

## DESIGN ASSESSEMENT OF BRIDGE BY FULL SPAN METHOD USING MIDAS SOFTWARE

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### ABSTRACT

Structural design of Full Span Method of Construction bridges allows them to cover longer distances than other types of bridges. Bridges are normally designed for dead load, live load and other occasional loads. All loading and unloading conditions in analysis and design are provided as per IRC code specifications. The whole modelling of the FSM parts of the bridge was done by using MIDAS CIVIL. Structural Design Requires A Full Understanding And Knowledge Of All The Components Comprising The Structure. With The Ever-Increasing Sophistication Of The Population And The Usage Of Vehicles, The Number Of Modern Road And Bridge Construction Projects In India Is Increasing. To Facilitate Traffic Flow, Composite Bridges Are Increasingly Being Implemented On A Wide Scale

For Highway Building. In Addition, New Technology And Equipment Were Gradually Applied To Road And Bridge Building. But, At The Same Time, There Are Several Flaws. In The Structures Due To The High Technical Requirements Of Bridge Building, Particularly The Composite Type Of Sections. The Full span superstructure erection method of construction is where the span elements are temporarily held in place until they are self-supporting and once capable of self-support the erection procedure advances to the subsequent span. The completion of one span at a time is the defining character for which the name “span-by span” is derived from. The most common use of span-by-span construction is to build long viaducts with spans of similar length. The method has been used most often for spans ranging from 25m to 45m. As spans increases, there is a significant

increase in the cost of the erection girder. Erection girder can support the segment from below, or above – under slung and overhead launching gantries. The Structure Is Designed In ccordance With IRC Guidelines.

### **INTRODUCTION**

MIDAS CIVIL is a software design & Analysis software that combines powerful pre-and post-processing features with an extremely fast solver, which makes bridge modelling and analysis simple, quick, and effective. Also, there are several easy parameter modification tools available that can be used for parametric analysis leading to optimized and economical design. MIDAS GEN and MIDAS CIVIL are programs for structural analysis and optimal design in the civil engineering and architecture domains.

### **OBJECTIVES**

To learn about the advance features in Midas civil. Analysis of FSM (Full



Span Method) Bridge using the procedure of completed state analysis.

Fig 1 FSM (Full span construction Method)

FSM (Full Span construction Method) is a very basic method in constructing post- tensioned concrete bridges. Dead weight of concrete, formwork and false work are fully shored over the full spans of a bridge until the concrete gains a certain level of strength. FSM can be economical if the horizontal alignment of a bridge is curved or the width of the bridge deck widens, provided that the height of the piers are not too high. In the case of a bridge with long spans, the use of continuous tendons can be limited, thereby requiring construction joints. Each segment may be constructed sequentially span by span.

### **INTRODUCTION OF FSM BRIDGE**

The FSM would involve casting full span segments. Segments of 100' length weighs 750 Tons. This is an incredible section of concrete and may appear to be challenging to produce. Yet, HSR projects around the world have used this construction method and the casting cells and all associated equipment have been employed for many years.

### **FULL SPAN METHOD (FSM)**

The **Pre-cast** full span method of construction (commonly known as FSM) is one of the fastest techniques used in construction of bridges and viaducts. The FSM involves casting

the whole bridge span in the casting yard and transporting the whole span with a specially designed multi-axle Tyre Trolley to the bridge site.



Fig 2FSM (Full Span Method)

When FSM is applied to a bridge with continuous spans, the first stage is a simple span, and it becomes continuous with the progress of the construction stages. In comparison with an analysis that does not consider construction stages, the construction stage analysis results in lower negative support moments higher positive span moments. As such, a bridge constructed by FSM needs to be analyzed with construction stages reflecting both the change in structure, element load and boundary conditions as well as time-dependent material properties, including creep, shrinkage and modulus of elasticity..

#### ADVANTAGES OF FSM BRIDGE

There is no need for false work to support the deck during casting in the spanned area. The deck segments are cast in casting yard hence improving concrete quality control and formwork. Work is repetitive resulting in manpower efficiency. Continuous supply of segments hence speeds of construction. Very good erection and Pre-cast cycle Modular Cross Section geometry Curvature, Inclination. Real Feeding from the Previous Erected span.

