ANALYSIS OF SINGLE SPAN PRESTRESS CONCRETE BOX GIRDER USING "MIDAS CIVIL" SOFTWARE

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ABSTRACT:-
It will not be an exaggeration to quote that India is under reconstruction, and the construction of heavy structures are common scene across the length and width of the nation. One of the important massive engineering structures is a bridge of which the design of the girder is the most critical element. The use of Codal provisions and manual design of these critical structural elements is tedious and time-consuming which invites the structural engineers to use various state-of-the-art design software. The various types of girders used in bridge structures are T- Beam, I- Beam & Box Girders. Bridge girders size, shape and section are basically designed and engineered on efficient, safe and economic criteria. The present study is based on analysing and designing a Pre-Stressed Concrete Single Span Box Girder using MIDAS CIVIL Software. Box Girder acts as a primary beam in the bridge having the shape of a hollow box usually in the shape of a rectangle or trapezoidal. The Box girder normally involves the Pre-Stressed Concrete, Composite Section & High Strength Tendons or High Strength Structural Steel. The dead load calculations including the girder's self-weight, its superimposed dead load in the form of its wear course and crash barrier, pre-stressed load, and temperature load are done physically and analysed using MIDAS CIVIL Software, whereas for the construction stage load and analysis software are directly used. The moving load considerations is as per IRC: 6-2017. The moving load involved here are on the basis of carriageway width and the vehicle loads that are defined in the project are as per class 70R and Class A. The time-dependent material stress such as Creep and Shrinkage, Compressive Strength are also defined as per IRC: 112-2011. The results obtained from the analysis of the model subjected to I.R.C. Loadings give Shear Force, Bending Moment, Deformation, and Beam Stresses in the whole model occurring due to various loads and load combinations.

Keywords: *Box Girder, IRC Loading, IRC: 6-2017, IRC: 112-2011, MIDAS CIVIL Software.*

INTRODUCTION:

The term “Prestress” is introduced in the society of civil engineering by Jackson, An American Engineer, who is awarded with a patent in 1886. A German engineer Doehring also received a patent for the application of the concept of prestressing practically on a floor in 1888, but his invention failed because of the low value of the steel pre-stress tendons and the creep strain and shrinkage losses of the concrete. In 1939, A French Engineer, Fressiynet successfully invented and applied the prestress concrete with a conical anchorage using a high-strength steel and high-strength concrete. After the world war-II, large number of brides were damaged due to the bombing and shortage of steel for repairing the bridges lead to the rapid development and application of the prestress concrete technology in the construction of bridges also termed as a rise in modern bridge engineering era.

In recent time, Because of the rise in population, increased traffic, and massive expansion of metropolitan urban centres, the development of highway infrastructure has grown exponentially. Despite the fact that highway construction is expanding quickly, the alignment of the road occasionally encounters various obstructions, such as a body of water, a valley, or a road. To avoid blocking the way beneath these obstructions and to address the economic impact they have on the alignment without rerouting it, a large structure known as a bridge is built. Bridges can be categorised based on their span and form. Bridges are divided into six categories: Beam, Truss, Arch, Cantilever, Suspension, and Cable-stayed. The bridges that are classified according to their span are small span bridge (up to 20m), medium span bridge (up to 50m) and large span bridges (50 to 150m).

A bridge's cross section is made up of a variety of components, including a crash barrier, wearing course, girder, bearing, pedestal, pier cap, pier, and pile cap. The most integral and important part of the bridge that helps in distributing the load from the wearing course to the bearing to the piers to foundation is the girder. There are basically three types of girder T- beam girder, I-beam girder and Box girder. Despite being challenging to design, box girders are frequently used because of their structural effectiveness, attractive appearance, improved stability, and serviceability. A box girder is a hollow cellular structure made of two web plates linked at the top and bottom by a shared flange. A box girder can be designed into single cell, multi or multiple cell. Box girder are further classified according to their shapes into rectangular, circular and trapezoidal. . As the span increases the dead load becomes the major factor from the economic point of view. The range of the span is more for the box girder as compared to the T-beam or I- beam girder which leads to the use of less number of piers for the same length this is one of the factor that makes the box girder economical and the other factor is the reduced dead load of the box girder due to its cellular structure where the unwanted materials that are not being used to its full capacity are eliminated. An open section lacks the torsional rigidity and strength that this cellular section, also known as a Box girder, provides.

