Analysis Of A Precast Segmental Bridge With Rcc Bridge Using CSI Bridge Software

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Abstract- *Bridges are those structures which built to span physical obstructions without closing the way underneath such as a water body, valley, or roads the purpose is to provide passage over obstructions. Precast bridges with segmental structure are commonly used for long span, due to researchers increasing interest in bridge modeling by using various span condition to check deflection of segmental bridge and RCC bridge, segmental bridge shows better results in comparison to RCC bridge, which is economical for longer spans, as the span increases then the most important factor dead load also increases. On increasing the length of span, the requirements of cross girders (diaphragms) in RCC bridge will also increases as to get desired effectiveness between main girders. In this research the contribution of different factors on shear strength, deflection of segmental bridge and RCC bridge has been investigated.*

I. INTRODUCTION

The technology is advantageous over cable stay construction in terms of complexity and time. It is particularly suitable for bridge sites where base shuttering is not practicable and foundation is costly. Because of the various benefits afforded by the construction process and structural structure, concrete cantilever bridges built using the balanced cantilever method have become quite popular. Segmental, cast-in-place concrete cantilever bridges are now routinely used to build long span bridges. Because bridges are subjected to strong internal forces and stresses, prestressing is an essential component. Segmental construction is one of the most used techniques for prestressed concrete bridges. By using the cantilever construction approach, this strategy avoids false work and temporary supports, resulting in no obstruction to traffic or the waterway beneath the bridge.

Precast Bridge

Precast buildings are substantially built before they are deployed. A precast construction is made of pre-stressed concrete, and the final form of the structure is placed where it will be used. Precast concrete is made out of fine stone gravels, cement, water, and admixtures. In the factory's batch plant, the concrete mix design provided by the civil is employed to prepare the mixture. A dispensing mechanism with an overhead crane transports the permitted batch of concrete to the moulds.

Fig 1: Precast Segmental Bridge

Types of Bridges

- Balance Cantilever Bridges

Bridges of this type are constructed by horizontally projecting cantilevers (bridge beams)
Into space and supporting them at the dorsal end.

- Progressive Placement Bridges

Construction begins at one end of the bridges, and the constructed portion is erected ahead of schedule as the construction process continues. This style of structure is appropriate for environmentally sensitive areas.

- Span by Span Constructed Bridges

Another successful technique of constructing bridges is span-by-span erection, which is a very frequent and cost-effective method. Precast bridge segments are lifted one by one to the tops of the piers using this process. This approach is employed in the construction of lengthy bridges.

- Incrementally Launched Bridges

In civil engineering, incremental launch is a quick way of building bridges. The deck of the bridge is constructed entirely from one abutment in this method. Pre-stressed concrete is used in this procedure, which is highly mechanized.

Types of RCC Girder Bridge

- I-beam- I- beam is a commonly used girder for bridges, I-beam cross section composed of two load-bearing flanges separated by a stabilizing web. The top flange of I-beam resist compression stresses and bottom flange.

- T-beam - A T-beam is a load bearing structure of reinforced concrete, with a t-shaped cross section. The top of the t-shaped cross section serves as a flange or wide compression member in resisting compressive stresses.

Finite Element Modeling (FEM)

In structural mechanics, the finite element method (FEM) is the most widely used discretization methodology. The subdivision of the mathematical model into discrete (non-overlapping) components of simple geometry, known as finite elements or elements for short, is the fundamental concept in the physical interpretation of the FEM.

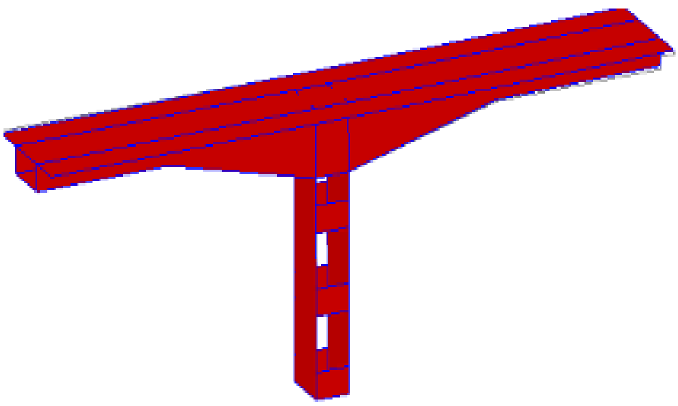

Fig 2: FEM analysis of Bridge

Seismic Analysis of Bridge

The seismic provisions are found in IRC - 6 (2000). In Seismic Zones II and III, bridges do not need to be designed for seismic forces if both of the following conditions are met: a) The span is less than 15 metres; b) The bridge's total length is less than 60 metres.

