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# Bridge Design and Analysis using BIM Software

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***Abstract: In the Bridge project, design and analysis include two main components: preliminary design and detailed design, to integrate Building Information Modeling (BIM) in the design process of the Bridge. Firstly 3D modelling of the Bridge needs to be carried out, that means. It has transferred 2D drawing into 3D models. The BIM mainly focuses on modelling analysis, detection and feedback and design.***
***Cantilever bridge construction is a step-by-step construction of a cantilever in segments and stitching them to segments previously casted by prestressing. When the cantilever segments are added to both sides of the pier, the bending moment in Bridge is negative & increases with the addition of each segment. While key blocks are added, the Bridge is converted from cantilever form to continuous form & the negative bending moment on the pier decreases.***
***In this project, a bridge model of span 130 m has been designed and analysed in midas civil to observe the rate of change of Bending moment, reactions and deflections at different stages of construction in construction sequence and Service conditions.***
***Keywords: Bridge Design, Segmental Bridge, BIM, Midas Civil, Bridge Model***

## I. INTRODUCTION

### *A. BIM in Bridge Engineering*

The infrastructure industry is embracing digitalization to keep up with future innovations and become more productive under the growing pressure of increasing costs, tight deadlines and sustainability issues. Building Information Modeling (BIM) has become a widely used tool for engineers and construction companies to improve the level of design and construction information, reach higher levels of collaboration and streamline project delivery all the way to facility management. Now, its sibling known as BrIM (Bridge Information Modeling) is paving the way for the practice to establish itself in bridge building.
Although BIM can be utilized in various types of building projects, its use in bridge construction has been limited. Instead of vertical architecture, bridges are horizontal travelways, and the projects are by default heavy construction assignments. Like a version of BIM customized to suit bridge projects, BrIM provides a complete representation of the physical and functional characteristics of a bridge asset, offering an information resource for its entire lifecycle.
Bridge Information Modeling (BrIM) boosts the quality of design with accurate information, consistent documentation, and improved constructability of structures. BrIM allows for accurate pre-fabrication and just-in-time material deliveries, and supports project collaboration across disciplines. Ultimately resulting in optimized solutions for all project parties as well as storing information for preventive maintenance.

### *B. Segmental Bridge Construction*

In contrast to classical monolithic structures, a segmental bridge consists of “small” pieces stressed together by using external tendons. Balanced cantilever bridges are adopted for comparatively longer spans where simply supported, continuous or rigid frame type superstructures are found unsuitable. Stability of the end cantilever is maintained by using temporary pier supports. This construction method consists of erecting the majority of a bridge deck without false work or scaffolding at ground level, by working in consecutive sections known as segments, each of which is cantilevered out from the preceding segment. After a segment is built, the prestressing tendons fixed to the extremities are tensioned, firmly attaching them to the preceding segments and thus forming a self-supporting cantilever which serves as a support for the subsequent operations. Construction Program.

## II. METHDOLOGY

### *A. Upper Slab*

In a simple box girder, the webs are often situated at a quarter of the width of the box girder (C ≈ B / 4). Its thickness at mid-span e4 is equal to D/25 or D/30, or even D/35 for very wide transversally prestressed box girders, with a minimum of 20 cm.

### B. *Thickness Of Web*

The total thickness Ea of the two webs can be estimated at Ea = L/275 + l.25 x B/L – 0.125: a relation in which L is the main span and B is the width of the upper slab.

### C. *Thickness Of Lower Slab*

In the central section of the spans, the lower slab must be as thin as possible (18 to 22 cm) in order to limit the self-weight of the box girder.

The thickness of the lower slab on the pier Ep is determined by the limitation of compression in the bottom fiber when the bridge is in service. This value, which is largely dependent on the span and widths of the slabs, varies between 35 and 80 cm or even more.