MIDAS CIVIL SOFTWARE:

Engineers may efficiently model and build with the help of Midas Civil, a Bridge Design & Analytical programme that blends the simplicity of modelling with cutting-edge analysis features. The software is flexible enough to handle complex geometry and has useful capabilities for simpler bridges. For engineers looking for optimum designs, it has a variety of design codes that are highly helpful.

LITERATURE REVIEW:

Vishal U. Misal et al [1] in their paper "**Analysis and Design of Prestressed Concrete Girder”**, performed the comparative analysis and design of the prestressed concrete girders using STAAD.PRO software and IRC class 70 R loading is taken into the consideration. The economic value is also taken into account depending on the span to depth ratio as well as self-weight of the particular girders. They concluded that box girder is more expensive than I girder. In contrast, it is also seen that the I-girder exhibits higher losses than the box girder.

Payoshni Mali et al [2] in their paper “**Comparison of Rectangular and Trapezoidal sections of Post Tensioned Box Girder”** performed comparison between the two sections of prestressed based on its shape is considered with the loading combination as given in IRC: 6-2000. They concluded that the rectangular section of the box girder has more shear force as compared to the Trapezoidal section and also the comparison between the torsional moments has been established.

Ajith Kumar R. et al [3] in their paper “**Study on the Structural Behaviour and Design of a Typical Single Cell Post Tensioned Concrete Box Girder Bridge**" compared longitudinal and transverse bending stress, shear stress, and torsional shear stress using manual computation and SAP2000 software. Moving loads are taken into account in accordance with IRC advice. They came to the conclusion that the shear stresses measured at the intersection of the webs and flanges are higher than the stresses in the web regions. The uniform force distribution is structurally seen well with the inclined webs of box girder. It is also seen that Trapezoidal box girder additionally exhibits greater resistance to shear caused by the loading.

Punil Kumar M P et al [4] in their paper “**Dynamic Analysis of Box Girder”** performed the analysis resulting in dynamic behaviour of box girder that is Bending moment, Torsion, Shear force and Displacement for various section depending upon span to depth ratio. Studying the behaviour of moving loads in relation to support response SAP2000 is used to analyse the bending moment, torsion, shear force, displacement, and axial force under conventional IRC loading.

Phani Kumar.Ch et al [5] in their paper **“Analysis and Design of Prestressed Box Girder Bridge by IRC: 112-2011”** Conducted analysis and design of a prestressed box girder bridge using IRC: 112-2011, taking high strength steel and high strength concrete into consideration, and analysing the model utilising a range of span to depth ratios, starting from 15 to 19. They get to the conclusion that as box girder depth increases, prestressing force drops and as a result of the lower force, the required number of cables also decreases. More concrete strength is used, and serviceability is controlled by prestressing force.

Sanket Patel et al [6] in their paper **“Comparative Study of PSC- Tee Girder and PSC-Box Girder”** performed comparative analysing of box and T girder using CSI Bridge 2014. They came to the conclusion that the box girder outperforms the T-girder in terms of serviceability as the span grows. Also, the box girder required less no. of cables as compared to the T-girder as the loading is maintained same in both the cases the box girder has relatively complex reinforcement as compared to the T- girder and is required skilled labour for the same.

M K Maroliya et al [7] in their paper **"Comparative Study of Flexural Behaviour of Reinforced Concrete Beam and Prestressed Concrete Beam"** studied the comparison of the structural performance of reinforced concrete beam with prestressed concrete beam from an economic perspective. They concluded that the prestressed concrete's moment developed a crack that was three times as large as the corresponding reinforced beam. Precast concrete beams have ultimate deflection behaviour that is roughly 60% less than that of reinforced concrete beams.

Miss P.R. Bhivgade et al [8] in their paper **"Analysis and design of Prestressed Concrete Box Girder Bridge"** performed Using SAP2000 14 Bridge Wizard, the analysis and design of a two-lane, simply supported prestressed concrete box girder that satisfies the deflection criterion is performed. They concluded that the box girder exhibits superior resilience to the torsion of the superstructure. Additionally, it has been noted that as depth increases, prestressing force and cable number decrease.

