Analysis of Composite Two Span PSC I-Girder Bridge using Midas Civil

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ABSTRACT
Bridge construction has gained global significance, with bridges being crucial components of every road network. The popularity of pre-stressed girder bridges is rising due to their enhanced stability, serviceability, economy, durability, and aesthetic appeal. For long spans, pre-stressed concrete is more efficient than reinforced concrete, making it ideal for bridges with spans over 10 meters. Pre-stressed girder bridges offer good stability, serviceability, and economic benefits without long-term traffic disruption. This paper explores the analysis of a Composite Two-Span PSC-I Girder Bridge under IRC loadings using MIDAS software, focusing on outputs like deflection based on stiffness scale factor.

Key Words: Bridge, Midas Civil, Composite I-Girder, Prestressed, IRC standards.

1. INTRODUCTION

Midas Civil is a Finite Element Analysis (FEA) software developed by Midas IT for bridge analysis and design. It simplifies and accelerates bridge modeling and analysis by integrating extensive pre- and post-processing tools with a fast solver. Additionally, it offers easy-to-use parameter change tools for parametric analysis, enabling efficient and cost-effective design creation.

The engineering design process for developing safe bridge structures involves these phases:

1) Acquiring a comprehensive understanding of the situation.
2) Calculating potential bridge loads according to IRC 6 2000.
3) Combining these loads to determine the maximum potential load.
4) Using mathematical relationships to estimate the material needed to withstand the highest load.

M Jagandatta et al., designed a Composite Single Span PSC-I Girder Bridge under IRC loadings using MIDAS software. The analysis covered bending moments, shear forces, and time-dependent characteristics like creep and shrinkage. The PSC span was designed following IRC standards, considering section properties, moments, prestressing forces, tendon profiles, prestressing losses, and shear stresses **[1]**. Menda Babu Rao et al. focused on composite pre-stressed I-girder bridges, which was beneficial for rapid construction since girders was pre-fabricated off-site and assembled on-site. These bridges offered good stability, serviceability, and was economical, minimizing traffic disruption. They were also simple to construct and suitable for short spans. The paper detailed the analysis and design of these bridges using MIDAS civil software **[2]**. Shubham S. Hande et al., compared a pre-stressed concrete bridge under IRC 6: 2000 and ASHTO-LRFD standards, using MIDAS CIVIL for modeling and analysis. Key structural parameters like shear force, bending moment, and torsion were examined. The findings indicate that AASHTO standards were less economical than IRC standards due to heavier vehicle loads **[3]**. Gokul Mohandas V and Dr. P. Eswaramoorthi analysed the superstructure and substructure separately, with the superstructure analysed for gravity and vehicular loads according to IRC standards. This study discusses modeling and analyzing prestressed concrete bridges in MIDAS Civil, noting that curved tendon profiles reduce stress and deflection compared to straight profiles **[4]**. Vinitha. P et. al., analyzed the suitability and economics of box girder and I-girder bridges, focusing on the radius of curvature and diaphragm spacing in curved girders. Models were created in MIDAS Civil software to study the influence of these factors, with torsion being a primary research area. The study aimed to determine the most economical bridge design for curved sections based on accurate analysis results **[5].** Qi Chu and Shaoxing Yue described that the road and bridge construction projects increase with urban development, new technology and equipment are enhancing construction quality. However, the high technical demands, particularly for seismic construction, lead to imperfections. Using Midas Civil technology, examined seismic damage issues in road and bridge construction and discusses crucial control measures to advance traffic infrastructure **[6]**. Jian Li et al., developed a method to combine Revit with Midas Civil software to improve the efficiency and accuracy of finite element modeling for large bridge structures. Using Visual Studio 2022, the team created a secondary development program to convert model information, generating a Midas Civil Text file to link Revit and Midas Civil. This method was tested on a single-box three-cell box-girder bridge, showing successful transfer of Revit model information to Midas Civil, significantly enhancing modeling efficiency and accuracy for complex bridge superstructures **[7]**. Jing-xian SHI and Zhi-hong RAN established a three-dimensional finite element model of a continuous rigid frame bridge with a main span of 120m using Midas Civil software. It simulated and analyzed the deflection and stress of the main beam at each construction stage of the continuous beam bridge, offering a reliable technical guarantee for the bridge's safe construction **[8]**. Rajathi Boominathan and Mr. Rameshwaram emphasized the need for robust bridge design in vulnerable areas like the Dibang Hydroelectric Project (HEP) in India, due to increasing extreme weather events. It focused on designing a truss steel bridge to withstand the challenging terrain and weather conditions of the Dibang region. MIDAS software was used for structural analysis and design, simulating the bridge's performance under heavy rainfall, strong winds, seismic activity, and temperature variations **[9]**. M Miranda et al., examined the structural response of a prestressed box girder concrete bridge under earthquake loads, using MIDAS Civil software to simulate responses under three soil conditions: hard, medium, and soft. The study found displacement values on the pier in the X direction to be 1.26 cm for hard soil, 1.53 cm for medium soil, and 2.02 cm for soft soil. Consequently, the bridge's displacement on hard soil was 21.4% smaller than on medium soil and 60.32% smaller than on soft soil **[10]**.