All other bridges must be built to withstand earthquake effects. The code defines response spectra analysis for bridges, although a linear or nonlinear time history analysis is used whenever an exact analysis is required.

Pushover Analysis

The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970‟s but the potential of the pushover analysis has been recognised for last 10-15 years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake.

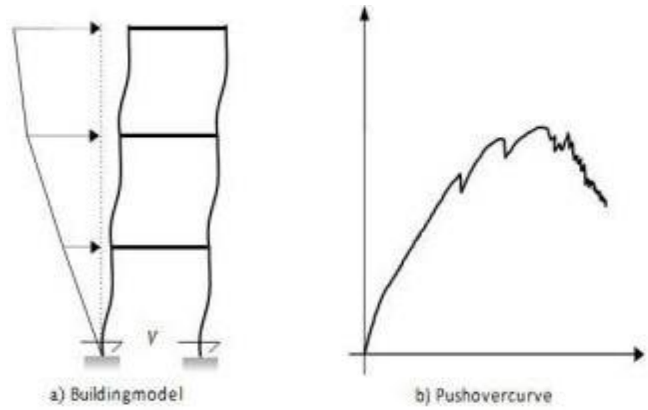

Fig 3: Pushover Analysis

II. LITERATURE REVIEW

Francesca Turchetti et.al (2023) in the research paper, risk-targeted design approach was developed for circular reinforced concrete bridge piers, based on a probabilistic optimization procedure aimed at minimizing the design resisting moment at the pier base. In particular, the proposed procedure addresses the design problem for RC piers in multi-span bridges. The only variables considered as free design parameters are the pier diameter and the longitudinal reinforcement ratio, which are the most important parameters that control the performance of a bridge pier designed according to capacity design principles. In order to reduce the computational effort, a meta model is built to describe the changes in the bridge dynamic behaviour and seismic fragility with these two design parameters. The optimal values of the design parameters are found as the solution of a simplified reliability-based optimization problem aimed at minimizing the pier resisting moment, without the need to resort to complex and time-consuming optimization strategies.

Conclusion stated that the design resisting moment at the base of the pier exhibits a significant inverse correlation with the target MAF of failure and can be used to define the objective (cost) function to be minimized, as its value also affects the design of the transverse reinforcement of the pier, the design of the foundations, as well as the forces transmitted to the superstructure. If both the pier diameter and the longitudinal reinforcement ratio are assumed as design parameters, non-smooth variations of the optimal values across adjacent sites could be obtained. This issue can be avoided by considering only a single design parameter and fixing the other. The site classification can influence the design results, especially in regions of high seismicity. Design maps should be built for different soil types to better estimate the effect of the site classification.

J. P´erez-Sala and A. Ruiz-Teran (2023) research paper proposed a new Finite Element model for Precast Concrete Segmental Bridge decks capable of reproducing the main characteristics of their behaviour at a reduced computational cost. The model accounts for the opening of the joints, the friction of external tendons at the deviators, and the combination of internal and external tendons. Moreover, the effect of the epoxy layer at the joints was analysed.

The model proposed has shown very good agreement with experimental results existing in the literature. After calibration, the influence of different modelling choices has been analysed. The results point out to a high impact of the modelling strategy adopted for the joints in the compression areas, requiring an adequate estimation of the point of contact between the segments. Additionally, consideration of friction of external tendons at the deviators showed limited relevance in the global behaviour of the model but was important for the correct estimation of stress increments in the tendons. The use of shell elements combined with the modelling strategy adopted for the joints offers better accuracy than existing models with a significantly lower computational time.

III. METHODOLOGY

Step 1 First step is to study different research papers from authors all across the globe to understand the research done in the same field and this gave our study base and scope for further research.

