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Segmental analysis and design of superstructure for box girder balanced cantilever bridge by IRC specification using MIDAS civil

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ABSTRACT

A bridge is a combination of substructure and superstructure that is built over a river, road, or railway to allow people and vehicles to cross from one side to the other. This paper describes about the analysis and design of box girder balanced cantilever bridge using MIDAS CIVIL by IRC loadings, characterized by central span of 130m with two symmetrical sides of 85m. Bridge deck is supported by two piers of 40m height from ground level. The bridge structure has been modeled using MIDAS CIVIL and analysis has been performed to get various output such as bending moment, shear force and time dependent properties such as creep and shrinkage at various points of the bridge. The PSC (prestressed) design of superstructure is performed as per IRC standards to get the output parameters such as principle stresses at construction stage, principle stress for prestressing tendon. While by using balanced cantilever bridge. Less form work has been required for this type of bridge.

Keywords: Balanced cantilever, Construction Stage, Prestressed concrete (PSC), Box girder and MIDAS Civil.

INTRODUCTION

The use of cantilever box Girder Bridge has been increased nowadays in India. The cantilever methods have the two different basics one is single cantilever method and the other one is double cantilever method. And hence double cantilever method is also known as balanced cantilever method. This method is mostly recommended in the places, where the scaffolding is not possible, places like deep valley, Long River, etc. Bridge construction commences from pier section and proceed in a balanced manner to mid-span. [1] MIDAS CIVIL is state of the art engineering software that set a new standard for the design of the bridge and civil structures. It features a user friendly interface and ideal design solution functions that can account for construction stages and time dependent properties. It's highly developed modeling and analysis functions enable engineers to overcome common challenges and inefficiency of finite element analysis .By

using Midas Civil it generates comprehensive traffic loads to AASTRO, LFRD, CSA-S6-00, IRC through influence line and surfaces. Cantilever design must require one bearing at each pier, but in the simply supported its need two bearings. By this width of the pier can be smaller. [2] Bridge deck had supported by two piers which develop friction in static conditions to withstand static forces and small displacement. [3] Reaction parameter offered by the pier has to be considered. [4-5] Important advantages of the method being economical to carry out the construction of bridge without disturbing traffic. [6] Low height of the bridge will supported on its foundation in order to avoid intervention / modification to the pier. [7] For the concrete bridge the time dependent properties are the factors which cause variation in stresses throughout the life period of the bridge. [8] When the depth of the box girder decreases, prestressing force also decrease and number of cables also decrease. By prestressing, high strength of

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concrete is utilized and also governs serviceability [1].

Structural Data

Span: 300m

Width of deck: 12.7m

Width of carriage way: 9.2m wide

No of lanes: 2No's

Type of super structure : Box Girder

Footpath details : 1.75m wide

on each side

Concrete Grade for Superstructure : M50

Steel Grade : Fe 500

Load Consideration

- Dead load of structural elements such as deck slab, box girder.
- Moving load due to IRC Class A Vehicle, IRC Class 70R Vvehicle.
- Forces due to Temp Rise/ Fall and gradient.
- Forced due to creep and shrinkage of concrete [2].

Model and construction stage

Plan and the construction stage of the balanced cantilever bridge has been shown below.

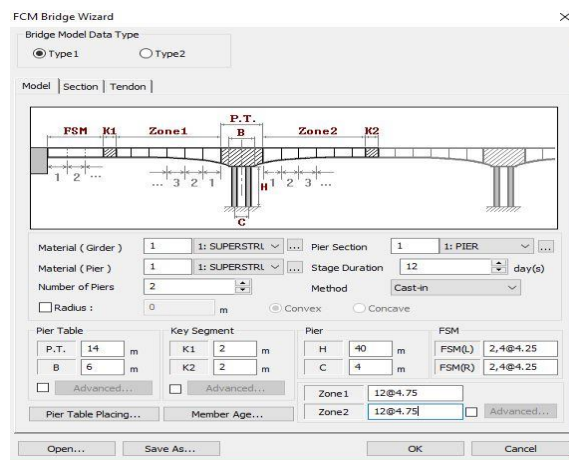


Fig.1: Basic parameter for FCM Wizard in MIDAS CIVIL

- Basic parameters in the structural data for the FCM (Balanced Cantilever Bridge) has been calculated as per data available for the construction of bridge in the specified area.
- Substructure and pier section data has been identified as per Indian standard.

