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Performance Based Assessment of RCC Bridge Structure Using Non Linear Push over Analysis

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Abstract : In this paper the nonlinear static push over analysis for I section bridge and U section bridge of same material and dimensions is done. There are presently no comprehensive guidelines to assist the practicing structural engineer to evaluate bridges structures and suggest design and select the suitable section for structural designs. In order to address this problem, the aim of the present work is to carry out a seismic evaluation case study for an RC bridge models i.e., I section bridge and U section bridge using nonlinear static (pushover) analysis. In the present study a 4 span RC bridge was selected and by defining FEMA 356 auto hinges conducted nonlinear static (pushover) analysis using (ATC 40) capacity spectrum method and software SAP2000 was used to analyze the bridge. The evaluation results presented here shows that, the performance of I section girder bridge is better as compared with U section girder of same material and same conditions.

Index Terms **- RC Bridge, FEMA 356, Nonlinear Static (Pushover) Analysis, SAP 2000, ATC 40.**

Introduction

In the recent century, India has seen many of nation's biggest earthquakes. All of the Himalayan belt and the east part of the nation can be hit by strong earthquakes with magnitudes greater than 8. Seismic hazard assessment of existing structures has become a national priority following the 2001 Gujarat earthquake and the 2005 Kashmir earthquake. There were changes made in 2002 to India's earthquake design code (is 1893, part-I). Overall, the order of magnitude of the design earthquake excitation has been much enhanced, and the earthquake zoning of some places has also been raised. Multi-story building evaluation methods are well-documented in academic journals and textbooks. Analyses are performed using a nonlinear static (push) approach. Existing bridges are receiving just a modest amount of attention. However, in any country's transportation system, bridges play a critical role. This means there is no earthquake resistant clause in Indian bridge building rules. It is common practice to build and construct bridges without taking seismic pressures into account. A comprehensive evaluation of existing bridge capability versus expected seismic force demands is therefore critical. No comprehensive guidelines are available to help structural engineers in analyzing existing bridges and making recommendations for improvements in design and implementation. Seismic assessment of an existing reinforced concrete bridge utilizing dynamic static (push) analysis is the primary goal of this work. An ATC 40 nonlinear static analysis (pushover) is utilized to validate the outcome. It wasn't until the last 10-15 years that nonlinear static analysis and force analysis were properly understood. Building capacity and gravity, as well as its seismic demand in the case of a specified earthquake, are the primary goals of this technique. This approach may also be used to assure the design of a new structure. An earthquake's "inactive force" is represented by sub-elements of a little higher load, and this higher load is used in trust analysis to adjust the indirect load of the structure's various components and sub-elements until the "planned removal" is surpassed. The elimination of the target was expected by a large change in the top structure (both elastic and inelastic) caused by a specific seismic movement. Using a systematic examination of earthquake strength and dynamics, pushover analysis measures a building's performance. Partially rotating and partially powered earthquakes are all necessary characteristics of circular shifts (on the roof or in any other reference region). Internal energy is redistributed as a result of geometric variation and material heterogeneity. These properties may be acquired via random analysis as summarized below.

Reinforced Concrete Bridges

Components of Bridge Structure

Following figure 1. Shows different components of bridge structure.