Step 2 this step includes defining the unit to design the model initialization where the units is measured as Metric SI. Steel code and concrete design code is locked as IS 800:2007 and IS 456:2000.

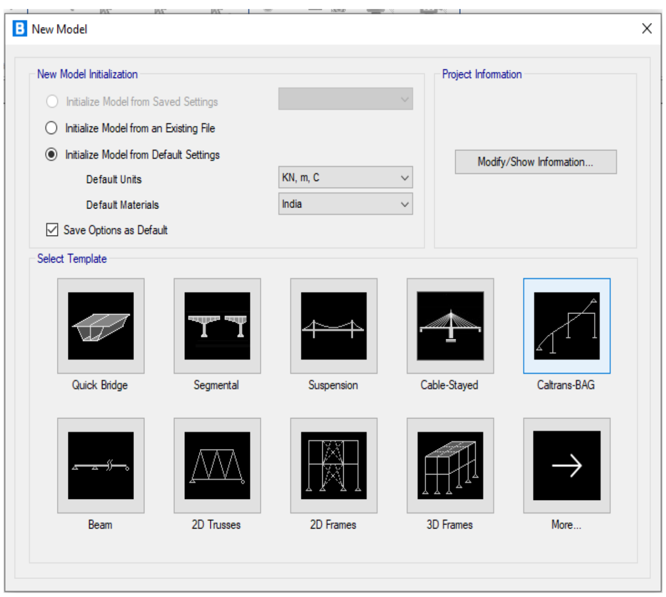

Fig 4: Initialization of Model

Step 3: Modelling of the section a working drawing

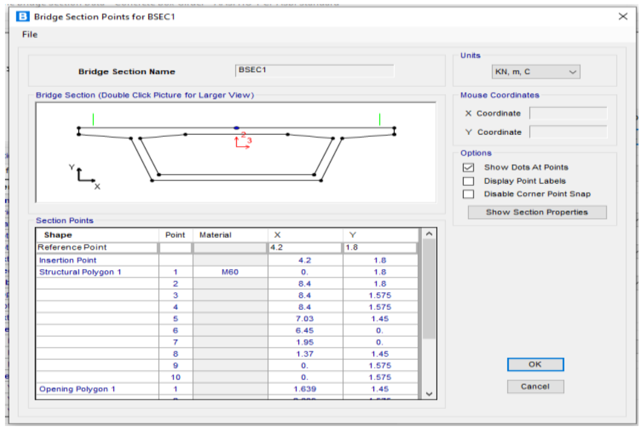

Fig 5: Modeling of Sectional Drawing

Step 4: Defining materials as per Indian Standards and assigning to the structural members

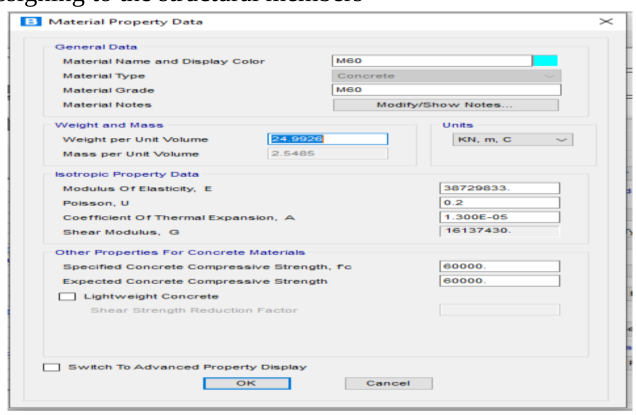

Fig 6 : Defining material

6: Assigning tendons to precast segmental beam.