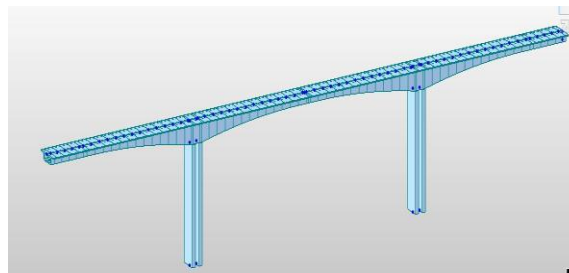


Fig.2: 3D Model view of FCM bridge

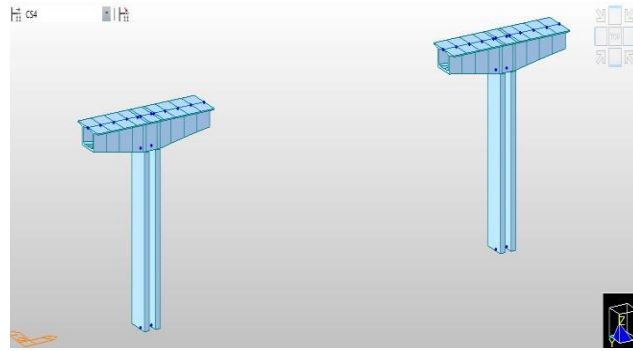


Fig.3: Segmental construction stage (CS4) of FCM

- Segmental Construction stage (CS) has been starts from stage 1(CS1) to stage 16(CS16). In the CS1 work starts from the pier section and in the CS16 it will end in the mid span of the bridge
- Construction stage work has been carried out simultaneously from the two pier sections.
- Precast segment and cast-in-situ construction techniques has been executed in his type of bridge [3].

Time Dependent property for concrete Compressive strength

The mean compressive strength of concrete at the age of 28 days for IRC 112 – 2011 has been calculated by using the below formula

$$(F_{ck} + \Delta f)$$

F_{ck} is the grade of the concrete used and delta_f is mean percent of concrete

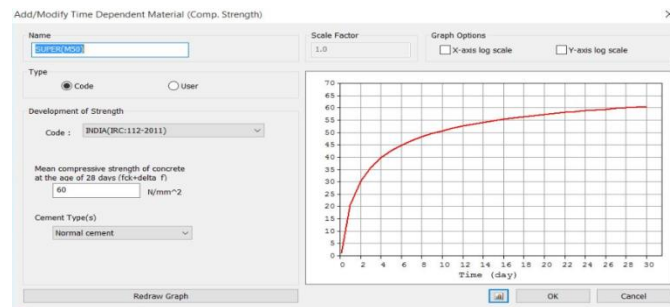


Fig.4: Time Dependent (Comp. Strength)

Creep/Shrinkage of concrete

Notional size of the member has been calculated using the formula as per IRC 112 – 2011 is

$$h = 2 * A_c / u$$

A_c = Section Area, u = Perimeter in contact with atmosphere

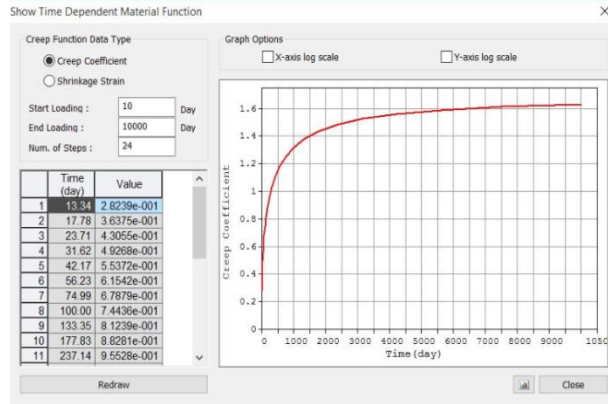


Fig.5: Creep Coefficient of concrete

Loading Parameter

Temperature Rise/Fall

Temperature Rise/Fall has been considered in the bridge design to calculate the stability of the structure in the different climatic conditions.