Shreyansh Patil et al [9] in their paper **"Comparative Study of PSC Box Girder Bridge Design Using IRC 112-2011 AND IRC 18-2000"** performed the comparison in design using IRC-112:2011 and IRC-18:2000 also the various parameters are defined using design code IRC-112:2011 depending on the span to depth ratio (L/D). They concluded that the span /depth ratio of 31 to 36 can be adopted for designing of box girder using IRC-112:2011 and it is observed that 5% to 12% of concrete is saved for the respective ratio's also concrete saving percentage increases as span increases.

Kokkonda Sricharan et al [10] in their paper **"Analysis and Design of Concrete T-Beam Girder Bridge and Box Girder Bridge: A Comparative Study"** performed the comparative analysis and design between T- Beam girder and Box girder and investigated based on dead and live loadings using CSI- Bridge Software. They concluded that T-Beam girder is more economical for the span length up to 20 m but if the span length is more the box girder is seem to be more suitable due to its high torsional rigidity because of its closed structure and Moment for T-Beam girder is seen to be more for up to 20 m span.

Amit Upadhyay et al [11] in their paper **"Comparative Study of PSC Box Girder Multi Cell (3-Cell) Bridge of Different Shapes"** with the aid of CSI Bridge, compared several PSC Box Girder Multi Cell (3-Cell) shapes (V-2017). The loading is considered as per IRC Class A loads and is analysed based on IRC-112:2011. They concluded that the PSC multi cell box girder is more suitable in resisting torsion and stresses as compared to other girders for longer spans.

Chetan T Naik et al [12] in their paper **"Analysis and Design of Multi Cell Post-Tensioned PSC Box Girder"** analysis and design of the box girder were undertaken using two sheathing pipes, namely HDPE and corrugated brilliant metal pipes as this has been an affordable alternative for the designing of multi cell box girder. They concluded that the design of multi cell box girder is more economical as compared to simpler span of I-girder with cast in-situ slab.

Nidhi P. Tiwari et al [13] in their paper **"Dynamic Analysis & Optimization of Prestressed Concrete T-Beam & Box Girder Bridge Superstructure"** performed the comparison between the T-Beam and the Box Girder analysing the static as well as the dynamic behaviour. They came to the conclusion that the Trapezoidal Box girder's bending moments, shear forces, deflections and stresses are higher than those of the T-Beam girder bridge and it is also seen that the Box girder is way more convenient solution than the T-Beam girder in accordance to the span increases.

Summary of literature review

S. No.	Ref No.	Name of Researcher	Title	Aspect Study	Findings and Conclusions	Source
i	1	Vishal U. Misal, N. G. Gore, P. J. Salunke	Analysis and Design of Prestressed Concrete Girder	Comparison Based on economy and losses	Box girder is more expensive than I girder. The I-girder experiences larger losses than the box girder.	IJIES Volume-2 2014
ii	2	Payoshni Mali, Shilpa Kewate, Savita Lokare	Comparison of Rectangular and Trapezoidal sections of Post Tensioned Box Girder	Comparison based on the shape of girder	Lesser shear force is present in the box girder's trapezoidal section as compared to the rectangular section Torsional moment resistance of Trapezoidal box girder is more as compared to rectangular section.	IJSER Volume 6 2015
iii	3	Ajith Kumar R., Dr. J. K. Dattatreya	Study on the Structural Behaviour and Design of a Typical Single Cell Post Tensioned Concrete Box Girder Bridge	Comparison between longitudinal and transverse stresses	In comparison to stresses in web parts, shear stresses at the web-to-flange junction are higher. The uniform force distribution is structurally seen well with the inclined webs of box girder. Trapezoidal box girders provide greater resistance to generated shear.	JCEET Volume-2 2015
iv	4	Punil Kumar M P, Shilpa B S	Dynamic analysis of box girder bridges	Study of design parameters	Moving load behaviour are studied with respect to support reaction Bending moment, Torsion, Shear force, Displacement and axial force under standard IRC Loading.	IRJET Volume-2 2016
v	5	Phani Kumar.Ch, S.V.V.K. Babu	Analysis and Design of Prestressed Box Girder Bridge by IRC: 112-2011	Comparison Based on different span to depth ratio	As box girder depth rises, prestressing force falls and due to lower force number of cables that has to be used also decreases. More concrete strength is used, and serviceability is controlled by prestressing force.	IJCRCE Volume-2 2016