2. MODELLING AND METHODOLOGY

2.1. Midas Civil Software:

Midas Civil, a software for integrated modeling, analysis, and design of civil, bridge, and building structures, is set to revolutionize the engineering profession. It simplifies adjustments and inspires new design ideas, leading to increased accuracy and productivity. The software also enables the creation of high-quality graphics visuals and animations for presentations. Modelling of Two Span PSC I- Girder Bridge was done by using MIDAS CIVIL software. The loading conditions were provided for both the models as per IRC 6: 2000 (Section II).

2.2. Loading details on PSC I- Girder Bridge:

Further, there were some common loading conditions in both the models, which are here below as:

a. **Dead load (DL):** The dead load sustained by the girder or component is made up of its own weight, as well as portions of the superstructure's weight and any fixed loads sustained by the member. During designing, the dead load may be anticipated pretty well, and construction and service can be managed. Moreover, weight of SIDL which includes earth-fill, wearing course, ballast, waterproofing, conduits, cables, pipes, etc. are installed on the structure.

b. **Live Load (LL):** Vehicles passing over the bridge create live loads, which are temporary in nature. These loads are impossible to predict correctly, and once the bridge is exposed to traffic, the designer has very little control over them. For the evaluation of a two-lane box girder, the similar categories of loadings are used.
As per IRC - Vehicle Load: Class A and Class 70R; Dynamic Allowance: 33%

2.3. Modelling:

- Create nodes in node tool bar. Display node numbers.
- Defining material and section properties in properties tool bar.
- Preparing geometry of PSC I-Girder using node numbers of elements and assigning predefined properties and cross-sectional details.

- Define creep and shrinkage and compressive strength also material links should be defined.
- Define tendon properties in tendon profile generation tool bar.
- Define rigid and elastic link for structure.
- Applying dead load, prestressing load from load tool bar.
- Selecting loading standard of IRC-6.
- Analyze box girder by selecting perform analysis.