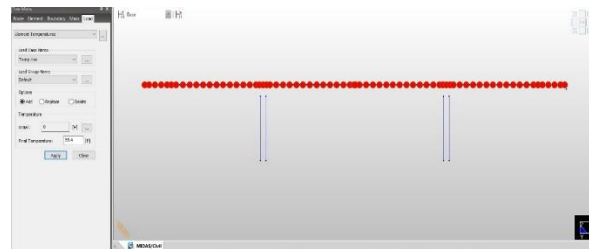


Fig.6: Temp rise in the FCM bridge

- Higher temperature has been considered will doing bridge design. In the MIDAS CIVIL temperature has been considered in F^0 .

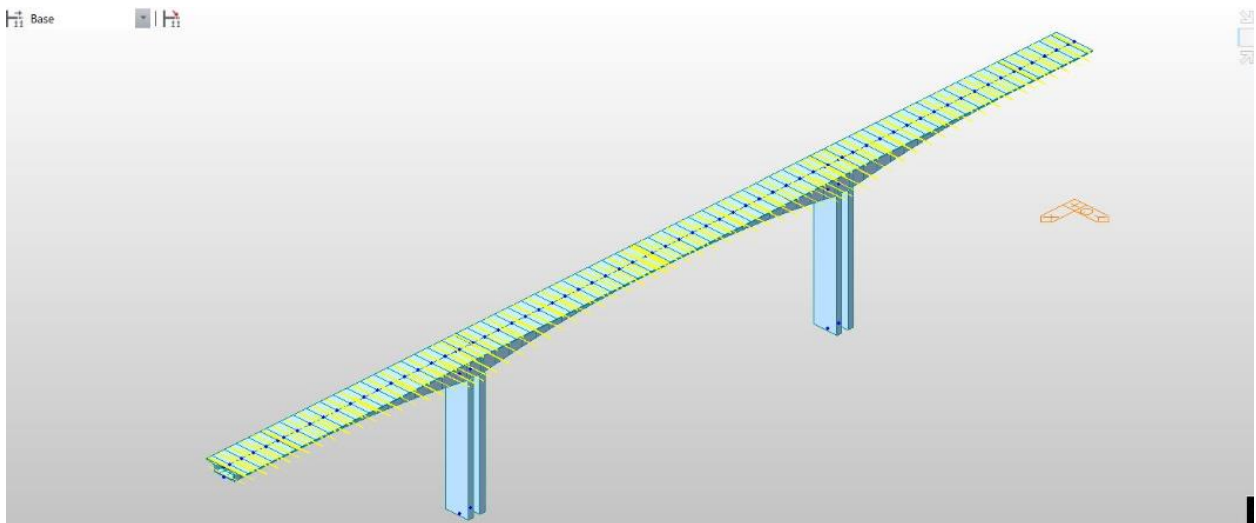


Fig.7 Temperature Gradient

Self-Weight of the concrete (Dead load)

Self-weight of the concrete has been act in the bridge deck of the FCM bridge.

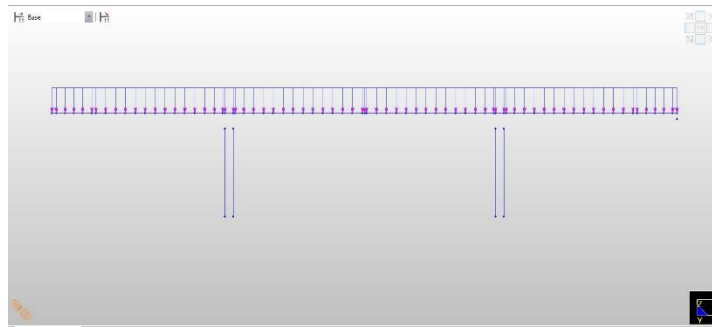


Fig.8 Self weight in the bridge deck

Prestressing Tendon

Tendon prestressing has been implemented by adding the tendon property

(19T15). Tendon property has been assigned using IRC 112 – 2011.

