PARAMETRIC ANALYSIS OF SINGLE SPAN PRESTRESSED CONCRETE I-GIRDER BRIDGE USING "MIDAS CIVIL" SOFTWARE: A REVIEW

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ABSTRACT:

Bridges are essential elements of modern transportation systems, providing efficient and effective links between different regions and contributing significantly to economic, social, and cultural development. As the population continues to grow and vehicle usage increases, the number of modern road and bridge construction projects in India is escalating. To alleviate traffic congestion, composite bridges are increasingly being adopted on a large scale for highway construction. The current study focuses on the analysis and design of a Composite Single Span PSC-I Girder Bridge under IRC loadings using MIDAS CIVIL Software. The analysis aimed to derive various results including bending moment, shear force, and time-dependent characteristics such as creep and shrinkage. The moving load consideration is as per IRC:6-2017 and compressive strength are defined as per IRC 112:2011. During the construction phase, the PSC (prestressed) design of the span is executed following IRC standards to acquire output parameters such as principal stresses for prestressing tendon.

Keywords: Midas civil, PSC I-girder, bridge, prestressing, tendons, IRC standards.

INTRODUCTION:

Bridges serve as the fundamental framework of the street network in both urban and rural areas. The utilization of three key types of bridges Prestressed, Girders, and RC boxes in modern infrastructure has facilitated the continuous growth of this industry. This advancement has proven to be an efficient tool for the swift and simplified construction of bridge infrastructure worldwide, accompanied by notable progress in the integration of technology and civil engineering.

Midas Civil is Finite Element Analysis (FEA) software designed by Midas IT for the analysis and design of bridges. It simplifies and accelerates the bridge modeling and analysis process by integrating extensive pre-and post-processing tools with a high-speed solver. The software also includes user-friendly tools for changing parameters, enabling efficient parametric analysis and facilitating the creation of cost-effective designs. The engineering design process for developing safe bridge structures involves the following phases:

1.Acquiring a comprehensive understanding of the situation.

2.Computing potential bridge loads according to IRC 6 2000.

3.Aggregating these loads to determine the maximum potential load.

4.Calculating mathematical relationships to estimate the required amount of a specific material to withstand the highest load.

The l-girder is one of the most used girders in the bridge infrastructure. The I- girder is used for medium span and short span bridges. It basically consists of the top and bottom flanges connecting with the single common web. I-girders are preferred mostly as they are easier for casting than the bay girder and requires a smaller number of labors for the casting. The I-girder Bridges and basically constructed in the form of composite of cast in-situ concrete situation.

LITERATURE REVIEW:

For the parametric analysis of PSC composite I-Girder bridge the following research are studied and the literature gap has been established based on the below research paper:

Menda Babu Rao et al [1] in their paper **"Analysis & Design of Composite Prestressed Concrete I-Girder Bridge Using MIDAS Civil",** performed analysis through Midas Civil software and stresses and deflection were under the limit as per the analysis. When the assigning is done in girder of prestressing tendon forces and profile, the tendon's stresses become safe.

The results also showcase that precast prestressed concrete girder deck slab is better than ordinary configuration of deck slab as in case of ordinary configuration of deck slab, the exposed area is more and so it requires long term maintenance and serviceability problems in the structure which is resolved for the case of precast prestressed concrete girder deck slab.

M Jagandatta et al [2] in this paper **"Analysis and Design of Composite Single Span Psc-I Girder Bridge Using Midas Civil"**, have concluded that the ultimate bending and shear resistance are evaluated for both standard and seismic conditions. The prestressing tendon profile and forces in the girders can be conveniently specified using Midas Civil. It serves as a comprehensive, fully integrated system for civil structural engineering tasks. Assigning tendon materials and profiles in the girder is secure, ensuring safe tendon stresses. Midas

Civil offers a streamlined solution for the analysis and design of various structural models, with a particular focus on bridges.

Rishabh Singh et al [3] in this paper **"Design and Analysis of Pre-Stressed I-Girders by Midas Civil Software",** have concluded that the numerous advantages of prestressing over RCC, backed by technical insights and its extensive utilization across industries by engineers, indicate its enduring application in the field, particularly with the integration of new structural elements and emerging technologies. The relaxation in moment generation and enhanced load-carrying capacity afford designers additional flexibility to accommodate higher working loads on structures. The future usage of prestressing by designers is poised to rise in the market, paralleled by advancements in software that will facilitate a deeper understanding of the phenomenon.

Varun.T.Naik et al [4] in this paper **"Comparative study of precast RCC I-Girder configuration for various span arrangements in a bridge super structure",** have concluded that The design has been assessed for ultimate shear strength in accordance with IRC guidelines for various span lengths and different girder arrangements, including systems with 3 girders and 4 girders. The four-girder system for spans of 20m, 25m, and 30m, with a girder depth of 1.8m, proves to be secure against ultimate shear resistance.

