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Seismic Performance and Evaluation of An Existing Highway Bridge Across the Palar River Near Kanchipuram

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Abstract: Structurally sound bridges are the need of people which made us converge all our views to design a major bridge. As of present scenario the design of a bridge includes, following updated code provisions for vehicle loads, wind loads, loads due to seismic activity and other environmental changes. Earthquake is a natural phenomenon and cannot be predicted, while it leads to loss of human life and property at the same time. Primary aim for an engineer is to design a structure to resist the seismic activity as far as possible reducing the damage to human life and property. We are adopting CSi Bridge Version 18.2.0 Build 1269 software for the nonlinear static analysis (Push-Over Analysis) of the bridge. Due to the unpredictable nature of Earthquakes and importance to life factor, every structure must be designed to resist earthquakes.
Keywords: ***Loads, slabs, Main girder, Pier, Pile cap, Structural Designing, CSi Bridge Version 18.2.0***

I. INTRODUCTION

The response of bridges under a moving vehicle is complex due to the interaction between bridge and the vehicle. As the bridge deck surface deteriorates over time, the road surface roughness profile will vary accordingly. We have taken up the design of an Essential Bridge Structure that is highly unavoidable for travel of men and material across the river. The present bridge is insufficient to resist the earthquake loads, considering the developments it is redesigned manual and using software as per present code provisions for vehicles loads and seismic loads. We are adopting CSi Bridge Version 18.2.0 Build 1269 software for the nonlinear static analysis (Push-Over Analysis) of the bridge. The design of the bridge is a Hammer Head type bridge considering the condition of the Palar river bed and specification of the reinforced concrete structure that would suit the best and been designed for the maximum possible traffic density. Considering the probable developments in the near future in both the districts being connected, the bridge is sure to fulfill the needs of the people in the area.

A. About CSi Bridge Software

1) Modelling, analysis and design of bridge structures have been integrated into CSi Bridge to create the ultimate in computerized engineering tools. The ease with which all of these tasks can be accomplished makes CSi Bridge the most versatile and productive software program available on the market today.
2) Using CSi Bridge, engineers can easily define complex bridge geometries, boundary conditions and load cases. The bridge models are defined parametrically, using terms that are familiar to bridge engineers such as layout lines, spans, bearings, abutments, bents, hinges and post-tensioning. The software creates spine, shell or solid object models that update automatically as the bridge definition parameters are changed.

B. Objectives

Following are the main objectives of the present study:

1) To understand the standard pushover analysis procedures and other improved pushover analysis procedures available in literature.
2) To carry out a detailed case study of pushover analysis of a reinforced concrete bridge using standard pushover analysis and other improved pushover analyses.

II. SITE INVESTIGATION AND PLANNING

A. Selection of bridge site

Detailed ground reconnaissance collection of adequate hydraulic ground data and subsoil investigation from an essential part of engineering survey for deciding the best possible location and type of bridge site is governed by engineering, economic, social and

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aesthetic considerations.

B. *Sub Surface investigation*

1) Sub surface Investigation of soil is essential for judging suitability for the proposed engineering work and for preparing adequate and economical design. The field and laboratory investigation are required to obtain the necessary soil data for the design called Soil Exploration. It is not secret that most of the failures of a structure is caused by the failure of the foundation.

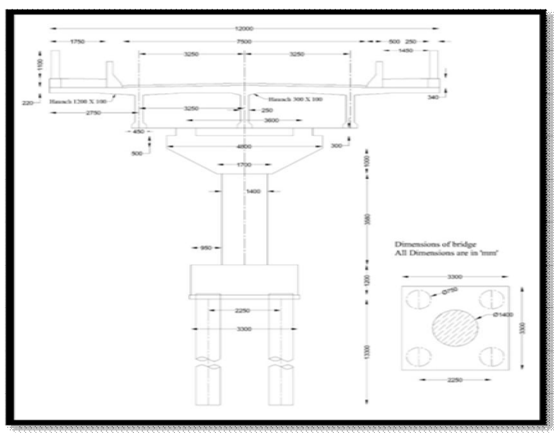
2) As per the soil profile which has been prepared by the Geotechnical Engineers at the site,Pile Foundation is best suited for this profile.