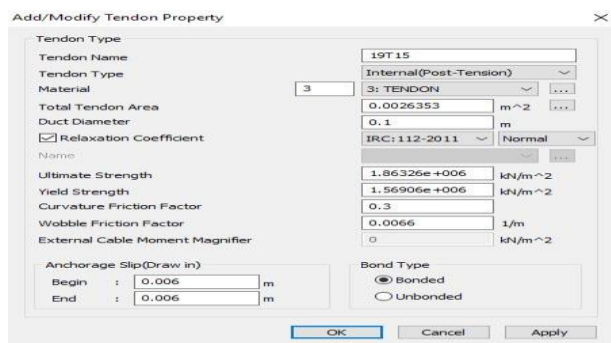


Fig.8 : Tendon property

Deformation in the bridge

Deformation in the bridge structure has been identified after applying the moving load and

the dead load. Diagrammatic representation of deformation has been given below,

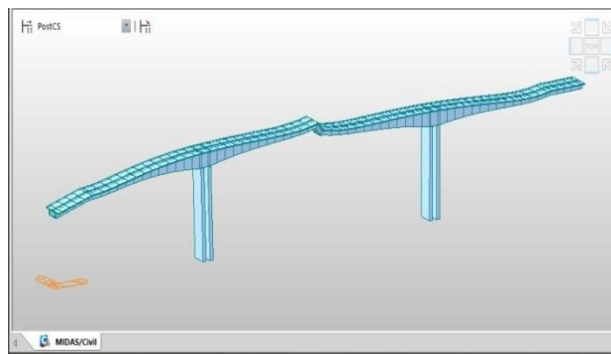


Fig.9: Deformation representation of full bridge section

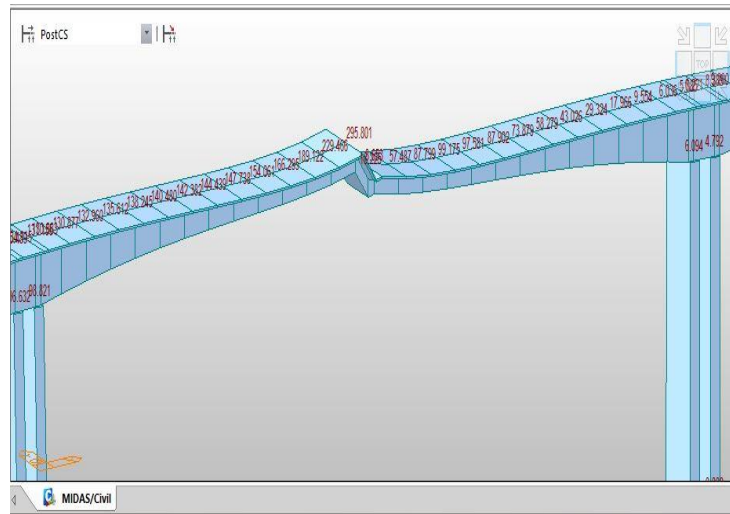


Fig.10: Representation of deformation values

By the above diagram the deformation values at the critical section has been given. Nominal deformation has been 229mm and the critical deformation value is 295mm. In the MIDAS CIVIL deformation has been shown as very critical. But in the nature deformation has been very less. We can identify that by deformation values which shown in the fig.10. [4-7].

Moving load cases

Moving load for the box girder bridge is IRC 6-2014. In the code , we refer that the carriage way is below 9.6m means we can use two way lanes. In the moving load we added CLASS A1, CLASS A2 load and CLASS 70R load [8].

