Seismic Analysis of Solid Slab Bridge

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Abstract - *Seismic analysis of a structure is done to estimate the performance of that structure in the events of earthquake. It can be carried out using various methods depending upon static, dynamic, linearity and non-linearity requirements. Seismic analysis is used to determine the demand and capacity of structure with respect to earthquake. Bridges having a significant role in terms of transportation and connectivity need to be analyzed for seismic action to fulfil its design period. Solid Slab Bridge is analyzed using Midas Civil software. Response spectrum method of analysis is used to determine its demand in terms of displacement and forces.*

***Key Words*: Seismic analysis, Solid slab bridge, Midas Civil, Response spectrum method, Demand.**

1. INTRODUCTION

Bridge is an important aspect of the infrastructure of the country. The main purpose of this structure is to facilitate connectivity between two destinations. The bridge is designed to serve its purpose from 25 to 100 years which is called as its design period. But in case of natural hazards, they may lead to failure of the structural system within its design period. One such natural hazard is earthquake which can cause great losses and damage to various aspects such as the structure itself as well as human in temporary and permanent manner. Earthquakes have proven to be unpredictable because of its varying size, length, magnitude, time, etc. Previously seismic analysis was not carried out, it has gained attention in recent years after the Gujrat and Kashmir earthquake which lead to great loss of life and property. Later on efforts were made to improve the performance of structure in seismic conditions by revising the Indian codes.

Seismic analysis of a structure guides in the design of earthquake resistance structure by elaborating the response of the structure in seismic events. Seismic analysis mainly comprises of four methods which are categorized under static and dynamic loading with respect to structural linearity and nonlinearity. Linear static analysis, linear dynamic analysis, nonlinear static analysis, nonlinear dynamic analysis are the four methods seismic analysis. Linear static analysis is adopted in case of structures with small height. This method is used for estimation of demands of structure whose response is dominated by primary mode. Linear dynamic analysis method of analysis is used for the estimation of demands of structure whose response is dominated by more than one node, this method is used to estimate the demand of any structure. This method can be categorized further as response spectrum method and elastic time history method. Nonlinear static analysis is carried under predominant vertical load and by increasing the load slightly which helps to determine the deformations. The performance of the structure is checked by using capacity curves. The nonlinear static analysis is also called as pushover analysis. Nonlinear dynamic analysis method is a combination of ground motion with detailed structural model. In this, model is subjected to ground motion record which produces checks of part distortions for each degree of freedom. This method is further classified as inelastic time history method, analysis is carried out by using the old earthquake records.

In this paper, seismic analysis of a reinforced concrete bridge is done. This bridge is a solid slab bridge having concrete piers of wall type. The structure is analyzed by using linear dynamic analysis method i.e. response spectrum method of analysis.

1.1 Objectives

- To predict the probable behavior of solid slab bridge with wall type pier in seismic events.
- To carryout seismic analysis using linear static analysis method.
- To determine the displacement and forces of the structure.

2. Description of the Bridge Structure

The bridge that is studied in this paper is located in Rahuri taluka of Ahmednagar, in Maharashtra, India. This bridge across Deo River is a reinforced concrete bridge. It is a simply supported bridge, having 12 numbers of spans. The total length of the bridge is 120000 mm having an equal span length of 10000 mm. As it a simply supported bridge, the bridge is analyzed for three spans i.e. two exterior spans (deck supported on abutment and pier) and one interior span (deck supported on two piers). The reinforced concrete slab deck is supported on reinforced concrete wall type piers. This is a road bridge categorized as a major district road having two lanes with 7500 mm roadway width.

3. Methodology

The flow chart in Fig. 1 shows the steps adopted to carry out the study.

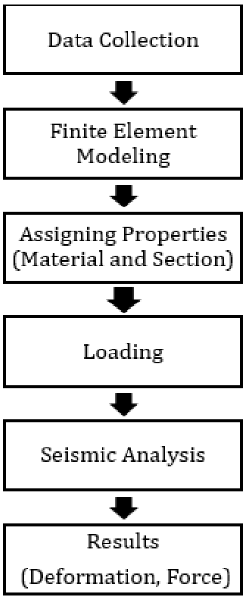

Fig -1: Flow Chart

4. Bridge Input and Analysis

4.1 Model

Modeling of a 120000 mm length bridge using MIDAS Civil software. Three spans are modeled as mentioned above according to the details and dimensions as detailed in Table 1 and the model is as shown below in Fig. 2,

Table -1: Model details

Description	**Details**
Name of the site	Rahuri-Sonai Road
Location of the project	Ahmednagar, Maharashtra, India
Deck	
Grade of concrete	M30
Grade of steel	Fe500
Deck slab thickness	770 mm
Pier Cap	
Grade of concrete	M30
Grade of steel	Fe500
Depth	300 mm
Width	900 mm
Length	8400 mm
Pier	
Grade of concrete	M25
Grade of steel	Fe500
Depth	4650 mm
Width	Top – 900 mm Bottom – 1130 mm
Length	Top – 8400 mm Bottom – 8630 mm