III. LIST OF LOADINGS

A. Dead load of girder (IRC:6 – 2014, Clause 203)
B. Live load on road way shall severe the following (IRC: 6 – 2014, Clause 204)
1) 1 or 2 lanes of IRC Class 70R wheeled loading.
2) 1 or 2 lanes of IRC Class 70R tracked loading.
C. Basic live load on footpath shall be 400kg/m^2 (IRC: 6 – 2014, Clause 206)
D. Wearing coat shall be 2KN/m^2 (IRC: 6 – 2014, Clause 206)
E. Railing + kerb load shall be 7KN/m^2 for railing on both sides (IRC: 6 – 2014, Clause 206)
F. Water currents forces(IRC: 6 -2014, Clause 210)
G. Seismic force are considered in design (IS: 1893 – 2002)

While designing road bridges any combination of above forces that can co-exist should be accounted for.

A. *Cross Section of Bridge*



B. *Design of Bridges*

The design is as per "Morice and Little Method". This method is based on anisotropic plate theory. In this case concrete bridge deck system is replaced by an equivalent anisotropic plate and then analysed according to the classic plate theory. Gayon and Massonncets have developed this approach which was later modified by Morice and Little. The method has the Merit that a single set of distribution coefficient for the two external cases of no torsion grillage and a full torsion slab enable the distribution behaviour of any type of bridge to be found.

Longitudinal analysis is done by using Morice and Little's method, Bending Moments and Shear Force are calculated at various points along the length of the main girder like at the support mid span 'd' from support L/4, etc. The sections are designed by working stress method as per IRC: 21 - 2000

Following designs are enclosed

1) Pile
2) Pile cap
3) Pier
4) Pier cap

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5) Girder and Deck Slab

C. Design and Detailing of Pile

Load of each pile = 1658 KN
Length of pile = 12.321m
C/C of pile = 2.225m

Reduction coefficient, $C_r = \left(1.25 - \frac{L}{48B}\right) = 1.25 - \left(\frac{16.26}{48 \times 0.75}\right) = 0.798$

Safe stress in concrete $\sigma_{cc} = 0.788 \times 8 = 6.38\ N/mm^2$

Safe stress in steel $\sigma_{sc} = 0.798 \times 190 = 151.62\ N/mm^2$

Minimum reinforcement = $\frac{1.25}{100} \times \frac{\pi}{4} \times 750^2 = 5522\ mm^2$

Provide 20Ø- 16 no's.

D. Lateral reinforcement

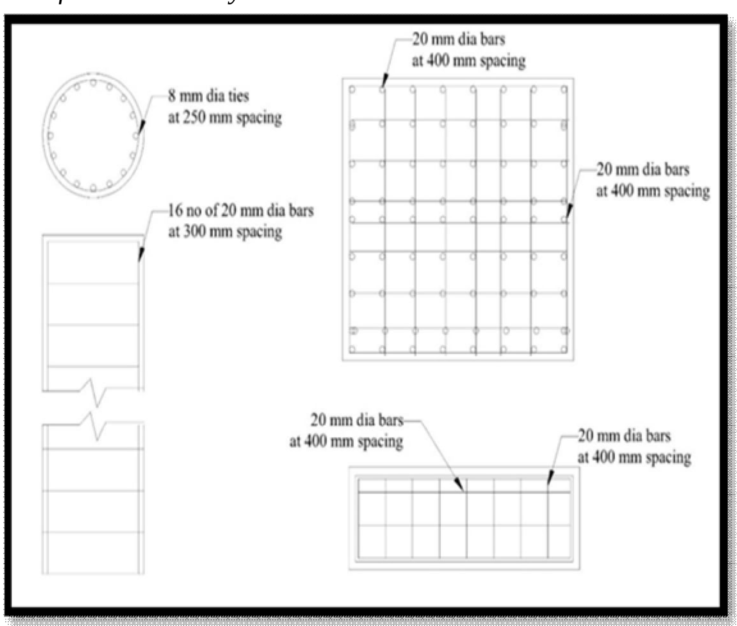
1) Ties: Main diameters/4 = $\frac{20}{4} mm = 5mm$

5mm
Adopt 8mm diameter Ties

2) Pitch: Least lateral diameter = 400mm

16 x diameter longitudinal bar = 16 x 20 = 320mm
48 x diameter of ties = 48 x 8 = 384mm
Adopt 8mm diameter 250mm c/c

E. Schematic Representation of Pushover Analysis Procedure



The seismic demand is then compared with the corresponding structural capacity or predefined performance limit state to know what performance the structure will exhibit. Independent analysis along each of the two orthogonal principal axes of the building is permitted unless concurrent evaluation of bidirectional effects is required.