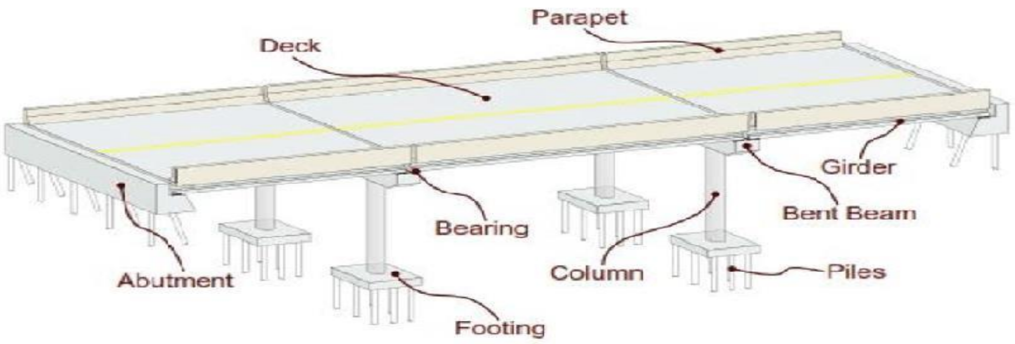

Figure.1: Components of Bridge Structure

Objectives

- Following are the main objectives of the present study:
- Investigation of loads and load combinations on the RC bridge.
- To perform pushover analysis on reinforced concrete U Section Bridge and reinforced concrete I section bridge.
- To optimize comparison between U section reinforced concrete bridge and I section reinforced concrete bridge on structural parameters like base shear and displacement

Methodology

- To understand seismic assessment structures and the application of pushover analysis, we conducted a thorough literature review.
- Using an existing RC bridge to determine its proportions.
- Model the selected I and U Section Girder Bridges in SAP2000 using the computer programme.
- As part of the bridge's nonlinear analysis, do modal analysis to identify dynamic features and input parameters.
- For nonlinear pushover analysis, compare the two bridge sections.
- Analyze the bridge models nonlinear statically and make findings.

Problem Definition

This section provides an overview of the computational models, key assumptions, and numerous factors that define bridge geometry for this study. Loads and load combinations on the bridge were investigated, the same bridge was modeled in SAP 2000 and Linear static, Modal and Seismic Analysis (Response Spectrum) was performed to determine the maximum bending moments and dynamic properties of the bridges to model the bridge and conduct linear static, modulation, and Earthquake analysis (Resonance Spectra) to identify the maximum bending times and flexible bridge characteristics. It follows that a nonlinear static (push) analysis is done to estimate bridge performance scores and count base shears and displacements as well as Practical Time, Spectral Displacement Capacity, and Demand utilizing ATC-40

Following Table 1. Gives us that the bridge details considered for analysis

Table 1.Bridge Details Considered For Analysis

Sr. No.	Particulars	
1.	Width of Bridge	11 m
2.	Span of Bridge	20m X 4m
3.	Main Girders	3
4.	Total Lanes	2
5.	Slab Thickness	0.3m
6.	Depth of Bridge	2.75m
7.	Loading Type	IRC Class A Train
8.	Loads	DL + IL + LL + EQ
9.	Modulus of Elasticity	27386128 KN/ m^2
10.	Strength of Concrete	30000 KN/ m^2
11.	Poisson’s Ratio	0.18
12.	Analysis	Linear and Non Linear

Data required in SAP 2000

Following table 2. Gives that the details of bridge considered for analysis

Table 2.Bridge Details Considered For Analysis

Sr. No.	Particulars	
1.	Concrete Grade	M30
2.	Density of Concrete	25 kN/M^3
3.	Live load Type	IRC Class A Train
4.	Impact Factor (i)	0.173
5.	Response Reduction factor (R)	3
6.	Importance Factor	1.2
7.	Poisson's Ratio of Concrete	0.18
8.	Soil Type	Type II
9.	Seismic Zone	Zone III
10.	Seismic Zone Factor	0.16

Following figure 2 shows the model of Designed bridge in SAP2000 Software.