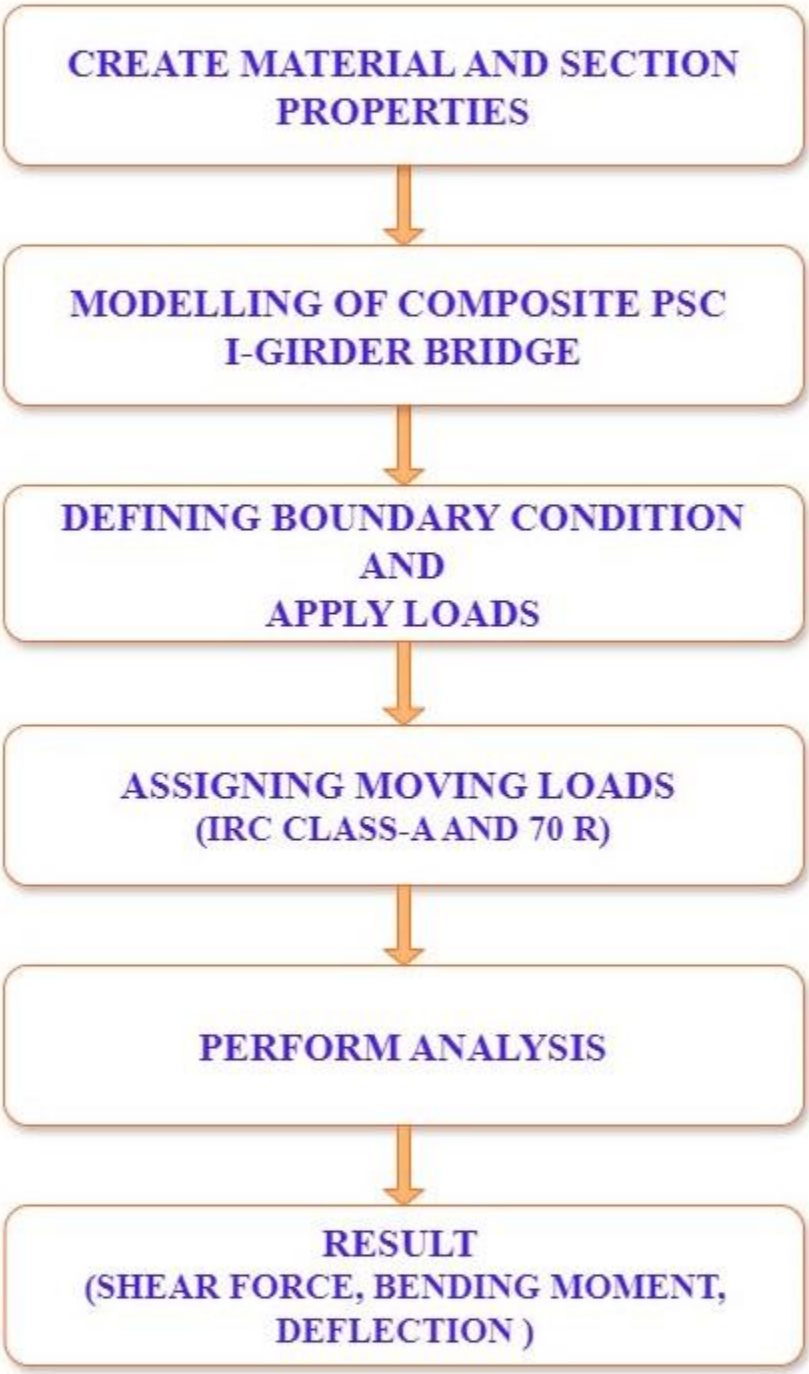

Fig.1: Work Flow diagram of Methodology

2.4. Structural Details:

Table.1: Description of Bridge parameter

PARAMETERS	DESCRIPTION
Bridge Type	PSC Composite (Composite I Girder)
Span Length	2 Span @ 22.8 m each
Expansion joint b/w 2 spans	40 mm
Width	15 m
Girder	5 Precast, post tensioned @ 3m c/c
Time Dependent Material (Creep, Shrinkage, Modulus of Elasticity)	IRC 112
Loads	Static Loads, Pre stress Loads, Moving Loads
Moving Loads	IRC 6
Load Combination	IRC 6 (2000)
PSC Design Check	IRC 112-2011

Table.2: Description of Material Properties

Material Properties	
PSC Girder	M40
PSC Deck	M30
Diaphragm	M40
Substructure	M30
Tendon	Fe540 Steel

Table.3: Description of Section Properties

Section Properties		
End Diaphragm	Solid Rectangle	1.4 m X 0.4 m
Internal Diaphragm	Solid Rectangle	1.4 m X 0.3 m
Pier	Solid Round	1.5 m (d)
Pier Cap	Solid Rectangle	1.4 m X 1.6 m

3. ANALYSIS AND DESIGN

Using Midas Civil software, both linear and non-linear analyses are conducted. Analytical techniques generate results, reducing structure failure rates, extending their lifespan, and enhancing safety. The models are illustrated in the Fig.2.