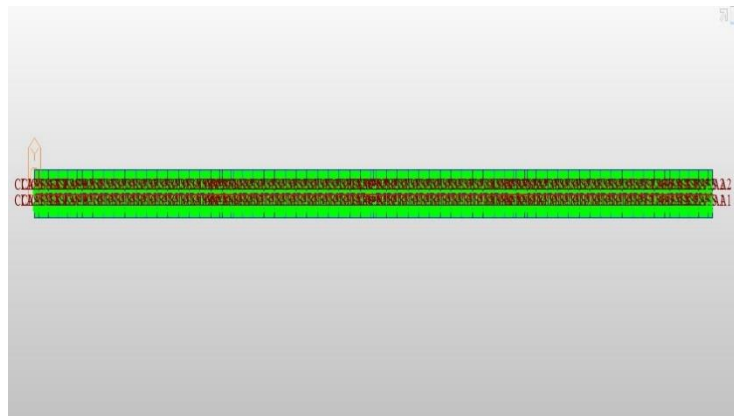


Fig.11: Implementation of Moving Load Cases in Deck Section

Analysis and Design of bridge structure (Results)

Analysis and Design of balanced cantilever bridge has been carried out using the IRC Specificatins. Modelling and Anlysis has been carried out to identify the Bending moment and the

shear force due to dead load ,live load, temperature rise and fall, creep and shrinkage in the beam section. By the use of the MIDAS CIVIL we can get the Beam Detail Analysis of the deck section. BMD due to dead load and Beam Detail Analysis has been represented below [9].

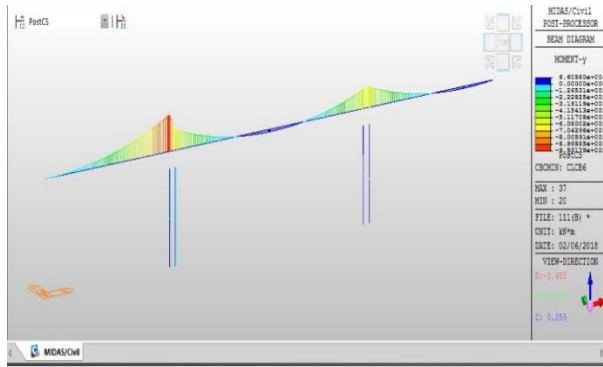


Fig.12: BMD due to Dead load

Maximum bending moment which act on the bridge section is 37 KN/m² and the minimum bending moment is 20 KN/m². Blue colour which

represents higher deflection and the red colour represents the minimum deflection.

- Check for the Shear force are also calculated in the bridge section.

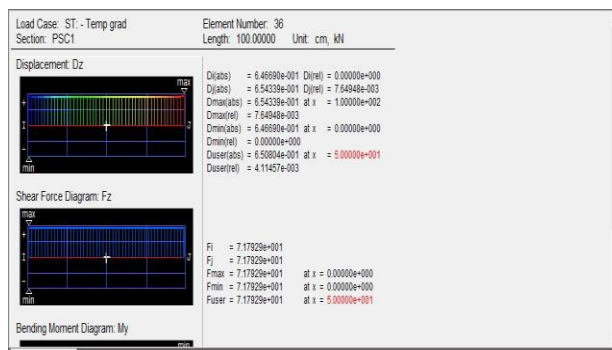


Fig.13: Beam details for the element 36 (Displacement and Shear force)