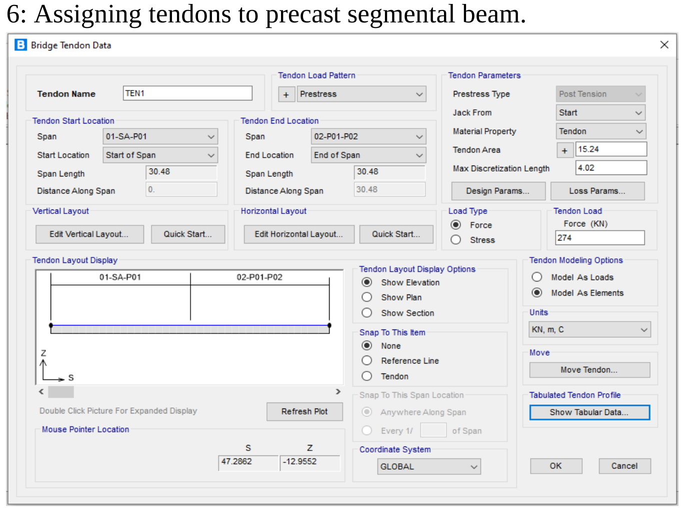

Fig 7: Defining and Assigning Bridge Tendons

step 7: Assigning Loading conditions to the model Precast Segmental beam with tendons.

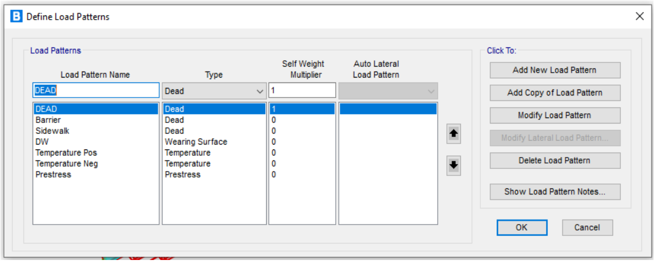

Fig 8: Defining Load Pattern

Step 8: Defining Vehicular Loading
Step 9: Defining Seismic loading as per IS 1893:2016 Part I
Step 10: Analyzing the stress on the structure.

Fig 9 Running Load Cases

Fig 10 Stress Analysis

IV. PROBLEM STATEMENT

Case Study
Case I:- RCC Bridge with post tensioning I Girder

Fig 11: RCC Bridge

Case II Segmental Bridge

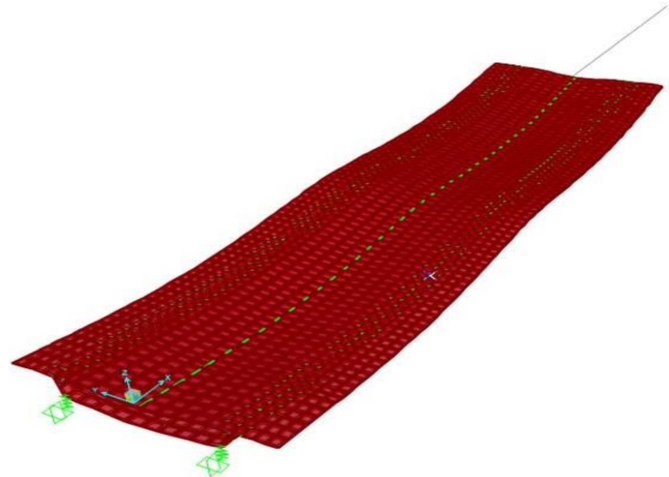

Fig 12: Segmental Bridge

Structural and Material Properties

Table 1: Geometrical Data

PARAMETERS	VALUE
Total Bridge length	300m
No.of Spans	10
No.of Girders	4
Length of each span	30m
Bridge width	12.5m
Bridge depth	2.4m
Diameter of circular column	2.0m
Height of the column	10m
Soil type	Type-1 (Hard & Rock Soil) Pile and combined footing
Design criteria	Modal analysis using Response spectrum method for performance push-over analysis is to be determined for the maximum deformed zone
Zone considering	V
Zone factor	0.36
Response reduction factor	5(RC girder bridge with seismic isolation factor)
Importance factor	1.2
Support conditions for column	Fixed

Table 2: Design Codes and Standards

Live load	IRC Class A
Regulation	IRC – 5,IRC – 6, IRC-18,IRC-112 & IRC-SP114
Seismic loading	IS:1893-2016, IS:1893(Part -3)
Serviceability conditions	IS 1984 & IS 2007
Wind load	IS 875 Part(III)
Vehicle Loading	IRC-6
Geometry	IRC -112
Permissible Stress	IRC -18

Material Properties

Table 4.3: Properties of Material

Properties of Material		
S.no	Description	Value
1	Sections	Standard
2	Young's modulus of steel, Es	2.17x10 N/mm2
3	Poisson ratio	0.17
4	Tensile Strength, Ultimate Seel	505MPa
5	Tensile Strength, Yield Strength	215 MPa
6	Elongation at Break Steel	70%

Table 4: Section Properties

Column size	10 x 2 m
Concrete slab thickness	0.225m
Abutment	4.2 x 1.5m

Loading Condition

Dead Load

The dead weight of the structure is the total weight of the components in a bridge. It included the weight of the superstructure plus the weight of the substructure components. The dead load can be calculated by the material properties enables in a structure.