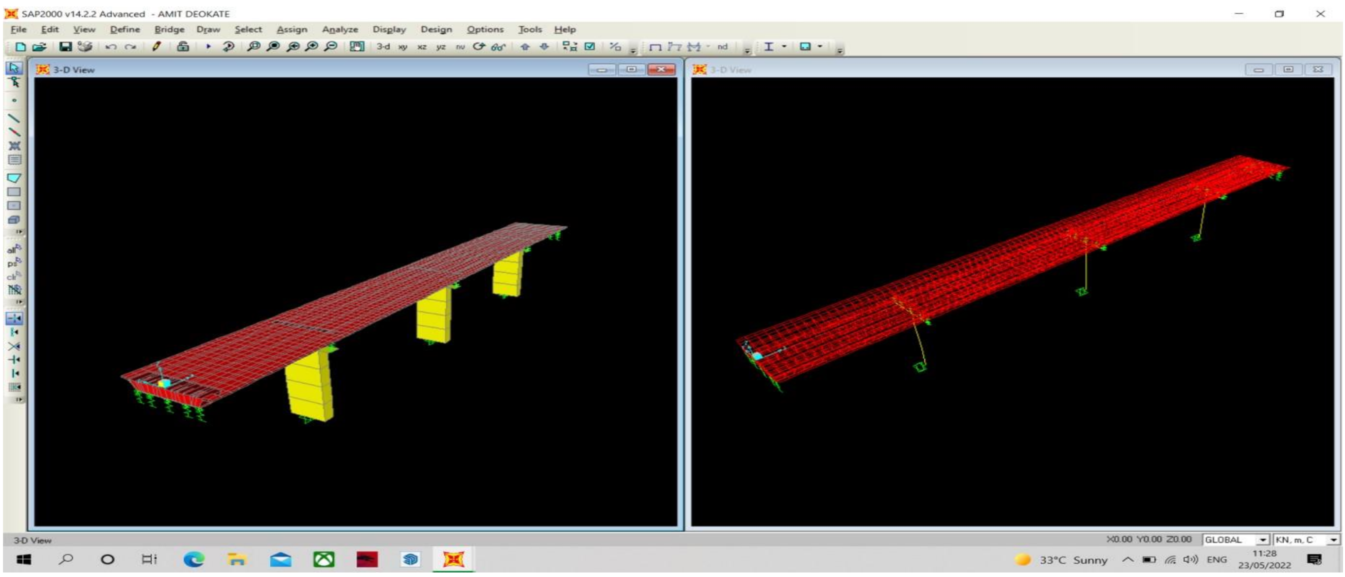

Figure.2: Bridge Model in SAP 2000

Results and Discussions

The chosen bridge model was subjected to non-linear static analysis. This part includes the results of the linear static analysis, the elastic modal characteristics of the bridge, the thrust analysis results, and the comments. The first thrust analysis was done in a controlled way to account for the structure's entire gravitational load (gravity thrust). The examination of the lateral push on the other side is done in a manner to regulate the removal from the end of the gravitational force. In order to verify the results of this study, we compared thrust curve force and spectrum removal requirements

Both a linear and an indirect analysis have been performed on the chosen bridge model. The findings of linear static analysis, modal stretch characteristics of the bridge, results of thrust analysis, and comments are included in this section. To determine the structure's overall gravitational pull, the initial thrust study was conducted under carefully controlled conditions (gravity thrust). When doing lateral push tests, it is important to manage the amount of force that is removed from the end of gravitational force. We compared the thrust curve's power to the amount of spectrum reduction needed to verify our findings.

Resultant Base Shear Vs. Monitored Displacement

Following figure 3 shows the Graph of Resultant base shear vs. monitored Displacement of I Section Bridge designed in SAP2000 Software