Pre-Cast = Quality Control.

No scaffolding, No Shoring.

Highly mechanized FSM Launcher

Multi-axle trolley

Special formwork with inner mould (hydraulically manoeuvred) Lifting cranes for pre-cast yard. Lifting cranes and custom designed straddle carriers for pre-cast bridge span in casting yards (capable of manoeuvring on site and stock pre-cast spans)

Having successfully completed the 2<sup>nd</sup> Incheon Bridge in South Korea, the largest in the world for this method of construction at 1,400t span – with our equipment, NRS is undoubtedly one of the most recognized reliable suppliers of the FSM system in the world today. 2<sup>nd</sup> Incheon Bridge, Korea – FSM Launcher and Tyre Trolley.

The pre-cast span for this project was 50m long and weighed 1,400t – the heaviest span in the world erected using the FSM method. The Tyre Trolley, TT-1500 consisting a total of 320 rubber tyres used to transport the bridge span, was also designed and supplied by NRS.

Wuhan-Guangzhou High Speed Railway, China delivered Tyre Trolley TT-900 to Bureau No. 19, Ministry of Railways, China for Transporting 33m PC bridge Spans

## **METHODS OF CONSTRUCTION OF FSM BRIDGES**

### **Pre-cast Bridge Construction Method**



Fig 4 Precast bridge construction method

Precast bridge construction method has been divided into three parts namely I beams and super Tee, Segmental and full span. Precast construction means that bridge members or segments are prefabricated at a location different from the site, transported to the site, and installed there. Construction with precast segments has several advantages in comparison with cast-in-place segmental bridges. Casting of the segments can be performed under controlled, plant-like conditions at the pre casting yard. This industrialized process allows easy quality control of segments prior to placement in the superstructure and saves money through reuse of the pre casting formwork.

#### **Cast in-Situ Bridge Construction Method**

In this method strength concrete as well as high strength materials such as wires, bars and steel strands should be used. After concrete hardening, the strands which have been passed through the concrete, have been pulled by a special jack and after receiving pre-determined force, the strands would be locked.

#### **Balanced cantilever bridge construction method**



Fig.5 Balanced cantilever bridge construction method

Balanced cantilever construction denotes building a bridge superstructure from both sides of the pier table in a scales-like fashion. This erection method is also known under the name free cantilever construction. It is one of the most popular bridge construction methods used. When two opposing free cantilever structures are attached as a single structure and erected in the same step, it is known as ‘balanced cantilever’. The economical range of span lengths for cast-in-situ cantilever construction begins at roughly 70m and extends to beyond 250m.

Considerable savings can be achieved by using this method rather than conventional bridge construction. The advantage of using this method especially in urban areas refers to its characteristic that it does not need any temporary shoring and it can disrupt traffic over water channels and in deep gorges which is very dangerous for construction workers. Balanced cantilevering can be carried out with cast-in-place or precast segments. For cast-in place balanced cantilevering a set of two form travellers is required, one for each arm of the cantilever. For multi-span bridges the form travellers can be dismantled after finishing cantilevering from one pier and can be set up for new use on the next cantilever.

### **Incremental Launching bridge construction method**



Fig 6 Incremental Launching bridge construction method

Incremental launch is a method in civil engineering of building a complete bridge deck from one abutment of the bridge only, manufacturing the superstructure of the bridge by sections to the other side. In current applications, the method is highly mechanised and uses pre-stressed concrete. Incremental launching construction of 50 -60m spans with half-span segments is typically based on weekly segment cycles and by-weekly span cycles with one shift per day.

The bridges are mostly of the box girder design and work with straight or constant curve shapes, with a constant radius. 15-to-30-metre (49 to 98 ft) box girder sections of the bridge deck are fabricated at one end of the bridge in factory conditions. Each section is manufactured in around one week.

The first section of the launch, the launching nose, is not made of concrete, but is a stiffened steel plate girder and is around 60% of the length of a bridge span, and reduces the cantilever moment. The sections of bridge deck slide over sliding bearings, which are concrete blocks covered with stainless steel and reinforced elastomeric pads.

### **Arch bridge construction method**



Fig 7 Arch bridge construction method.