Live Load

Indian Road Congress IRC: 6-2017 code is referred for the moving load analysis of these cable stayed bridge models. Two lanes for IRC Class A vehicle load is considered with impact factor of 8.8%. This condition of load is assigned as live load on both lanes of bridge models.

Seismic Load

As per code IRC: 6 -2000, all bridges are to be designed for seismic zone 3 and above. The seismic force in both x and y direction is applied with a minimum of 5% damping for any concrete structures. The soil type is considered as type II which is a gravely medium hard soil. And the importance factor is taken as 1.5. For the dynamic analysis of the cable stayed bridge a response spectrum function is defined as per IS: 1893- 2002. The response spectrum function is defined for a minimum of 5% damping for cement concrete structure.

Impact Effect

The live loads on the bridge generally have higher affects than that if they would have been in stationary position. The action that they apply on the bridge structure is generally dynamic in nature and is taken into the account by the static methods therefore on allowance for the impact is required.

V. RESULTS AND DISCUSSION

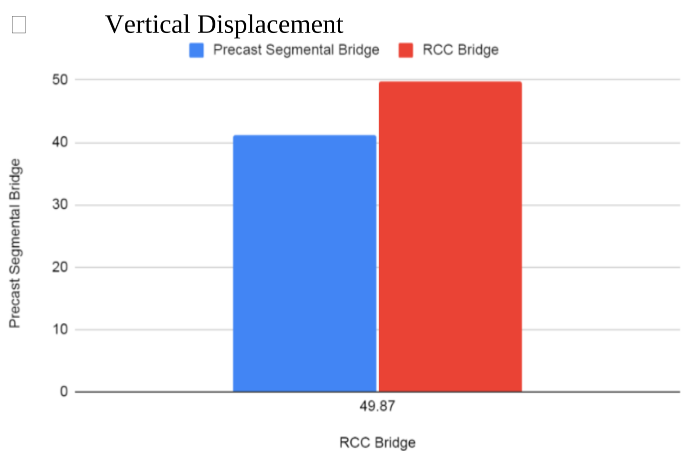

Fig 13 : Vertical Displacement in mm

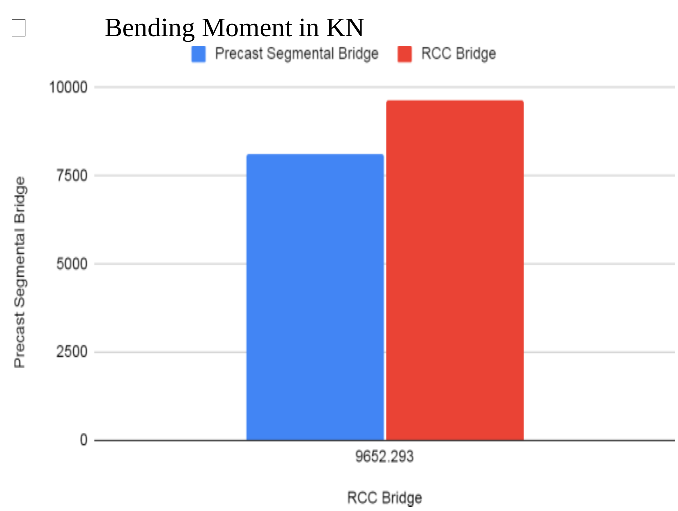

Fig 14: Bending Moment in KN

- Shear Force in KN

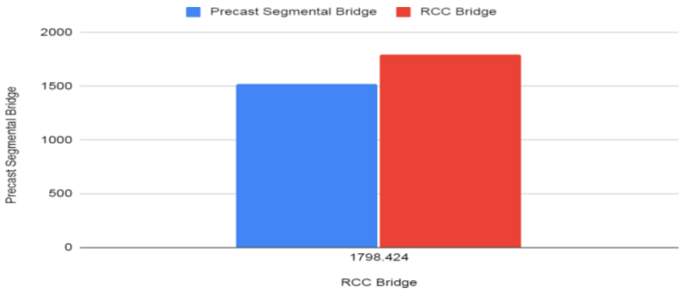

Fig 15: Shear Force in KN

- Axial Force

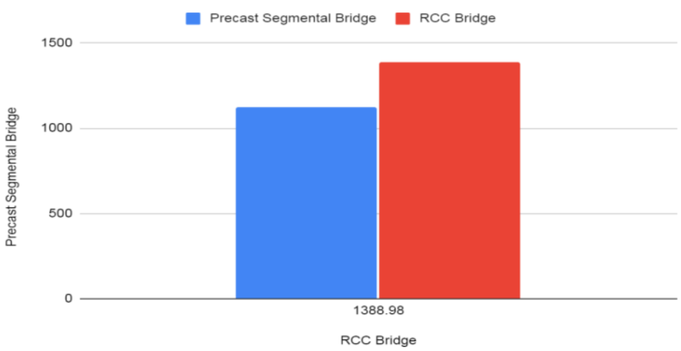

Fig 16: Axial Force in KN