Then Assumed a Cross Section and Elevation of Bridge for design and analysis as shown in Fig 1, Fig 2

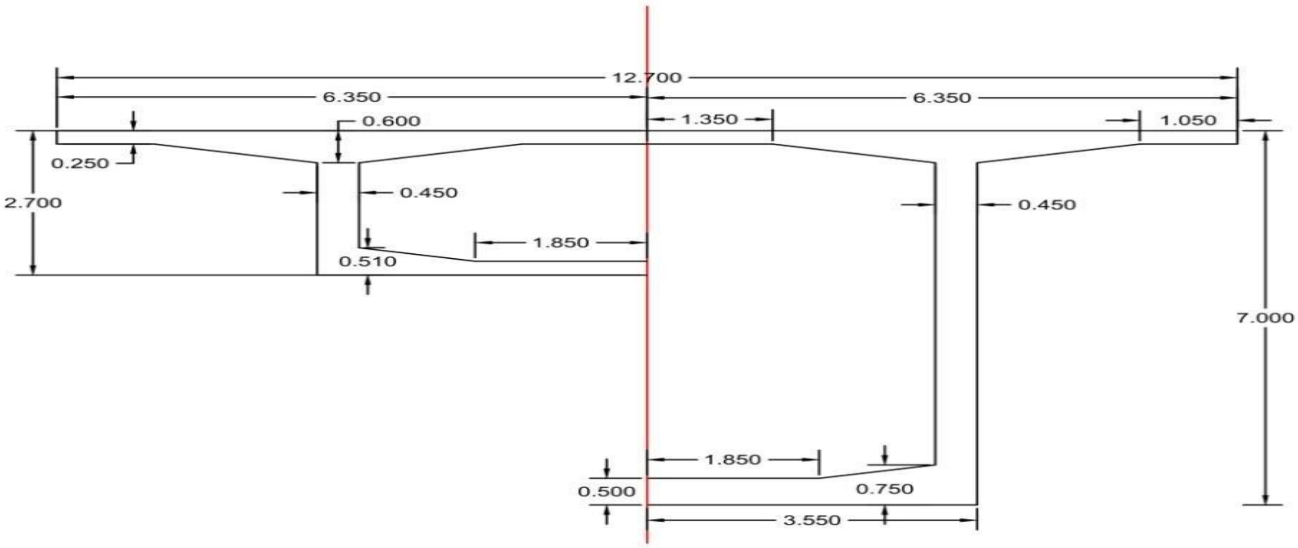


Fig. 1. Cross Section of Bridge

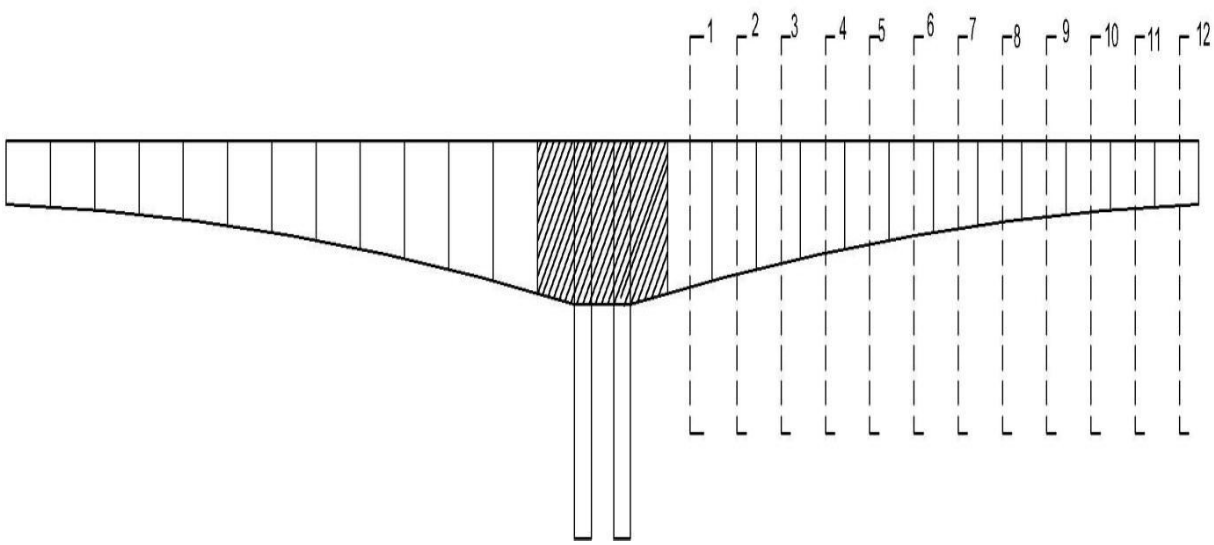


Fig. 2. Elevation of Bridge

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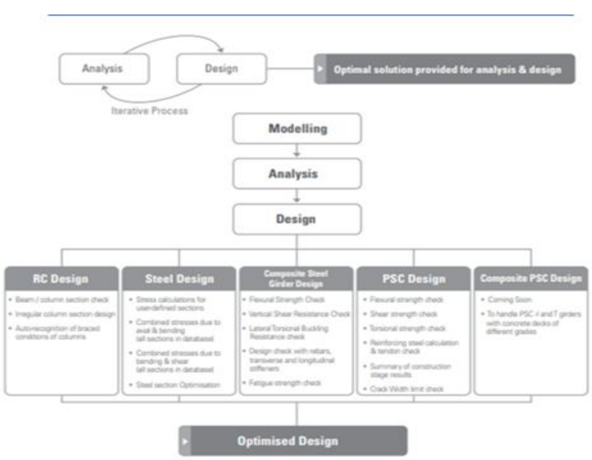
1) *Analysis and Design in MIDAS CIVIL 2018:* The segmental bridge is modelled using the MIDAS Civil-2018 where the structure is modelled using free cantilever method known as balanced cantilever segmental method. During modelling, the bridge is divided into the segments from Construction Stage 1 to Construction Stage 13, with a construction period of 14 days for the 12 segments of length 4.75 m each out of which first 7 days is assigned for installation of formwork, reinforcement bars, ducts etc and next 7 days for pouring of concrete and post tensioning of tendons, curing and 30 days is assigned for the construction of end segments and key segments each, At each construction stage the elements are activated. In segmental bridge construction process the construction is started from both the piers simultaneously with the help of Form Traveller (Gantry) hence time dependent effects are important to be considered in construction stage analysis. The weight of the form traveller applied is 700kN, which includes the formwork and its support devices is internally converted into a vertical force and a moment, which is then