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# A Comparative Analysis of Reinforced Concrete Bridges Utilising Pushover Analysis

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**Abstract- Push-over analysis is a nonlinear method for seismic evaluation of structures. It is an analysis based on performance. It provides engineers with the ability to design reliable structures. This paper examines the seismic response of RC bridges in terms of base shear and displacement on three- and six-span bridges using pushover analysis. In the present analysis the bridge is designed as per IS 456:2000, IS 1893:2016 and IRC 6 2016. The roll over analysis is conducted in accordance with ATC 40 and FEMA 356. This study's primary objective is to compare the capacity of two bridges with different spans using nonlinear static pushover analysis. The bridge's pushover analysis was conducted using the structural analysis and design software CSI Bridge version 22.**

**Keywords- Pushover analysis, Bridge construction, Pushover curves, Base shear, inflexible analysis.**

## I. INTRODUCTION

A bridge is an essential component of transportation networks for connecting two locations. The initial cost of building a bridge is considerable. Additionally, it is not possible to construct structures in a brief amount of time. Earthquakes have an effect on structures such as bridges. Therefore, bridges should be designed with earthquakes in mind. In India, numerous earthquakes have occurred in the last century.

More than fifty percent of the country is designated earthquake-prone. If a bridge is damaged, the country's economy will be impacted indirectly. There is a need for research on bridge damage control. Bridge response is determined by elastic analysis. It does not provide a failure mechanism or force redistribution, as plastic hinges do.

Failure mechanism is determined through inelastic analyses, such as nonlinear pushover analysis. On the basis of time-independent displacement geometry, force distribution and target displacement are determined. In the 1970s, nonlinear pushover analysis was introduced into practise, but its potential has only been recognised within the last 10 to 15 years.

The primary purpose of pushover analysis is to estimate the strength and drift capacity of a structure. This method can be used to create novel structures. In India, the bridge design code does not require seismic design. To evaluate capacity, therefore, foreign regulations such as FEMA and ATC 40 are considered.

## II. LITERATURE REVIEW

**Kimeze and Kyakula, et., al.,2023** Pushover analysis is typically performed using the concentrated plasticity model, in which a hinge is situated at the location where yield occurs. The yielded block spread plasticity model replaces an elastic sub-element of the beam with a yielded sub-element having a reduced cross-section and second moment of area when a point reaches yield. These two models disregard splitting.

This study proposes a spread cracking and yielding block model to investigate the effects of considering cracking during modelling on the accuracy of estimating deformations in reinforced concrete (RC) structures during pushover analysis. To account for the progressive spread of fracture in the beam, the proposed model includes a sub-element with cracks. A single-story RC frame is utilized because lateral

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load distribution is not an issue. Comparing the proposed model to existing models reveals an improvement in the accuracy of the rotational, displacement, moment, and lateral load capacities, respectively.

All theoretical models underestimate the eventual floor displacements and lateral load capacities, according to experimental findings. However, the proposed model is more accurate on both fronts than the two existing theoretical models.

**Fujii and Masuda et., al.,2021** This paper assessed mode-adaptive bidirectional pushover analysis (MABPA) for base-isolated irregular structures. The improved MABPA predicts the first and second modal response peaks using energy balance during a structural response half cycle. For base-isolation retrofitting of an irregular reinforced concrete structure, the main building of the old Uto City Hall, which was extensively damaged in the 2016 Kumamoto earthquake, was studied in numerical instances.

The MABPA peak response and nonlinear time-history analysis findings demonstrated that MABPA can accurately forecast peak relative displacement. The modified building models performed well for ground motion in this investigation, including the 2016 Kumamoto earthquake**.**

## III. METHODOLOGY AND ANALYSIS

### 1. Characteristics of Model:

Table 1. Characteristics of Model 1- Three Span RC Bridge.

| | | |
|---|---|---|
| 1 | No of Spans | 3 N0 |
| 2 | Length of Each Span | 20 m |
| 3 | Total Length of Bridge | 60 m |
| 4 | Width of Bridge | 7.30 m |
| 5 | Column | 0.60 m x 0.45 m |
| 6 | Beam | 0.60 m x 0.45 m |
| 7 | Concrete | M 40 |
| 8 | Steel | Fe 500 |
| 9 | Foundation | Fixed |
| 10 | Bearing | Fixed |

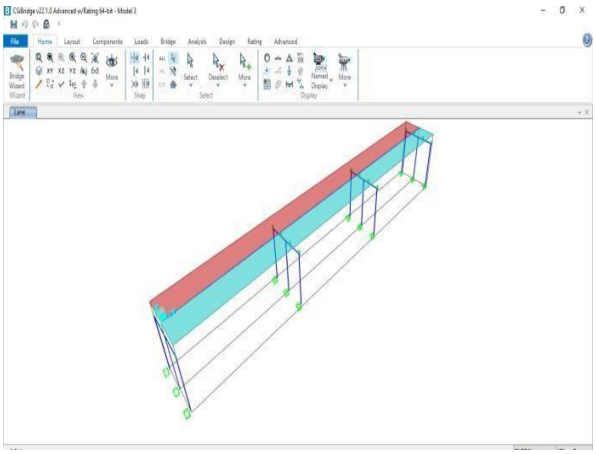

Fig 1. Model 1- Three Span RC Bridge in CSI Bridge Software.

