}{g}$$

Provided that for any structure with T < 0.1 sec, the value of Ah will not be taken less than Z/2 whatever be the value of I/R
Where,
Z = Zone factor
I = Importance factor, Table 3.2
R = Response reduction factor, Table 3.3
Sa/g = Average Acceleration coefficient for rock or soil sites as.

3. Importance Factor (I)

Bridges are designed to resist design basis earthquake (DBE) level, or other higher or lower magnitude of forces, depending on the consequences of their partial or complete non-availability, due to damage or failure from seismic event. The level of design force is obtained by multiplying (Z/2) by factor 'I', which represents seismic importance of the structure.

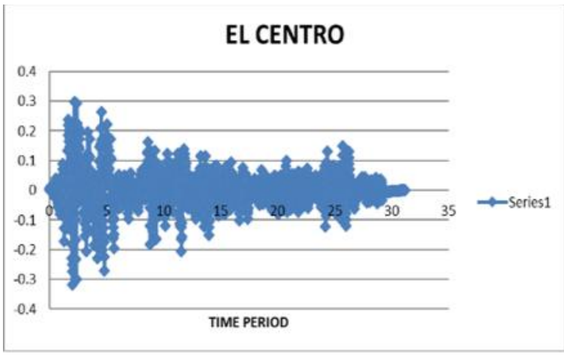
a) Extent of disturbance to traffic and possibility of providing temporary diversion,
b) Availability of alternative routes,
c) Cost of repairs and time involved, which depend on the extent of damages, -minor or major.
d) Cost of replacement, and time involved in reconstruction in case of failure.
e) Indirect economic loss due to its partial or full non-availability

3.2 ABOUT SOFTWARE (ANSYS)

The finite element method (FEM) is the most popular simulation method to predict the physical behavior of systems and structures. Since analytical solutions are in general not available for most daily problems in engineering sciences numerical methods like FEM have been evolved to find a solution for the governing equations of the individual problem. Much research work has been done in the field of numerical modeling during the last thirty years.

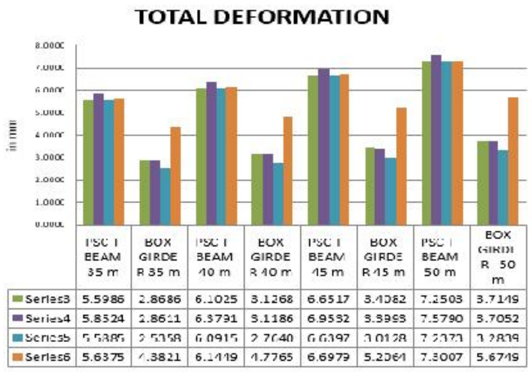
IV. RESULTS AND DISCUSSION

4.1 Data Collected



Idealization of above problem statement is modeled in finite element analysis tool ANSYS. Following models are prepared for comparative analysis of bridge structure.

	BOX GIRDER	PSC T-BEAM
MODEL NO.1	35m span	35m span
MODEL NO.2	40m span	40m span
MODEL NO.3	45m span	45m span
MODEL NO.4	50m span	50m span



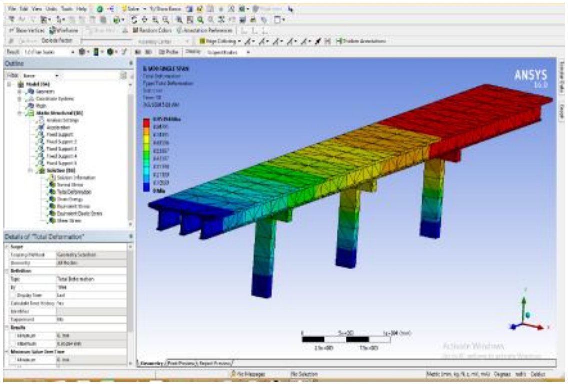
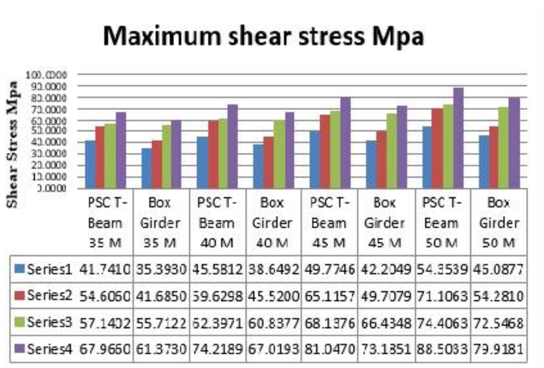


Fig 3. Total deformation



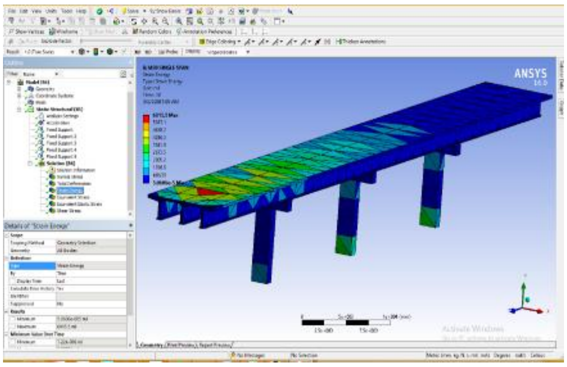
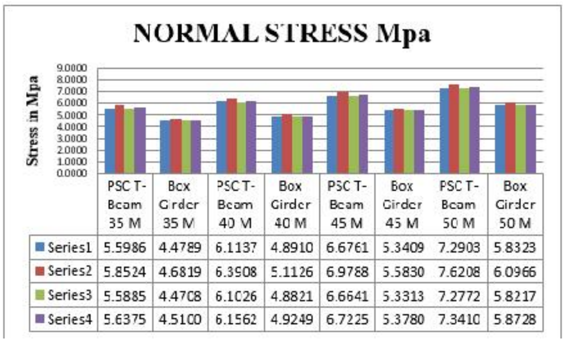


Fig 4. Maximum shear stress



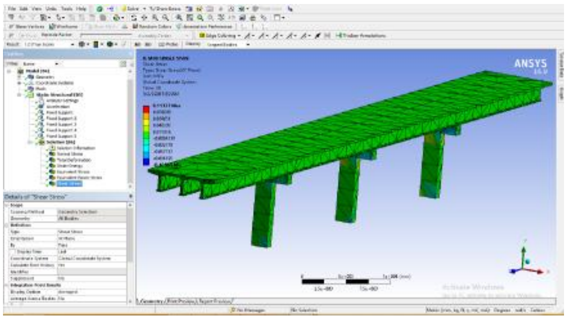


Fig 5.Normal shear stress

V. CONCLUSION

As the Above results shows that Total Deformation of PSC T-Beam & Box Girder for span 35m ,40m 45m, 50m will be subject load steps0.2 to 0.8. As the Above results shows that Equivalent Stress of PSC T-Beam & Box Girder for span 35m ,40m 45m, 50m will be subject load steps 0.2 to 0.8. Whereas Equivalent Stress of PSC T beam Is more than box girder in all spans by 20-25% for every load step.As the Above results shows that Maximum Shear Stress of PSC T-Beam & Box Girder for span 35m ,40m 45m, 50m will be subject load steps 0.2 to 0.8. Whereas Maximum Shear Stress of PSC T beam Is more than box girder in all spans by 5-10% for every load step.As the Above results shows that Time Period of Box Girder Box Girder is less than PSC T-Beam subject mode shapes 1 to 6 by 10-12%.

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