### **COMPLETED STAGE ANALYSIS MODELLING**

First create the model for the completed state analysis, perform completed state analysis, and then create the construction stage analysis model under a different name.

The FSM bridge modelling procedure for the completed state analysis is as follows:

1. Define material and section properties
2. Analyse initial equilibrium state of FSM bridge
3. Create a model and enter boundary conditions.

Divide pylon (tower) members to generate pylon transverse beams

Create & remove pylon transverse beams

## LITERATURE

### **Midas Civil**

Midas Civil is a structural engineering software that is often used for designing and Analyzingbridges, buildings, and other large-scale structures.

Numerous studies have evaluated the capabilities and performance of Midas Civil software. For example, a study by **Abdalla and Elsharty (2018)** evaluated the accuracy of the software in predicting the behaviour of post-tensioned concrete bridges.

The study found that the software was capable of accurately predicting the behaviour of the bridges, including concrete cracking, deflection, and tension in the post-tensioning strands.

Another study by **Wong et al. (2019)** evaluated the performance of Midas Civil software in analyzing a steel-concrete composite bridge. The study found that the software was able to accurately predict the behaviour of the bridge, including the stresses and strains in the steel and concrete components.

A review by **Wang et al. (2017)** found that the software was capable of handling complex structural models with ease and provided advanced analysis capabilities. The review also noted that the user interface was relatively easy to use, even for users with limited experience in structural engineering.

### **Full Span Method (FSM)**

Several studies have been conducted on the full span method, demonstrating its effectiveness in analyzing complex structures. For example, a study by Tezcan and Karakuzu (2018) analyzed the structural behavior of composite wing panels using the full span method.

## PRECAST CONSTRUCTION

Precast construction means that bridge members or segments are prefabricated at a location different than the site, transported to the site, and installed there.

Mathivat (1983) gives the maximum economical span of bridges built in precast segment as about 150 m, since cost for the placement equipment increase considerably the longer the spans are.

Construction with precast segments has several advantages in comparison with cast-in-place segmental bridges. Casting of the segments can be performed under controlled, plant-like conditions at the precasting yard.

This industrialized process allows easy quality control of segments prior to placement in the superstructure and saves money through reuse of the precasting formwork. Surface finishing works, such as texturing, sandblasting, painting, and coating can be performed on the ground level without scaffolding when the segments are still accessible from all sides prior to installation in the superstructure.



Fig-9

#### LOADING INPUT ON THE COMPLETED STRUCTURE

##### **Wind Loading**

Wind loading 3 KN/m

Total Height = Section Depth + Barriers + Noise barriers = 3 + 1 + 2.5 = 6.5m

Wind Pressure= 2.3/KN m

Wind Load = (Horizontal Load)<sup>2</sup> 6.53/19.5/m KN

= (Eccentricity Moment)19.5/1.4628.47/KN M

Load / Static Loads/ Beam Loads/ Element

Select All Iso View

Load Case Name>Wind

Load Group Name>Default

Load Type>Uniform Loads

Direction>Global Y

Value

Relative

x1(0) ; x2 (1) ; w(19.5)

Select All

Load Type>Uniform Moments/Torsion

Direction>Global X

Value

Relative

x1(0) ; x2 (1) ; w(-28.47)

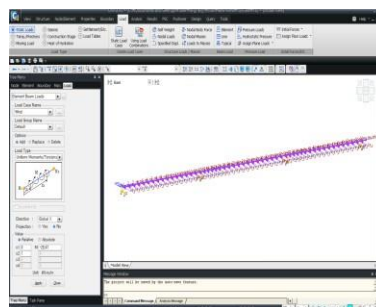


Fig.37. Wind Loading Input

## Temperature

Specify the temperature loading acting on the entire structure.

The System Temperature function allows us to specify strain,  $t (T_2, T_1)$  , over the entire structure as temperature loads.

Specify the differential temperature between the top and bottom chords.

The Beam Section Temperature function generates a temperature differential between top and bottom chords on a part of a rectangle. Since PSC sections are not rectangular sections, they need to be converted into equivalent rectangular sections to be able to specify temperature differential loads.