- Cost Analysis

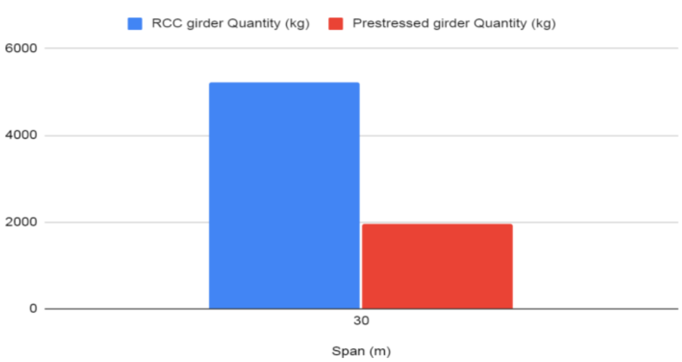

Fig 17: Cost of Quantity of Steel

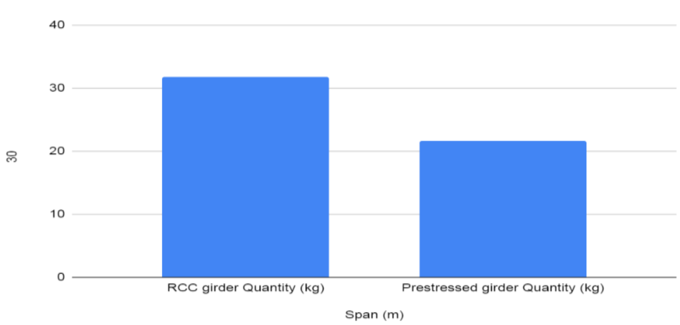

Fig 18: Quantity of Concrete

VI. CONCLUSION AND FUTURE SCOPE

- The displacement was well contained by 5.6% in precast segmental bridge when compared to RCC bridge.
- The maximum bending moment will occur at the point where the bending moment is greatest. Bending moment was higher in RCC bridge by 9.1% in comparison to Precast Segmental bridge.
- Shear force was 13.121% higher in RCC Bridge when compared to Precast Segmental bridge.
- Axial force was found to be 9.98% on higher side for RCC bridge when compared to Precast Segmental Bridge.
- Precast segmental girder requires lesser dimensions with respect to RCC girder of same loading conditions. Precast segmental girders are economical than RCC girders for higher spans. In case of the design of precast girders, for 30 m span the quantity of concrete can be saved up to 46.52% while that of steel up to 167.67%.

FUTURE SCOPE

- In this study we are comparing segmental and RCC bridge whereas in future we can select different type of bridges
- Analysis should be conducted using different analytical applications.
- The segmental precast bridge model, described in this report, should be was constructed and tested on the dual shake tables of SEESL
- In this study we are utilizing IRC loading whereas in future AASHTO specification can be use.

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