The analysis results are sensitive to the selection of the control node and selection of lateral load pattern. In general, the centre of mass location at the roof of the building is considered as control node. The lateral load generally applied in both positive and negative directions in combination with gravity load (dead load and a portion of live load) to study the actual behavior.

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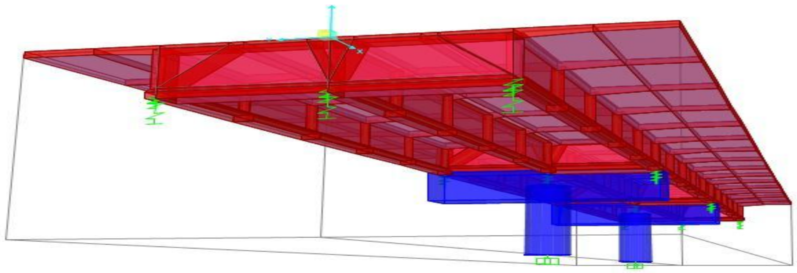
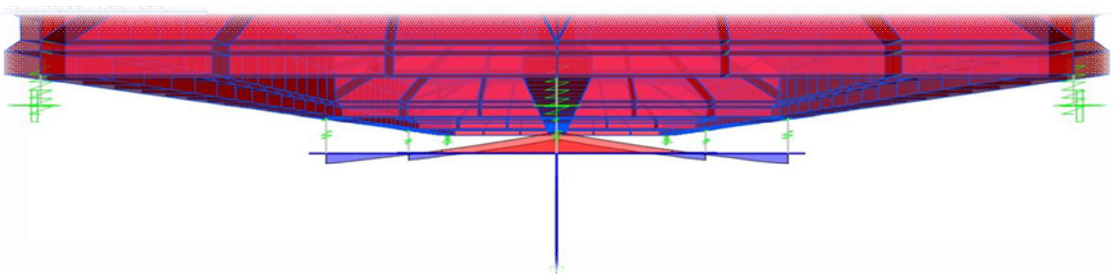
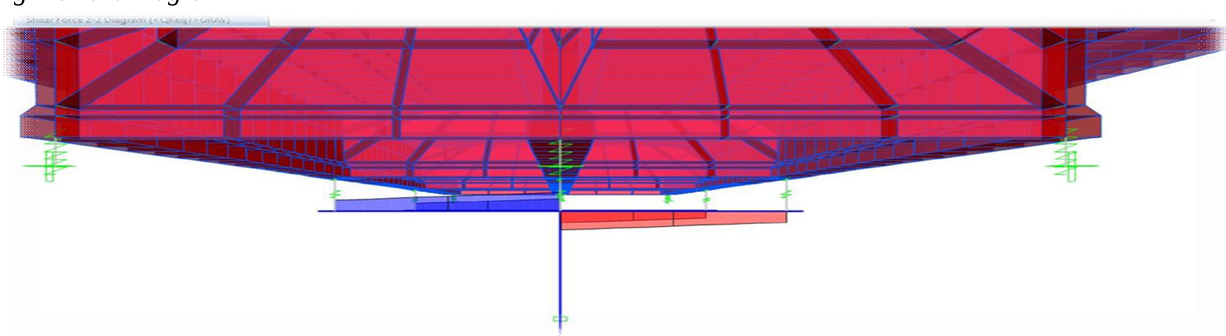
1) Bridge Model