vi	6	Sanket Patel, Umang Parekh	Comparative Study of PSC. Tee Girder and PSC. Box Girder	Comparison based on the type of girder	Compared to the T-girder, the box girder exhibits improved serviceability as the span grows.. Box girder has relatively complex reinforcement as compared to the T- girder. The box girder required less no. of cables as compared to the T-girder as the loading has been maintained same	IJSTE Volume-2 2016
vii	7	M K Maroliya	Comparative Study Of Flexural Behaviour Of Reinforced Concrete Beam And Prestressed Concrete Beam	Comparison based on Structural Behaviour	The prestressed concrete's moment developed a crack that was three times as large as the corresponding reinforced beam. The ultimate deflection of a reinforced concrete beam is around 60% more than that of a prestressed concrete beam.	IJERA Volume-2 2012
viii	8	Bhivgade P.R	Analysis and design of Prestressed Concrete Box Girder Bridge	Study based on different span to depth ratio	Box girder exhibits better resilience to the superstructures twisting.	2013
ix	9	R. Shreedhar, Shreyansh Patil	Comparative Study of PSC Box Girder Bridge Design Using IRC 112-2011 AND IRC 18-2000.	Comparison in design Based on different span/depth ratio	Span to depth (L/D) ratio of 31 to 36 can be adopted for designing of box girder using IRC-112:2011. 5% to 12% of concrete is saved for the respective ratio’s and concrete saving percentage increases as span increases.	IJSE Volume-5 2016
x	10	Kokkonda Sricharan, Mohd Ibrahim Hussain, Shaik Laeeq Ahmed, Abdul Aziz	Analysis and Design of Concrete T-Beam Girder Bridge and Box Girder Bridge: A Comparative Study	Comparison based on the type of girder	T-Beam girders are more cost-effective for spans up to 20 m But if the span length is more the box girder is seem to be more suitable due to its high torsional rigidity because of its closed structure. Moment for T-Beam girder is seen to be more for up to 20 m span.	IRJET Volume-8 2021

xi	11	Amit Upadhyay, Dr. Savita Maru	Comparative Study of PSC Box Girder Multi Cell (3-Cell) Bridge of Different Shapes	Comparison based on types of Box girder	The analysis is done using IRC-112:2011 and the loading is regarded as IRC Class A loads.	GRD Journal for Engineering Volume-2 2017
xii	12	Chetan T Naik, Dr.M M Achar, K Lakshmi	Analysis and Design of Multi Cell Post-Tensioned PSC Box Girder.	Study based on Economical Aspect.	Two sheathing pipes namely HDPE and corrugated bright metal pipes as this has been an economical solution for the designing of multi cell box girder. Design of multi cell box girder is more economical as compared to simpler span of I-girder with cast in-situ slab	IOSR-JMCE Volume 12 2015
xiii	13	Nidhi P. Tiwari, K.R.Dabhekar	Dynamic Analysis & Optimization of Prestressed Concrete T-Beam & Box Girder Bridge Superstructure.	Study based on static and dynamic behaviour	When compared to a T-Beam girder bridge, the trapezoidal box girder has higher parameters such as forces and bending moments. As the span rises, box girders are a far more practical alternative to T-Beam girders.	IJSTE Volume-3 2017

METHODOLOGY:

i. The research methodology involves analysing of single span PSC Box Girder of span 40m with carriageway width of 7.5m.
ii. The model is generated using MIDAS CIVIL 2022 software.
iii. The load definitions are set up according to the IRC: 6-2017.
iv. The Design code used here is IRC112:2011.
v. The construction stages is considered here will be of 2 days, 14 days and 10000 days.
vi. The boundary conditions defined is of rigid link, elastic link and the supports.
vii. The various results that will be interpreted like Shear Force distributions, bending moment distributions and deflections.

Refer to the Flow chart given below for modelling definitions.