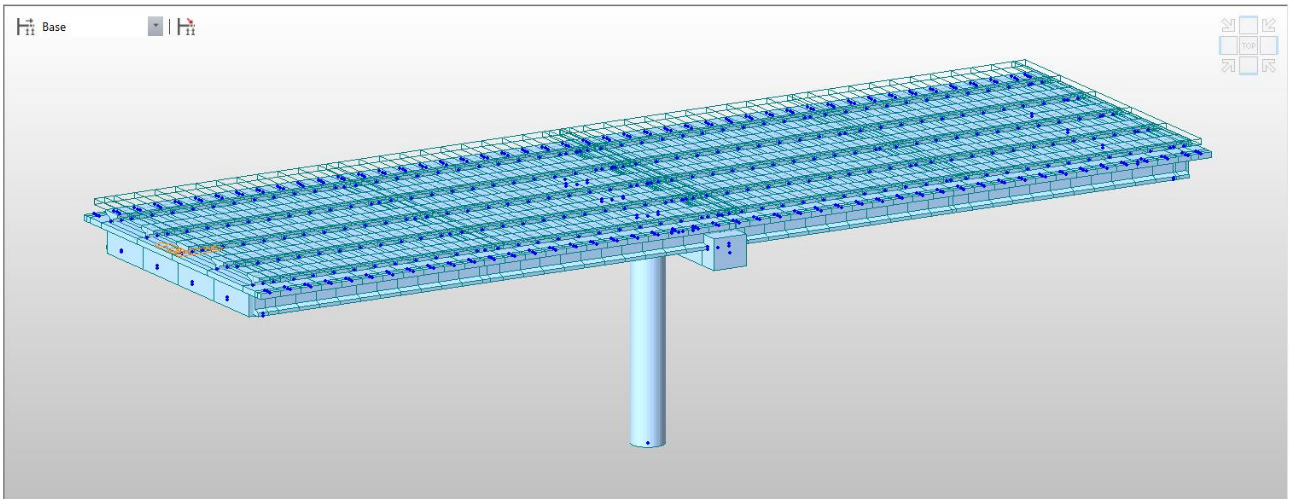

Fig.2: Generated model of Isometric view in MIDAS Civil (Composite Two Span PSC I- Girder Bridge)

4. RESULTS AND DISCUSSIONS

Following analysis using Midas software, the Composite Two Span PSC I- Girder Bridge result is examined. Under varying loading circumstances, primary structural analysis parameters such as deflection and mode shape are investigated based on various stiffness factors.

The deflection increases on decreasing stiffness factor, i.e., 1.0, 0.95, 0.90, 0.85, 0.80, 0.75, 0.70, 0.65, 0.60, 0.55, 0.50. The deflection of bridge is shown in Table.4.

Table.4: Deflection values based on various Stiffness scale Factor.

Stiffness Factor	D_X (m) Max.	D_Y (m) Max.	D_Z (m) Max.
1.00	0.133721	0.036881	0.223405
0.95	0.134984	0.037991	0.223405
0.90	0.135955	0.038103	0.249205
0.85	0.136997	0.039824	0.252695
0.80	0.137984	0.040256	0.26894
0.75	0.138725	0.041568	0.278235
0.70	0.139852	0.042589	0.287125
0.65	0.140865	0.043589	0.298278
0.60	0.141897	0.044895	0.298768
0.55	0.142562	0.045876	0.308546
0.50	0.143566	0.046576	0.315893

5. CONCLUSIONS

1. It is very easy and safe to design and analysis the prestressed post tension girders and deck slab using Midas civil.
2. The prestressing tendon profile and forces in the girders can be easily assigned using Midas civil.
3. This research used Midas Civil show the deflection for various stiffness factors of bridges model.
4. Midas civil is a civil structural engineering fully integrated solution system.
5. Midas civil is the one step solution for the analysis and design of any model of structures and especially bridges.

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