applied at the end of the cantilever segment.The loads applied on the bridge structure are generally on higher side than the vehicle loads for which it is designed, hence in construction stage highest deflection occurs during the construction, the two cantilevers undergo different creep, shrinkage and tendon losses, resulting in different stresses and deflections at the time of erecting the Key Segment, such differences need to be reflected in preparing the construction stages for analysis.

Layout of Bridge Model

Table 1. Data used for Analysis and Design of Bridge in Midas Civil

| | | |
|---|---|---|
| 1 | Pier Section | 2 no's RCC pier 1.8m x8.1 m at 4.2 m c/c |
| 2 | Grade of Concrete Used | M-40 for Pier and M-50 Superstructure |
| 3 | Pier Table | 14m wide at top and 6 m wide at bottom, height of 30 m from the ground level |
| 4 | Superstructure | 12 segments of 4.75 m length each, key segments of 2m length |
| 5 | Form Traveller | Weight of gantry is taken as 700 kN |
| 6 | Creep/Shrinkage | Start of loading at 10 days and end at 10000 days (As per IRC:112-2011 ) |

Design Process for Bridge



*2) Loads and Load Cases*

In the analyses of a bridge, the following load cases are to be considered

*a) Dead Load:* The weight of each and every element is considered, it is calculated directly from the software for the model input.

*b) Additional Loads:* Weight of the wearing coat, temperature loads , Crash Barrier load is added as additional loads .