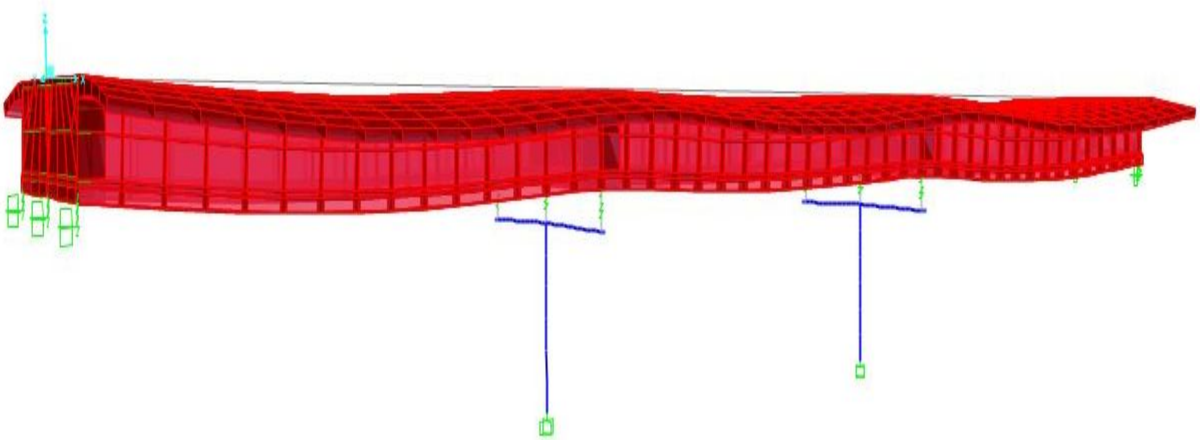
2) Shear Force Diagram



3) Bending Moment Diagram



4) Deformed shape of Bridge Model



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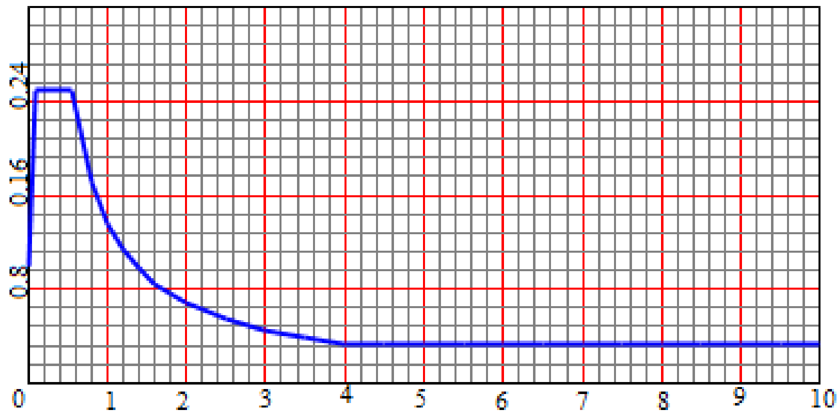
5) Response Spectrum Curve



IV. DEMAND/CAPACITY RATIOS

The demand/capacity ratios for each bent in each direction are reported in the following table. Values less than 1.0 indicates that an adequate capacity exists for a given bent and direction for the ground motion hazard used in the seismic design request. Values greater than 1.0 indicated an overstress condition.

Table 23: Bridge Seismic Design 01 - Bent D-C, Part 1 of 2

DesReqName	SpanName	Station m	Direction	GenDispl	Demand m	Capacity m	DCRatio
QReq1	Span 1	14.7	TRANS	<QReq1>GD_TR11	0.00044	0.001761	0.25
QReq1	Span 1	14.7	LONG	<QReq1>GD_LG11	0.000179	0.000791	0.226
QReq1	Span 2	29.4	TRANS	<QReq1>GD_TR21	0.00044	0.001761	0.25
QReq1	Span 2	29.4	LONG	<QReq1>GD_LG21	0.000179	0.000639	0.2797

V. RESULTS

The selected bridge model is analyzed using Nonlinear Static (Pushover) analysis. This chapter presents Pushover analysis results. Pushover analysis (Push Y) was performed first in a load control manner to apply all gravity loads on to the structure (gravity push). Then a lateral pushover analysis in transverse direction (Y - direction) was performed in a displacement control manner starting at the end of gravity push.

Here the performance of the bridge, according to IRC 6 – 2014and IS 1893 – 2002 for Zone – II was satisfied. Therefore it requires no retrofitting.