Sushma Siddi et al [5] in this paper **"Design and analysis of suspended steel girder bridge using "Midas civil",** Based on the reviewed research, It is evident that MIDAS Civil provides significant advantages for modeling bridge structures. By utilizing MIDAS software, engineers can efficiently analyze and design Suspended Steel Girder Bridges, and seamlessly export the created models. This involves analyzing critical parameters like displacements, safety indices, and more. Furthermore, comparing the software-designed outcomes with manual design calculations enhances the understanding of the software's efficacy and reliability.

M K Maroliya et al [6] in this paper **"Comparative Study Of Flexural Behavior Of Reinforced Concrete Beam And Prestressed Concrete Beam",** have concluded that in reinforced beams, a higher number of cracks were observed, albeit narrower, compared to prestressed beams. This disparity may arise from stress concentration induced by loads and inadequate concrete compaction due to insufficient vibration. Prestressed beams, on the other hand, exhibited fewer cracks, albeit wider, likely owing to their inherent design and construction methods. Moreover, upon load removal, prestressed beams demonstrated greater deflection recovery, indicating a more elastic behavior. Consequently, prestressed beams are deemed more adept at withstanding fatigue loads compared to reinforced beams.

Vishal U. Misal et al [7] 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 considered depending on the span to depth ratio as well as the self- 75 weight of the girders. They concluded that box girders are more expensive than I girders. In contrast, it is also seen that the I-girder exhibits higher losses than the box girder.

R.Shreedhar Spurti Namadapur et al [8] in this paper **"Analysis of T-girder Bridge using Finite Element Method"** have concluded that, the straightforward span T-beam extension underwent analysis using IRC guidelines and loading (including dead load and live load) as a one-dimensional structure. Additionally, a finite element analysis of a three-dimensional structure was conducted using Staad Pro software. Both models were subjected to IRC Loadings to determine the maximum bending moment. Upon analysis, it was observed that the results obtained from the finite element model were lower than those obtained from the one-dimensional analysis. This indicates that the results obtained from IRC loadings are conservative, while finite element analysis provides a more realistic design approach.

Raja moori Arun Kumar et al [9] in this paper **"Study on Analys of Concrete T-Beam Girder bridge"** have concluded that is the bending moment and shear force experienced by PSC (prestressed concrete) T-Beam Girders are lower compared to RCC (reinforced concrete) T-Beam girder bridges. This characteristic enables designer to specify lighter sections for PSC T-Beam Girders than for RCC T-Beam Girders, even for a 24m span. Additionally, the moment of resistance of PSC T-Beam Girders surpasses that of RCC T-Beam Girders for a 24m span. Moreover, the cost of concrete for PSC T-Beam Girders is lower than that for RCC T-Beam Girders.

Amit Saxena et al [10]in this paper **"Comparative Analysis and design of T-Beam and box Girder Bride"** have concluded that the dead load bending moment and shear forces exerted on T-Beam girders are lower compared to those on a two-cell bridge. This feature allows designers to specify lighter sections for T-Bar support than for Box Brace support, even for a 25m span. Moreover, the moment of resistance of steel for both types has been evaluated, leading to the conclusion that T-Beam girders exhibit greater capacity for a 25m span.

LITERATURE GAP:

From the above literatures, it is found that there is minimum development in the parametric study of the composite I-Girder bridge and that to using the MIDAS CIVIL Software. So, the basic focus of this present study is to learn and to study the design parameters like shear force, bending moment, Displacement and overall cost using the MIDAS CIVIL Software.

OBJECTIVE OF RESEARCH:

The main objective of the present study is to study the design parameters of the superstructure of the single span PSC composite I- girder bridge.

The structural response parameters that are taken into the account are: -

1. Support reactions at the base of the superstructure caused due to its self-weight and the moving load and due to the load combinations.

2. Bending moment,

3. shear force and

4. Displacement of the structure.

NEED FOR STUDY:

I. In the current scenario, there is heavy development in the construction and the maintenance of the bridges. By the growing highway infrastructure, construction of bridges is also tremendously increased.

II. The software plays an important role as it minimizes time as well as effort. The manual calculations and the software results can be verified easily, and this Verification is also important as a minute error in the calculations or the designs of the bridges manually or with the software can lead to the collapse or damage of the bridges which leads to the loss of a huge amount of lives as well as the economy.

III. The proper analysis and the study of each and every parameter like shear, deformations etc. of each element can easily be studied. This gives a wide variety of extensions in exploring the various kinds of codes that have only been used while designing the bridges.