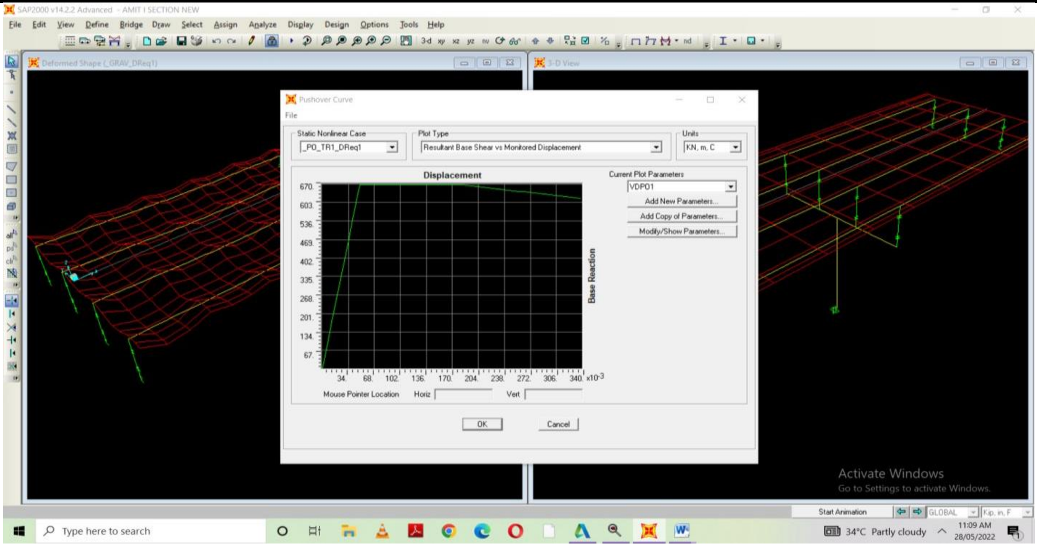

Figure 3: Resultant base shear vs. monitored Displacement (I section)

Following figure 4 shows the Graph of Resultant base shear vs. monitored Displacement of U section bridge designed in SAP2000 Software

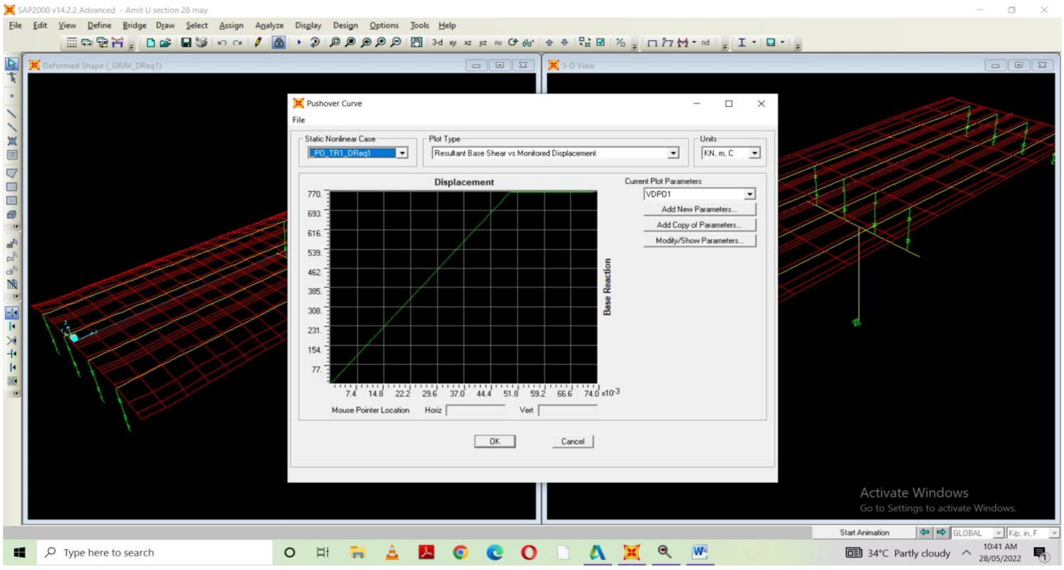

Figure.4: Resultant base shear vs. monitored Displacement (U section)

Resultant Base Shear vs. Monitored Displacement

Following Table 3 Gives the resultant Base shear and monitored Displacement of I Section and U section bridge designed in SAP2000 Software, it shows that the base shear Based on the analytical study the value of base shear for U section bridge increases with 14.9% when compared with I section bridge and The following Figure 6 shows the Displacement for U Section Bridge decreases with 5% when compared with I section.