*c) Gantry Load:* Form traveller load is considered as the Gantry Load. This load is implemented on preceding one before the construction of one segment and slide to next one after construction of the segment ,this load is considered as 700 KN. After the completion of construction of the bridge, the gantry load is removed.

*d) Pre Stress:* Post-tension cables are arranged according to the load characteristics. Post tension loads are considered as strain.

*e) Time Dependent Loads:* Creep, Shrinkage and Compressive strength gain characteristics is evaluated at each stage of construction and age of concrete, which corresponds to the Modulus of Elasticity at the specified period of construction.

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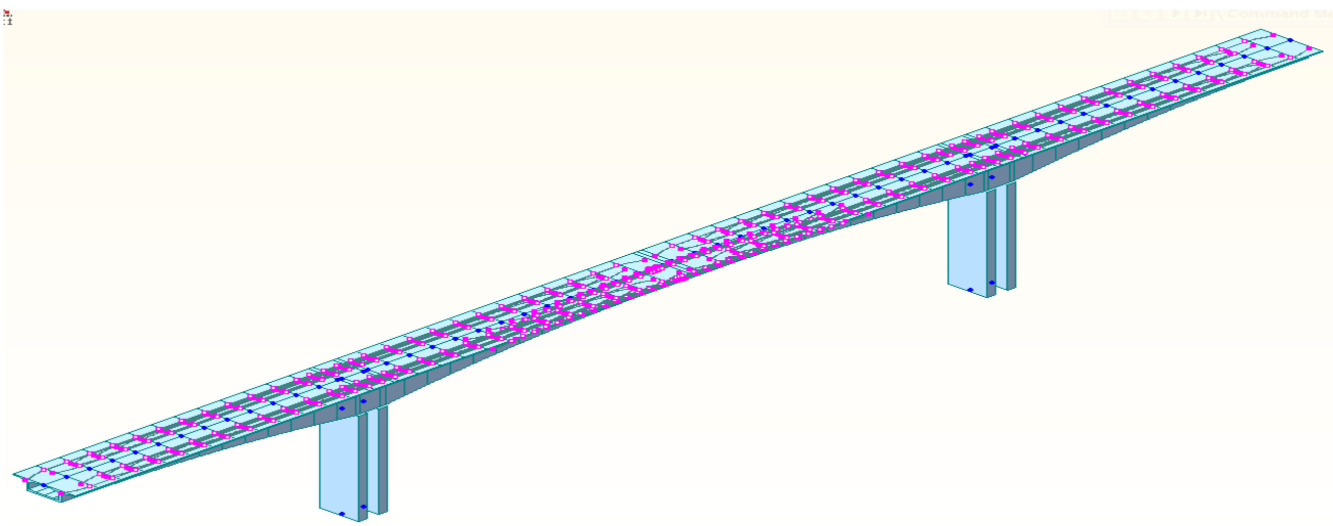
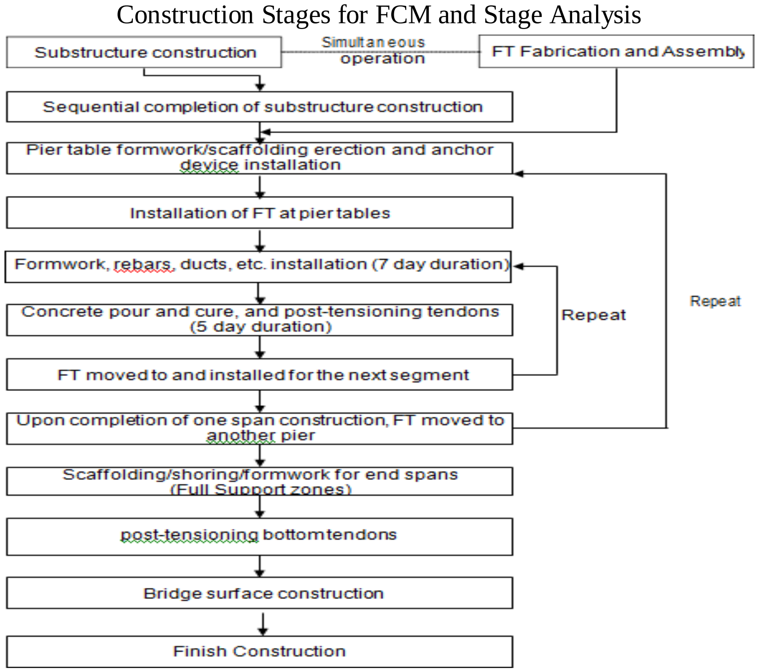
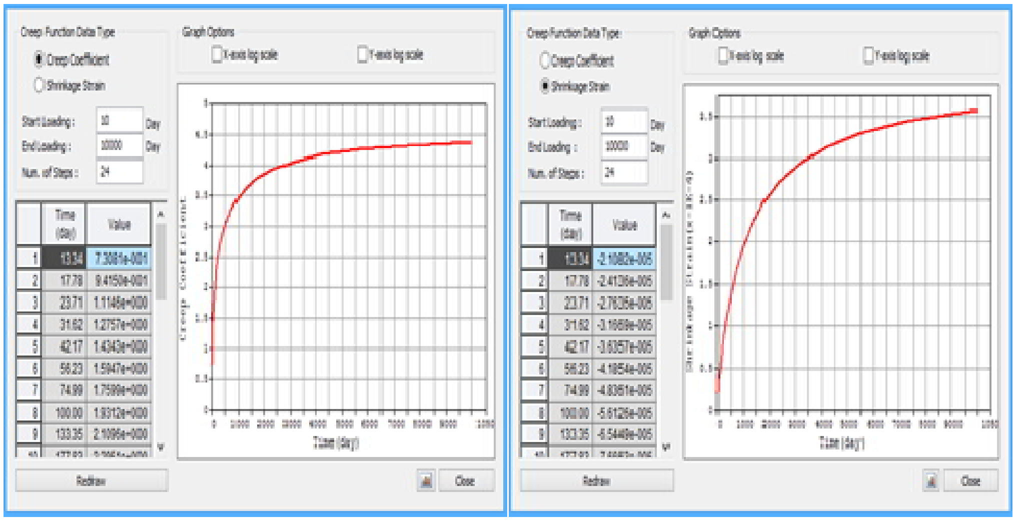
Tendon Profile View