Where temperature differentials exist as shown below, the parts experiencing the temperature differentials are converted into a rectangle defined by dotted lines having the same area and centroid.

Beam Section Temperature can be defined as either General Type or PSC Type.

General Type assumes the section as a rectangle. When PSC Type is specified, the sections defined as PSC Type in defining Section Data are automatically converted into rectangles and loaded on the parts experiencing temperature differentials.

Although the Beam Section is defined as PSC Type in this example, which results in a simple input process for loading for a temperature differential between the top and bottom chords, input is carried out as General Type after converting into a rectangle.

Figure 39 shows the calculations for cross sectional area and centroid of the top part of the PSC Box section using SPC (Section Property Calculator). The instruction for using SPC is separately documented in user's manual.

Using the above calculation results in conversion into an equivalent rectangle, which will be loaded, as follows:

$$\text{Area} = 2.896m^2$$

$$H = 20.312977m$$

$D = 0.625954m$

Load Case Name> Top-Bot Temp Diff (+)

Load Group Name>Default

Direction >Local-z ; Ref. Position >Centroid

B (4.626) ; H1 (0.71) ; H2 (1.336) ; T1 (5) ; T2 (5)

Select All

Delete the defined Section Temperatures (select ① and delete)

Load Case Name> Top-Bot Temp Diff (-)

B (4.626) ; H1 (0.71) ; H2 (1.336) ; T1 (-5) ; T2 (-5)

Input for Temperature Differential between Top & Bottom Chords

The sequence of defining the live load is as follows:

Select a Code defining live load: Define Moving Load Code

Define lanes: Traffic Line Lanes

Define vehicles: Vehicles

Define live load cases: Moving Load Cases

Select a Code, which specifies live load

### **Define traffic lanes**

Eccentric and symmetrical loading can be considered for the transverse position of traffic lanes. In this tutorial, we specify only a symmetrical loading case as described below.

The eccentricity is positive (+) if the traffic lane (center) is on the right side of the elements in the direction of traffic, and vice versa.

Click OK

## Definition of Vehicle Loads

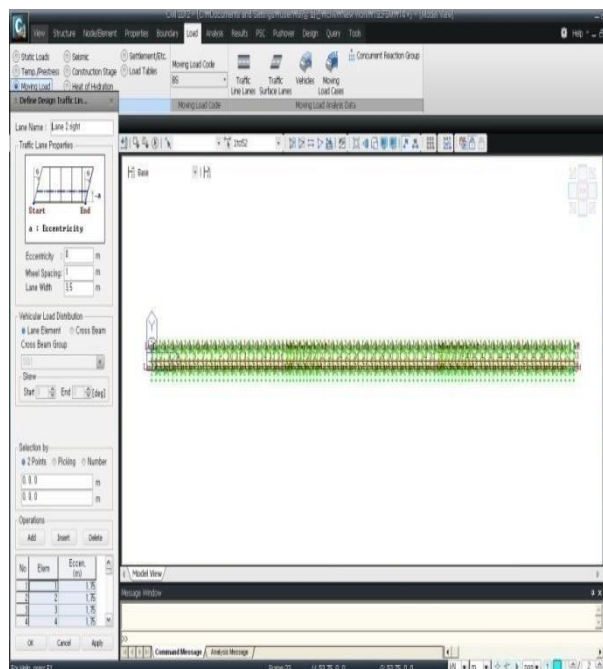
Define the vehicles for live loads.

Load / Moving Load Analysis Data / Vehicles

Standard Name > BD 37/01 Standard Load " Vehicular Load

Name > HA & HB(Auto)

Vehicular Load Type > HA & HB(Auto) ↵



## Conditions for applying live loads

To consider Load Cases, which combines the effects of HA and HB vehicle, Load case name MV U 1, MV U 2 3, MV S 1 and MV S 2 3 are created as below.