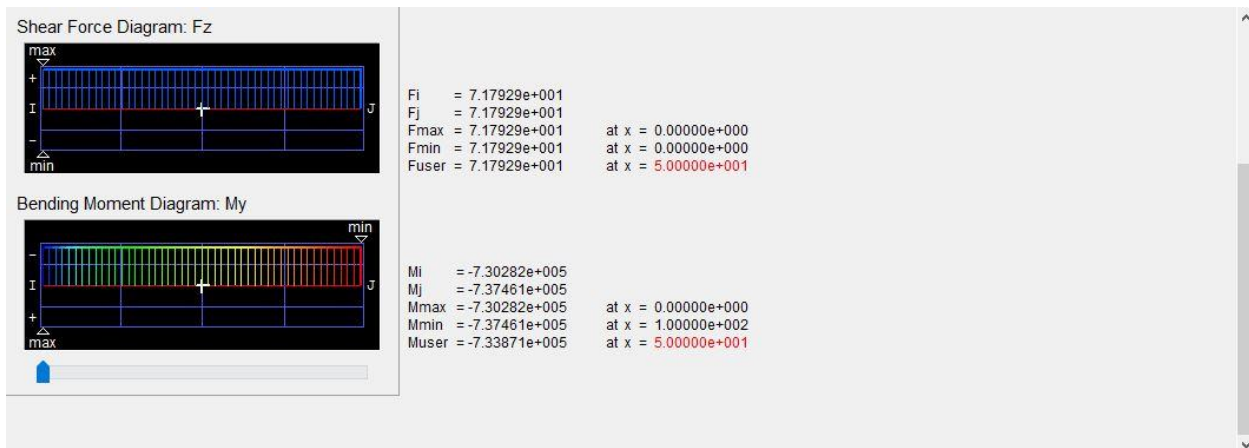


Fig.14: Beam details for the element 36 (Bending moment)

Design

Design of PSC and pier section has been carried out using the design code of IRC 112-

2011. For an PSC section the reinforcement has been added, for that cover has given as 50mm. main bar and sub bar girdes are Fe500 [10].

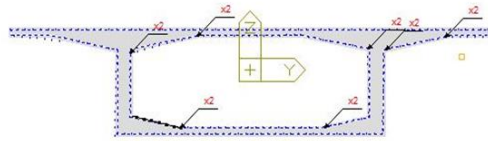


Fig.15: Reinforcement diagram for one section

Pier section

MIDAS/Civil		RC Column Design Result	
	Company		Project Title
	Author	midas	File Name
			C:\...lmanivasan1444(a).mcb

1. Design Condition

Design Code IRC:112-2011
 Unit System N, mm
 Member Number 73 (PM), 73 (Shear)
 Material Data fck = 50, fy = 500, fyw = 500 MPa
 Column Height 40000 mm
 Section Property PIER (No : 1)
 Rebar Pattern Total Rebar Area Ast = 384750 mm² (Rhost = 0.0267)

Fig.16: Pier section data

Design consideration for pier section has been given. Total of 4 pier section has been used for the bridge design. Here we can added the value for the pier section(1).Total rebar area for the pier 1section is 384750mm² [11]

Camber Result

Graphical representation of the Camber result has been given below.

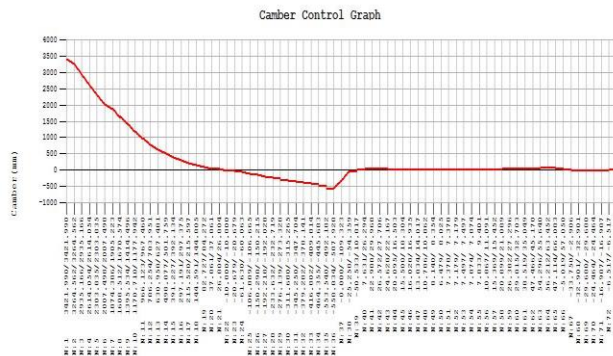


Fig.17: Camber Control Graph

The X-axis of the graph represents the length(or nodes) of the bridge and the Y-axis represents the corresponding camber. Two values are produced for each node. The upper value signify the cambers to be considered at the time of installing the formwork whereas the lower value signify the displacement that would occur upon removal of the formwork after casting the concrete at the corresponding nodes.

If the above conditions are satisfied, the deflection of the main girder will be “0” and remain horizontal upon completion of construction.

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CONCLUSION

The following observations are made from result obtained by balanced cantilever bridge

- Less formwork,concrete and steel are required for the balanced cantilever bridge design.
- Only one bearing at every pier has been requires for balanced cantilever bridge design. By this processs width of the pier can be smaller.
- In the pier table Bending moment is maximum.
- High skilled labours has been required to do construction work.
- IRC 112 requires increased cover for pre-tensioned stands, which leads to increased thickness of web andPSC bex girder bridges.