Construction Stages for FCM and Stage Analysis

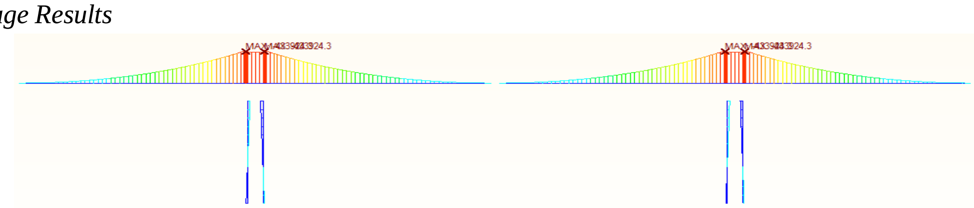


Defination of Creep and Shrinkage

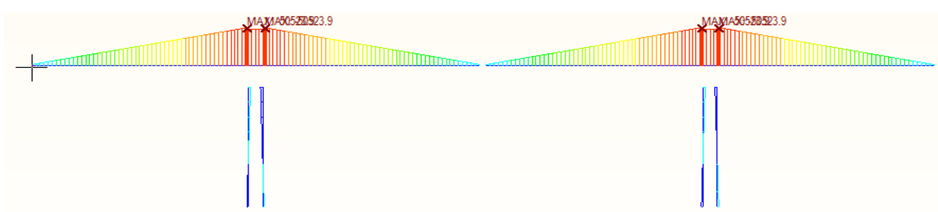


## III. RESULTS OF ANALYSIS

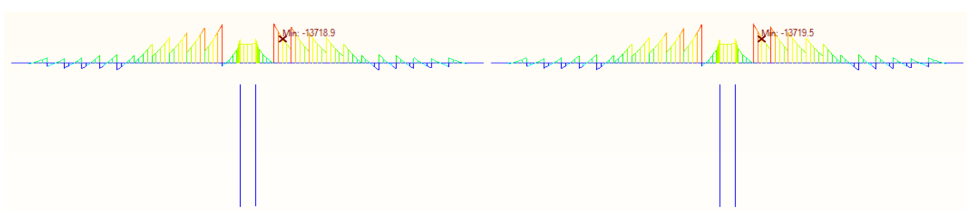
### *A. Construction Stage Results*



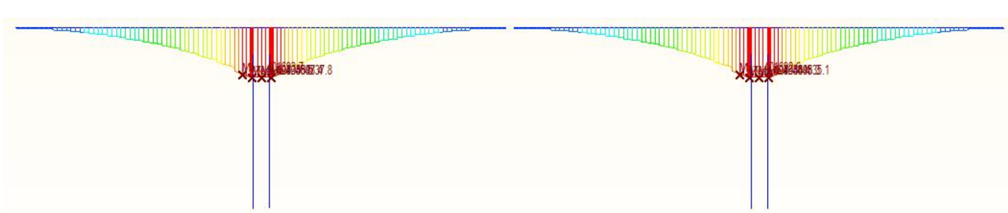
Max Moment Occured at Section 1 near the Pier due to Dead Load is : -433924.3 KN-M



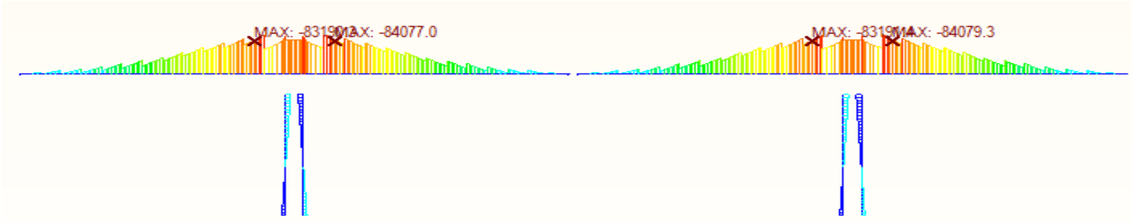
Max. Moment Occured at Section 1 near the Pier due to Gantry Load is : -50523.9 KN-M



Max. Moment Occured at Section 1 near the Pier due to Creep of Concrete is : -13718 KN-M



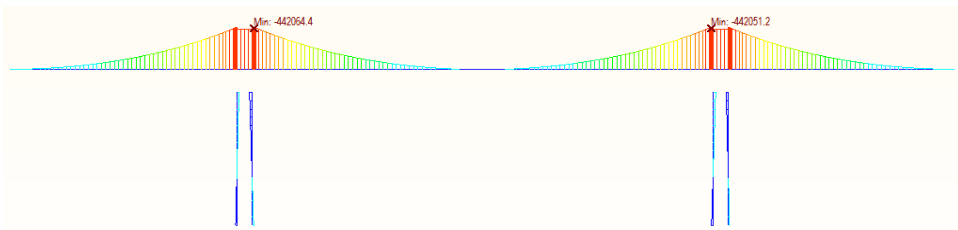
Max. Moment Occured at Section 1 near the Pier due to Prestressing is : 404837.5KN-M