Load Case Name		Type of Design Combination Factor		
		Ultimate State	Limit	Serviceability Limit State
Combination of Loads	Combination 1			
	Combination 2 & 3			

Table 1. Definition of Load Case Name

Load Case Name (MV U 1)

Check on Auto Live Load Combination

Type of Design Combination Factor>Ultimate Limit State

Combination of Loads>Combination 1

Load Case Data

Vehicle>HA & HB (Auto)

Assignment Lanes

List of Lanes (Lane 1 left, Lane 2 right)  Selected Lanes

## CHECKING ANALYSIS RESULTS

### Checking Construction Stage Member Forces & Stresses

Member forces can be checked in a diagram using the Beam Diagram function. If a beam element is selected after invoking Quick View, member forces at any particular point on the selected element can be checked in detail.

Results / Forces / Beam Diagrams... CS4

Load Cases/Combinations>CS:Summation ; Step>Last Step

Components>My Display Options> Solid Fil

1 Type of Display Contour (on) ; Legend (on) ↵

Type of Display>Quick View

Using the Beam Stresses(PSC) function, the stresses in a PSC section can be checked in a diagram. A total of 10 locations, Top/Bot vetices (1 to 4), Center (7 & 8) and shear checking points (5, 6, 9 & 10) defined at the time of defining the PSC section, can be checked.

Let us check the bottom chord stress for CS:Summation at the last construction stage.

Results / Stresses / Beam Stresses(PSC)...

CS4 "

Load Cases/Combinations>CS:Summation ; Step>Last Step

Section Position>Position 3 Components>Sig-xx(Summation)

Type of Display Contour (on) ; Legend (on

Using User Defined Diagram, different results (displacements / member forces / stresses) for different elements/groups can be produced.

We will generate results for displacements in the left span, bending moments in the middle span and stresses in the right span in a single diagram simultaneously. Let us check displacements / member forces / stresses for CS:Summation at the last construction stage.

Results / Diagram / Define Diagram...

CS4

### Checking Results using Graphs

The change in stresses with the progress of construction stages in the support element (No.36) will be checked in a Graph.

Results / Stage/Step History Graph

CS4

Define Function>Beam Force/Stress ↵

Name(36\_ax) ; Element No.(36) ; Stress

Point>I-Node ; Components>Axial ↵

Name(36\_b(+y)) ; Components>Bend(+y) ↵

Name(36\_b(-y)) ; Components>Bend(-y) ↵

Name(36\_b(+z)) ; Components>Bend(+z) ↵

Name(36\_b(-z)) ; Components>Bend(-z) ↵

Mode >Multi Func.

Step Option>All Steps Load Cases/Combinations>Summation ↵

### **Checking Results using Tables**

Tables are also useful in checking construction stage analysis results. Tables can be manipulated in various ways by right-clicking on the tables. From “Records Activation Dialog”, tables can be generated by selecting elements to be checked for stresses, load cases, construction stages (steps), elements on which points of stress output are required, load cases, construction stages (steps), stress output locations on elements, stress output locations on a section, etc. The Sorting Dialog allows us to sort/arrange the data based on the sorting criteria. The Style Dialog allows us to change the data type and produce results. Let us check top vertex stresses for CS:Summation at the last construction stage.

### **Pre stress Losses**

We can check the change in tendon tension at each construction stage due to prestress losses.

In the “Tendon Time Dependent Loss Graph” dialog box, only the tendons included in the stage selected in the “Stage” selection window can be

checked. A Graph is generated for selected tendons, selected Stage and selected Step.

### **Checking Tendon Information**

The tendon information used in construction stage analysis can be produced in a table. The coordinates of the tendons placed in elements are produced.

Elongation of tendons is produced.

Timing of tensioning each tendon, elongation of tendons and elements at the start and end points of the tendons and their sum are produced.

The effective stresses and effective prestressing force in the tendons can be checked by group and construction stage. Vertical and horizontal force components of the tendons can be readily obtained from the distance from the centroid of the section to the tendon group and the orientation of the tendon (direction cosine).

## CHAPTER-VI

### CONCLUSION

The Design And Analysis Of Full Span Method of Construction of Bridge is Done By Using Midas Civil Software. These Results Including Bending Moment Shear Force At Each Node At Every Point Within The Element Can Be Easily Obtained From The Software.

When the span is complete the **assembly truss is lowered and moved to the next span where construction cycle begins until the bridge is complete.**

#### REFERENCE

1. Indian Roads Congress, 2010, Standard Specifications And Code Of Practice For Road Bridges, India
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