VI. CONCLUSIONS

Bridges extends horizontally with its two ends restrained and that makes the dynamic characteristics of bridges different from buildings. By analyzing the structure 'Pushover Analysis', it was concluded that

A. Modal analysis of a 3D bridge model reveals that it has many closely spaced modes.

B. Further investigation is required in order to make a generalized evaluation procedure for bridge structures with different configurations.

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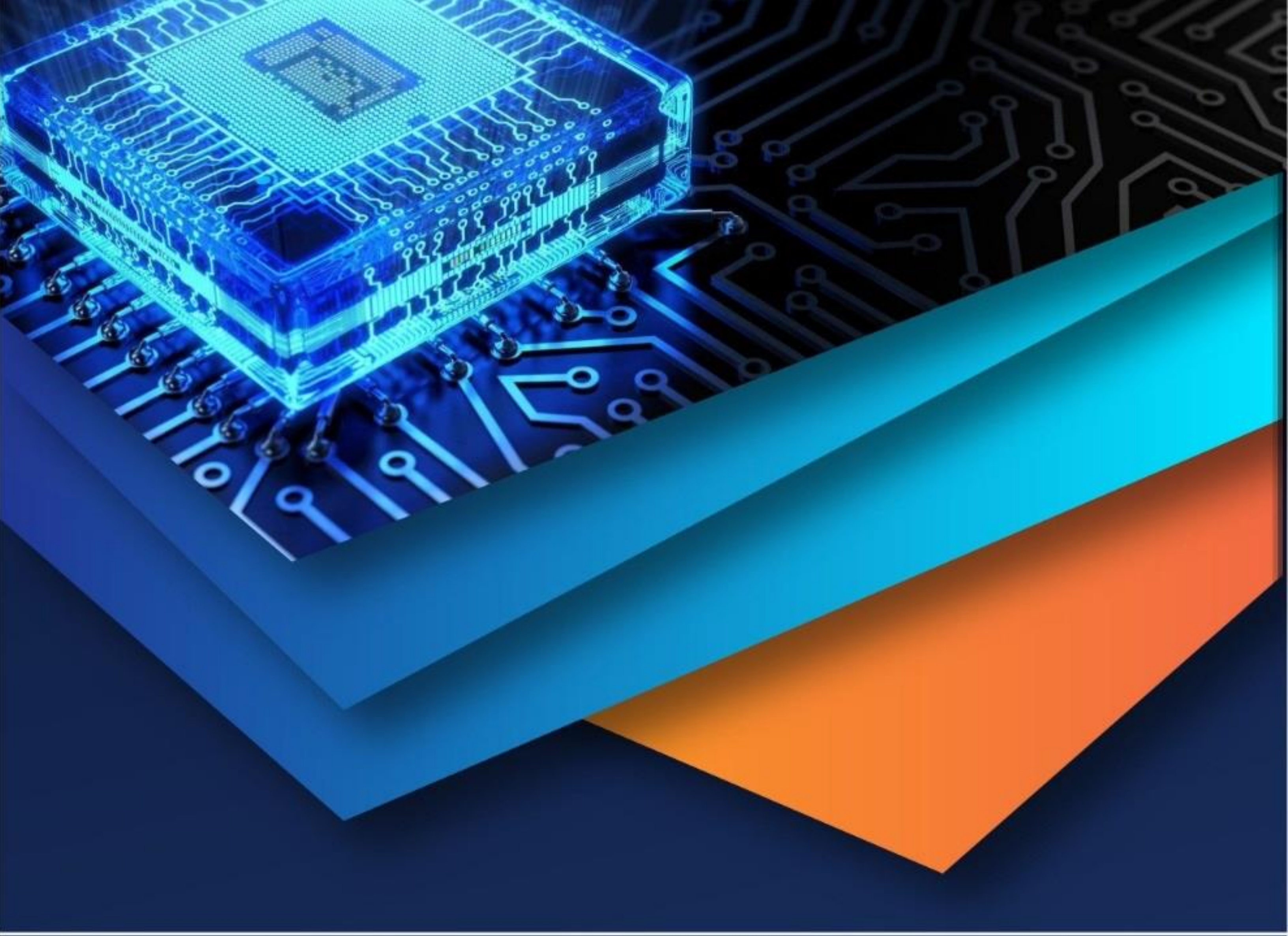

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