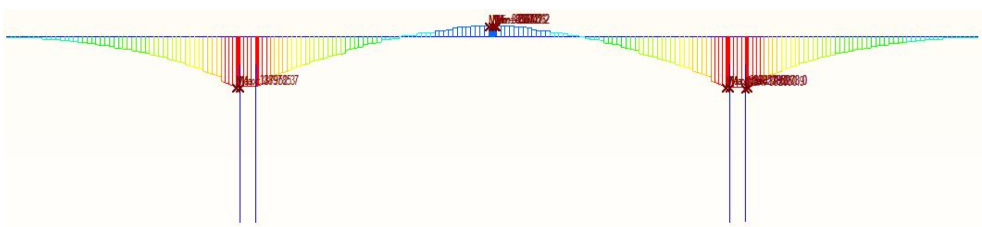

Construction Stage Summation Moment (-84077 KN-M )

In the final stage of Construction Stage, The Maximum Summation Moment ( moment due to dead load + Erection Load + Prestressing Load + Creep ) occurred at the section near the pier at construction stage 13 is -84077.2 KN-M.

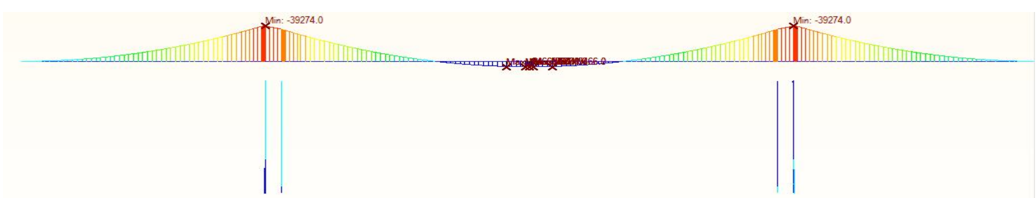
*B. Service Stage Results*



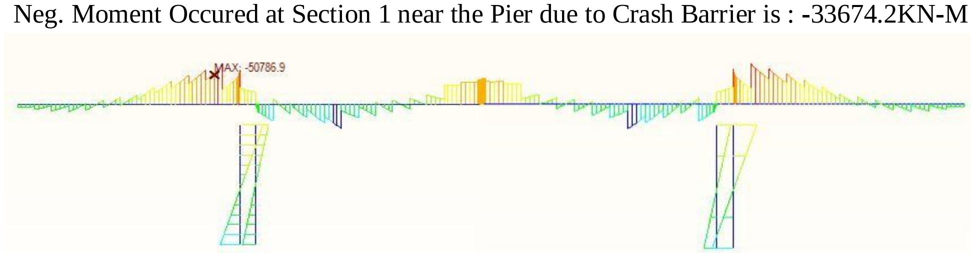

Max. Moment Occured at Section 1 near the Pier due to Dead Load is : -442064.4KN-M



Max. Moment Occured at Section 1 near the Pier due to Prestressing is : 389785.7KN-M




Neg. Moment Occured at Section 1 near the Pier due to Crash Barrier is : -33674.2KN-M




While in Service Stage, after the addition of key block the cantilever bridge turns in to continuous bridge and the moments will decrease when compared with construction stage moments.

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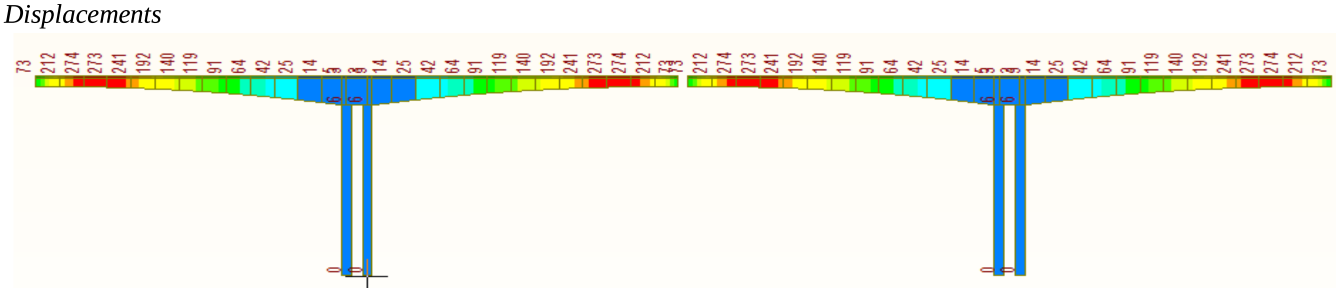
In Service Stage, The Maximum Summation Moment is -50786.9 KN-M