IV. The study of prestressed concrete bridges leads to the proper application of high-end steel and high grade of concrete. This also helps in gaining knowledge about under the service loads without any stresses complex and heavy structures can be designed by prestressed concrete resulting in the crack free structure.

METHODOLOGY:

In present research, Single span Prestressed I-Girder Bridge model is created. The following steps brief about the methodology:

i The research methodology involves design parametric analysis of Superstructure of single span PSC composite bridge of span 24m.

ii.The model is generated using MIDAS CIVIL 2024 software.

iii.The load definitions are set up according to the IRC: 6-2017.

iv. The Design code used here is IRC 112:2011.

v. The construction stages for PSC composite bridge will be 1day, 14 days, 14 days, 10000 days.

vi. The boundary conditions defined are rigid links, elastic link and the supports.

Vii.The various results that will be interpreted like Shear Force distributions, bending moment distributions and deflections.

MODELLING DEFINITION:

For the design parametric Analysis, the model is defined as per the IRC code mentioned above. The models here generated is composite PSC 1- Girder Bridge. Here, the model is created following various steps:

1. Material Definition 2. Section Definition 3. Boundary Definition 4. Load Definition 5. Construction Stage Analysis Definition

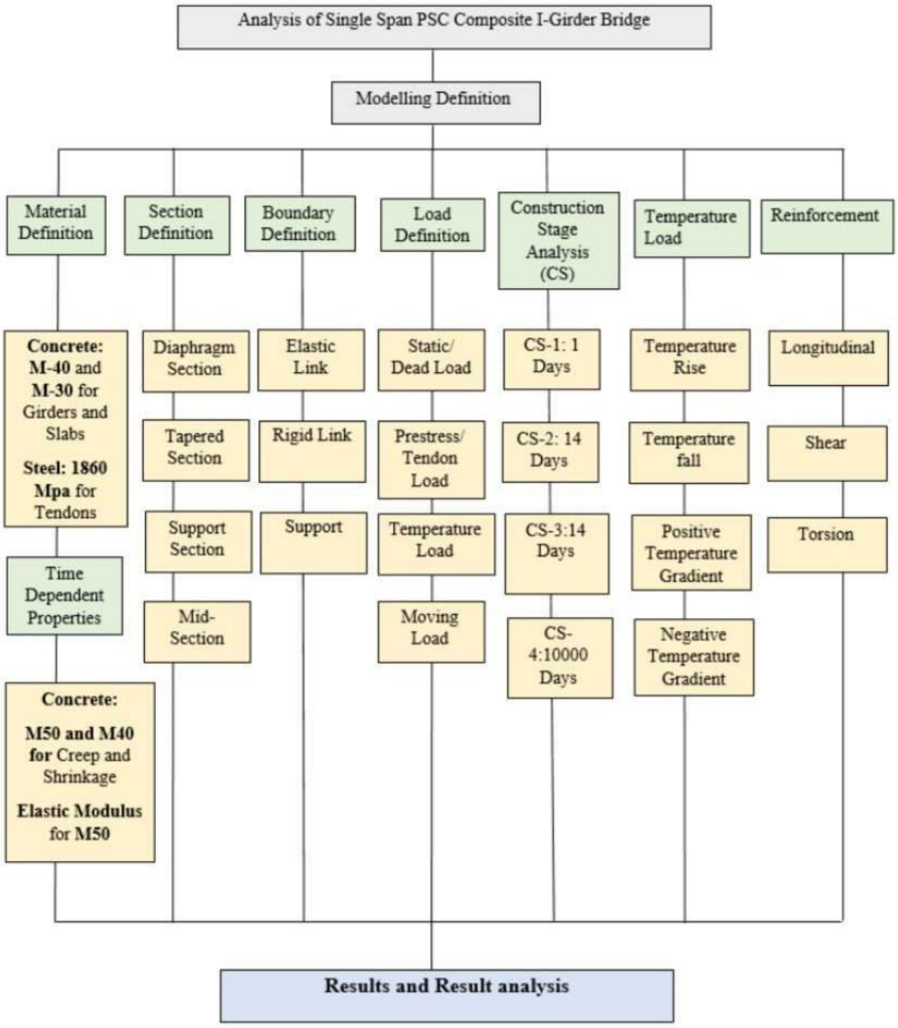

Figure: Flow Chart of modeling definition for single span PSC composite I Girder Bridge

1. Material Definition:

The minimum grade of concrete that is used for the prestressed concrete bridge structures is M-30 and above. And the minimum strength of the tendons that are used for the prestressed concrete bridge structures is 1100N/mm².