Table 3: Base Shear and Displacement

Section Type	Base Shear	Displacement
U Section	770	0.0495
I Section	670	0.0518

The following Figure 5 Shows the base shear Based on the analytical study the value of base shear for U section bridge increases with 14.9% when compared with I section bridge

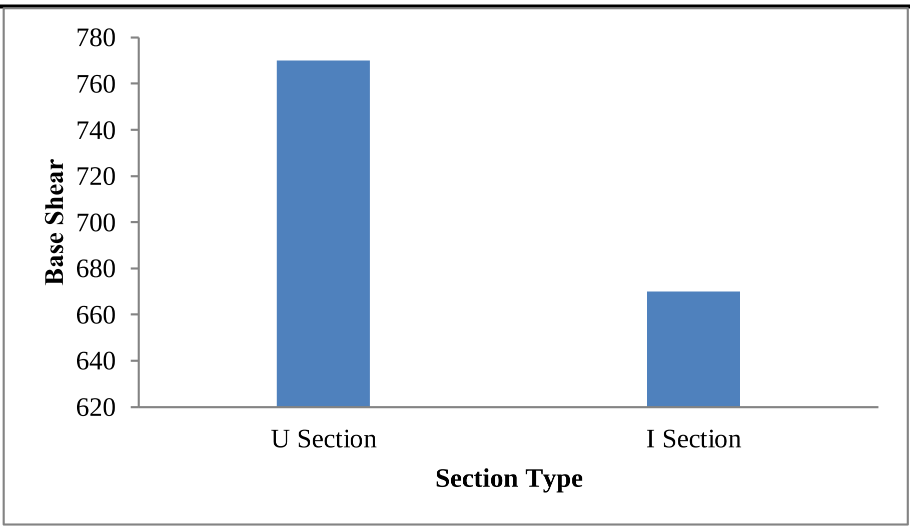

Figure 5: Base Shear

The following Figure 6 shows the Displacement for U Section Bridge decreases with 5% when compared with I section.

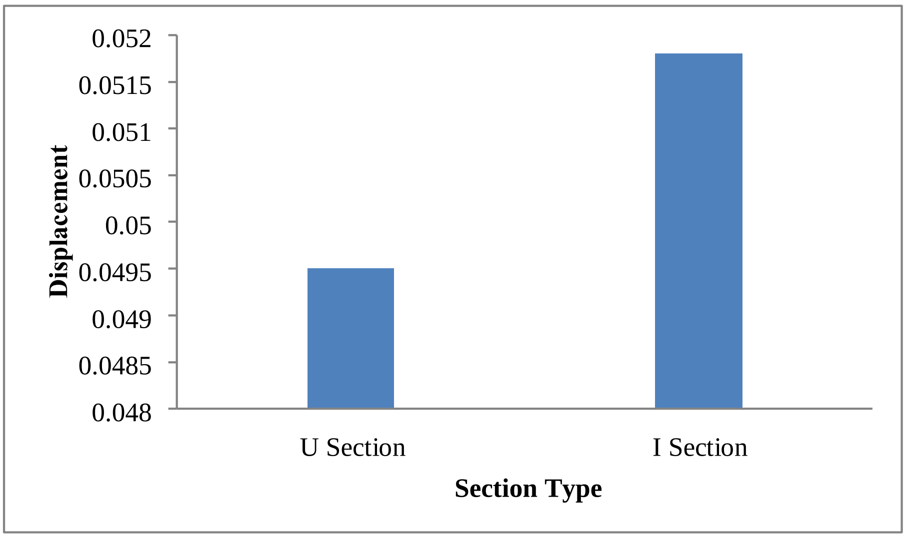

Figure 6: Displacement

CONCLUSIONS

The modeling of reinforced concrete U section and I section bridge is carried out by using SAP 2000 software, based on the push over analysis the following conclusions were drawn

- The base shear of U section bridge is significantly increases under same loading conditions when compared with I section bridge with reduced displacement capacity.
- According to analytical results, the I section reinforced concrete bridge is better option for construction when compared with U section reinforced concrete bridge geometry.
- The I section bridge shows good performance in terms of base shear, displacement, spectral acceleration, spectral displacement as compared with U section reinforced concrete Bridge.

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