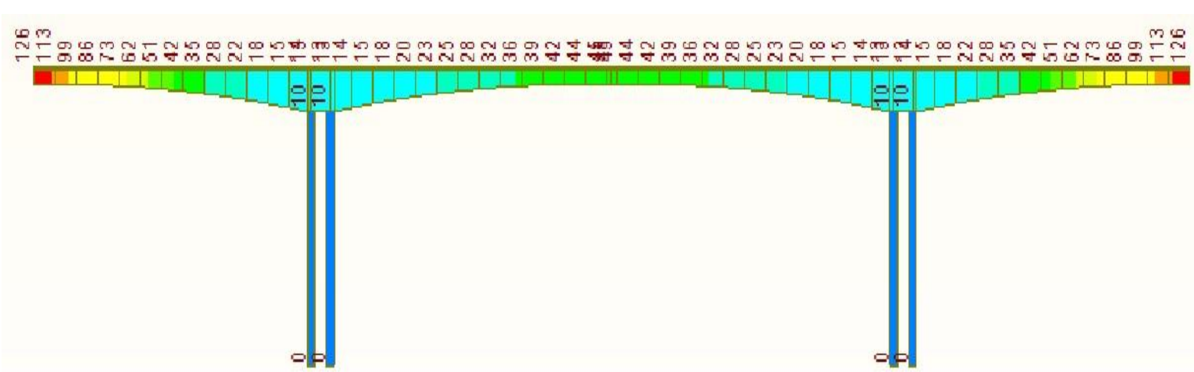
Reaction Forces

| CONSTRUCTION STAGE | REACTIONS |
|---|---|
| CS STAGE-1 | 34577 KN |
| CS STAGE-2 | 37809 KN |
| CS STAGE-3 | 40801.14 KN |
| CS STAGE-4 | 43576.6 KN |
| CS STAGE-5 | 46157.2 KN |
| CS STAGE-6 | 48571.2 KN |
| CS STAGE-7 | 50843 KN |
| CS STAGE-1 | 34577 KN |
| CS STAGE-2 | 37809 KN |
| CS STAGE-3 | 40801.14 KN |
| CS STAGE-4 | 43576.6 KN |
| CS STAGE-5 | 46157.2 KN |
| CS STAGE-6 | 48571.2 KN |
| CS STAGE-7 | 50843 KN |
| CS STAGE-8 | 52992.2 KN |
| CS STAGE-9 | 55045.2 KN |
| CS STAGE-10 | 57026 KN |
| CS STAGE-11 | 58958.6 KN |
| CS STAGE-12 | 60867 KN |
| CS STAGE-13 | 62789.6 KN |
| AT SERVICE STAGE | 74184.6 KN |

### *C. Displacements*



In the last stage of construction stage, the maximum displacement observed is 274 mm



In the service stage , the maximum displacement observed is 49 mm when both Class A + 70 R vehicle is loaded.

## IV. CONCLUSIONS

1) By Designing and Analysis by Midas Civil that the maximum negative Moment developed in construction stage of free cantilever is decreased from -84077.2 KN-M to -50786.9 KN-M on addition of key segment at the centre of the span.
2) That is approximately 40% of the moment is decreased when the bridge falls under service condition.
3) The Reaction force offered by support on each and every stage is tabulated.
4) Deflection due to dead load at construction stage 13 is observed as 274 mm.
5) When the key block is added and by applying bottom prestressing the deflection is decreased and at maximum loading ( Class A + 70R) is observed as 49 mm.
6) BIM can be used from design stage to end of the utility period of the structure and significantly reduces the risk related to time and cost overrun.

## V. ACKNOWLEDGMENT

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