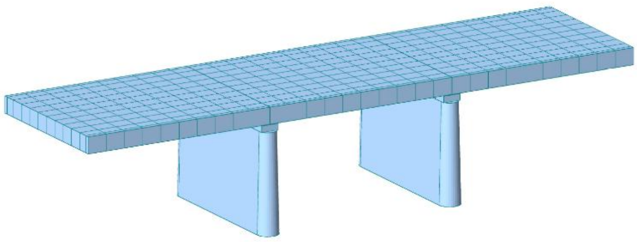

Fig -2: Bridge Model Isometric View

4.2 Loading

The loads assigned to the bridge are as per the guidelines provided in IRC: 6 - 2017 as follows,

Dead Load:

It includes the self-weight of the structure including the components attached to the structural members such as crash barrier, etc. Wearing coat of 750 mm is input having 22 KN/m³ unit weight.

Live Load:

This is entered in the software in form of moving load. For two numbers of lanes, one lane of Class 70R or two lanes of Class A are applied.

Seismic Force:

The bridge site lies in Seismic zone III with a seismic zone factor to be 0.16 and the condition of exposure has been considered as moderate. As the bridge site has rocky strata, the soil type is I. The damping ratio is adopted to be 5%. The importance factor and reduction factor is taken as 1.00.

The load combinations are generated from the software with reference to IRC 6.

4.3 Seismic Analysis

Seismic analysis of Deo River Bridge is done by using Ritz Vector Analysis followed by Response Spectrum method of linear dynamic analysis.

This method of analysis is used for the estimation of demands of structure whose response is dominated by more than one node, this method is used to estimate the demand of any structure. Linear dynamic analysis can be categorized further as response spectrum method and elastic time history method. Using response spectrum method the big values of displacements and member forces in every mode can be identified by using smooth spectra which is common for numerous earthquakes. The response spectrum method allows to contemplate multiple mode shapes from the response of the structure. These mode shapes are combined for evaluation of the total response of the structure. Mode shapes ca be combined by using the methods such as Square Root of the Sum of the Squares (SRSS), Complete Quadratic Combination (CQC), etc. The Table 2 shows the response spectrum input generated by software after defining the seismic parameters as mentioned in 4.2.

Table -2: Response spectrum analysis input generated by software

Period (sec)	Spectral Data (g)
0	0.08
0.54	0.1481
1.02	0.0784
1.5	0.0533
2.04	0.0392
2.52	0.0317
3	0.0267
3.54	0.0226
4	0.02
4.5	0.02
5.04	0.02
5.52	0.02
6	0.02

5. Results

Tables 3, 4, 5 and 6 indicate the displacements in longitudinal and transverse directions whereas Tables 7 and 8 indicate the forces.

Table -3: Maximum displacements in longitudinal direction

Load case: RS: RS_X	
DX (Displacement component in GCS X)	151.22 mm
DY (Displacement component in GCS Y)	0.00 mm

Table -4: Maximum displacements in transverse direction

Load case: RS: RS_Y	
DX (Displacement component in GCS X)	0.00 mm
DY (Displacement component in GCS Y)	151.16 mm

Table -5: Displacement at pier top in longitudinal direction

Load case: RS: RS_X	
DX (Displacement component in GCS X)	0.153 mm
DY (Displacement component in GCS Y)	0.00 mm

Table -6: Displacement at pier top in transverse direction

Load case: RS: RS_Y	
DX (Displacement component in GCS X)	0.00 mm
DY (Displacement component in GCS Y)	0.006 mm

Table -7: Forces

Load case: RS: RS_X	
FX (Nodal inertia force in GCS X)	261.67 KN
FY (Nodal inertia force in GCS Y)	0.01 KN

Load case: RS: RS_Y	
FX (Nodal inertia force in GCS X)	0.03 KN
FY (Nodal inertia force in GCS Y)	170.09 KN

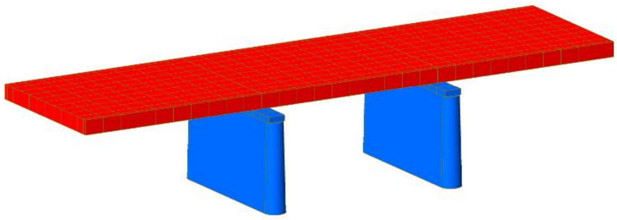

Fig -3: DY due to load case RS_Y

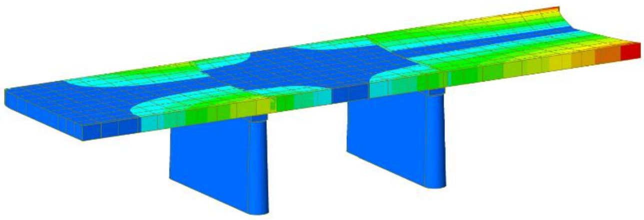

Fig -4: DX due to load case RS_Y

6. CONCLUSION

In seismic events for solid slab bridge, in both X and Y directions i.e. longitudinal and transverse direction displacement is maximum in superstructure than substructure. So failure will occur initially at the deck level.

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