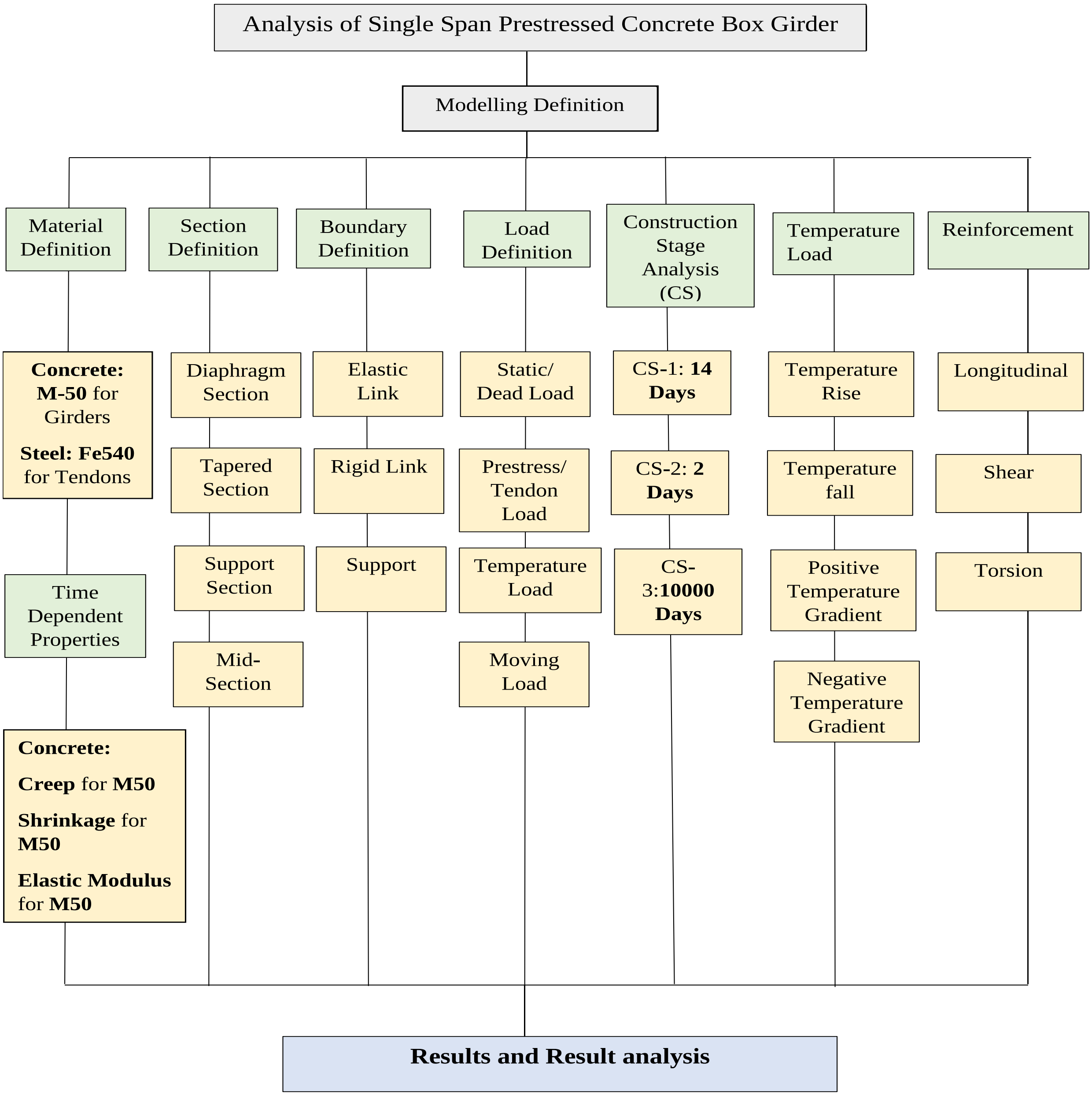
CONCLUSION:

i. The load definitions that is used here are dead and moving loads. The dead load that are defined the self-weight of the girder, superimposed dead load - wearing course & Crash barrier, pre-stressed load, and temperature load.
ii. The moving load is defined as per IRC: 6-2017. The moving load involved here are on the basis of carriageway width and the vehicle loads that are defined in the project are as per class 70R and Class A.

iii. The time-dependent material stress such as Creep and Shrinkage, Compressive Strength are also defined as per IRC: 112-2011.

iv. For modelling and analysis purpose, MIDAS CIVIL 2022 software is used.

v. As it is a review paper, the final results that will be obtained due to IRC loading and various stress occurring due to load combinations will be discussed in the final paper.



vi.

Fig: Flow Chart of modelling definition for single span PSC box Girder

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