CONCRETE	M-40 for Girder and M-30 for Slab

STEEL	1860MPa Strength for Tendons

Another property that usually determines the force and stress behavior pattern of the bridge is the time dependent material properties like creep, Shrinkage and Elastic Modulus/ Compressive Strength of concrete. This time dependent material properties are basically defined as per IRC 112:2011. The value that is taken for generating these properties are:

CONCRETE	Creep And Shrinkage for M-50&M-40
	Elastic Modulus for M-50

2. Section Definition: The PSC I-Girder Bridge section is break into Four types:

I. Diaphragm II. End section/Support III. Mid-Section

I. Diaphragm Section: In the case of PSC Composite 1 Girder Bridge. The Diaphragm is Situated in the transverse Horizontal direction to sustain the loads moving across the longitudinal axis due to the static as well as the moving load.

II. End Section/Support: In PSC Composite I-Girder Bridge to sustain the load and the T-Girder is usually more solid and strong enough to resist the forces acting on it so T-Girder is usually used in the support section.

III. Mid-Section: Mid-section is the middle part of the superstructure that starts from right next to the last support element to the left next to the last support element. This is the section which carries the maximum load acting due to the dead as well as moving load. This section transfers the load to the support section/ End section.

3.Boundary Condition:

The boundary definition here is basically provided to simulate the bearing, bearing stiffness and DOF's. The three governing factors for the simulating the bearing conditions are: -

I. Rigid links II. Elastic link III. Supports

The basic need of providing the bearings is to smoothly accumulate the force coming from the load acting on the deck of the bridges. The bearings can be said as the neck of the bridges between the superstructure of the bridge and the substructure of the bridge. It easily restores the displacement caused due to the force acting on the bridge and transfers the load from the superstructure of the bridge to the piers.

4.Load Definition:

Various Loads acting on the structure is the main factor for causing the parametric behavior such as Stresses, Forces, and Deformations etc. Thus, it becomes necessary to analyze and design the structure on the basis of these parameters. The loads that are taken into consideration for the analysis of these models are: I. Static/Dead Load II. Prestress/Tendon Load III. Temperature Load. IV. Moving Load .

I. Static/Dead Load: The load acting due to the self-weight of the structure is called the static load. The load acting due to the wet concrete and crash barrier in case of the 1-girder Bridge lies under superimposed dead load. So generally, the Static/Dead Load loads taken for defining or analyzing the model are i. Self-weight of the bridge. ii. Superimposed dead load due to crash barrier iii. Superimposed dead load due to wet concrete.

For composite I-girder Bridge: The Superimposed dead load that is taken into consideration for composite I-girder Bridge are: A) SIDL due to wearing course. B) SIDL due to a crash barrier C) SIDL due to Wet Concrete.

II. Prestress/Tendon Load: These loads are caused by the tendons used for prestressing concrete. Tendons of the same tensile strength are used but some of their parameters and arrangements are different. All the tendons can resist the tensile force acting on the bridge.

III. Temperature gradient: The uniform temperature of the structure basically deals with the rise and fall of the temperature. This causes the axial expansion or contraction, if restrained longitudinally in the bridge structure.

For determining the temperature of a particular city or region, Annexure F of IRC: 6-2017 gives the maximum and minimum temperature.

IV. Moving Load: The line loads that are uniformly concentrated in the form of wheels over the deck of the bridge are known as moving load. IRC loadings are considered for defining the moving load. According to the IRC loadings, the loads are categorized into two vehicle categories: 1. Class-70R loadings.2. Class-A loadings.

5. Construction Stage Analysis Definition:

This enables us to specify the construction phases that are required to evaluate a bridge structure that considers the effects of changing structure configuration, elastic and time dependent displacements (creep and shrinkage).

The boundary, load, and activated and deactivated element groups are used to identify each building step. A distinct element group, boundary group and load group are retained for each stage, creating an independent structure.

The usual sequence for the construction stage analysis for the composite 1 Girder Bridge is:

Step 1: Cast the girder in the casting yard and do first stage stress at girder age of 7 days.

Step 2: Girders are shifted to temporary bearings at proper location and stage 2 stressing is done at girder age of 21 days.

Step 3: Slab concrete is cast when girder age is 28 days

Step 4: Slab formwork is removed when slab age is 14 days

Step 5: Wearing course & crash barrier are set up at slab age of 28 days

Step 6: Expected structure life is 30 years, so a final stage of 10000 days is considered to check time dependent effects.

CONCLUSION:

i. The load definitions that are 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 is based on 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 purposes, MIDAS CIVIL 2022 software is used.

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

FUTURE SCOPE:

I. The main aim of the present study is to analyze the parametric effect on the superstructure of the prestressed concrete Composite I-Girder Bridges using the MIDAS CIVIL Software.

II. There is a further possibility to extend the project for future research, the sub-structure of the bridges can be designed, and analysis of Steel composite Bridge and the overall structure can be thus compared with PSC-I Girder Bridge.

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