Table 2. Characteristics of Model 2- Six Span RC Bridge.

| | | |
|---|---|---|
| 1 | No of Spans | 6 N0 |
| 2 | Length of Each Span | 10 m |
| 3 | Total Length of Bridge | 60 m |
| 4 | Width of Bridge | 7.30 m |
| 5 | Column | 0.60 m x 0.45 m |
| 6 | Beam | 0.60 m x 0.45 m |
| 7 | Concrete | M 40 |
| 8 | Steel | Fe 500 |
| 9 | Foundation | Fixed |
| 10 | Bearing | Fixed |

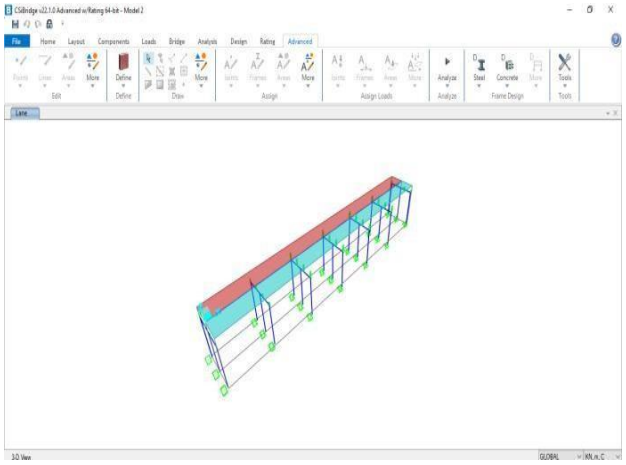

Fig 2. Model 2- Six Span RC Bridge in CSI Bridge Software.

### 2. Analysis:

A structure is exposed to gravity loading as well as a monotonically increasing lateral load pattern via elastic and inelastic behaviour until an ultimate state is attained in the pushover static nonlinear analysis technique. The arrangement of the lateral load may

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be proportional to the distribution of mass along the structure's height and mode shape, and it may indicate the range of base shear brought on by earthquake loading. An output pushover curve that graphs a strength-based parameter versus deflection is produced. Performance may, for instance, plot the bending moment versus plastic rotation or connect the strength level attained in certain parts to the lateral displacement at the top of the structure. Results reveal the structural system's ductile capability and reveal the mechanism, stress, and deflection at which failure occurs.

According to FEMA 356 criteria, discrete hinge points where plastic rotation occurs are ascribed material non linearity when analysing frame objects. Strength decreases, displacement regulated, and all other nonlinear software characteristics, such as link assessment P delta effect and staged constructions, are taken into account during the static pushover analysis. The various models with varying spans, concrete quality, and steel quality are examined. CSI Bridge software is used in this instance to conduct pushover analysis for the bridge while taking gravity, push x, and push y load situations into account. The pushover study produced pushover curves.

## IV. RESULT

The Pushover analysis is carried out for two models. The pushover curves for model 1 in 'X' Direction (longitudinal) and in 'Y' Direction are shown in figure 3 and 4. A brief comparison of results were tabulated in the table 3. Base shear for different models is shown in table 3 and figure 5.

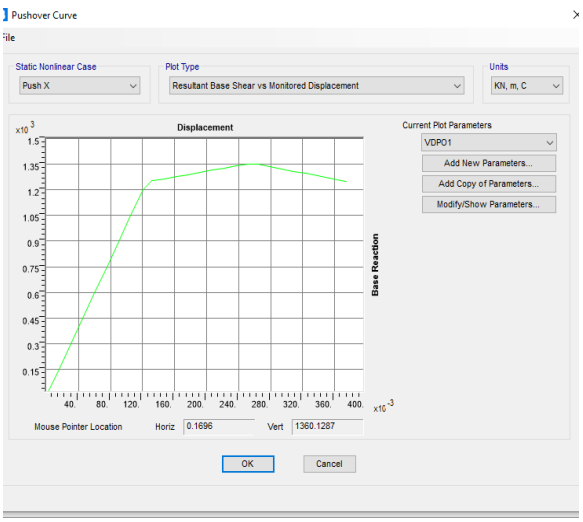


Fig 3. Pushover Curve in Longitudinal Direction

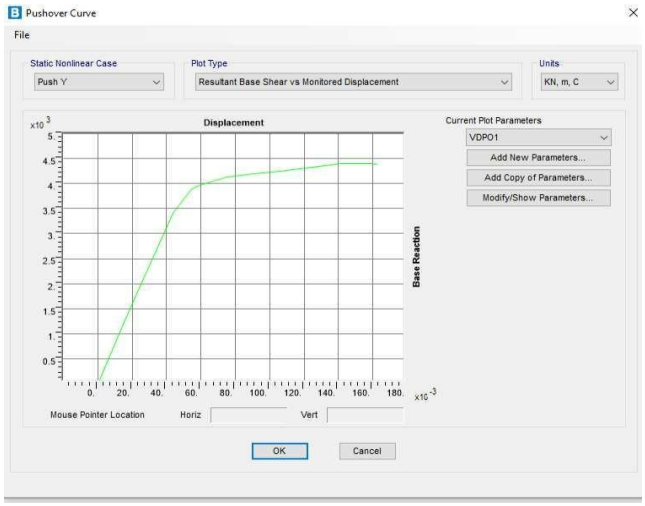


Fig 4. Pushover Curve in Lateral Direction.

Table 3. Bridge Model comparison on base shear.

| Model | Comparison between | Base shear % increase | Base shear % increase |
|---|---|---|---|
| 1 & 2 | Model 1 and Model 2 | 4.23 | 5.44 |

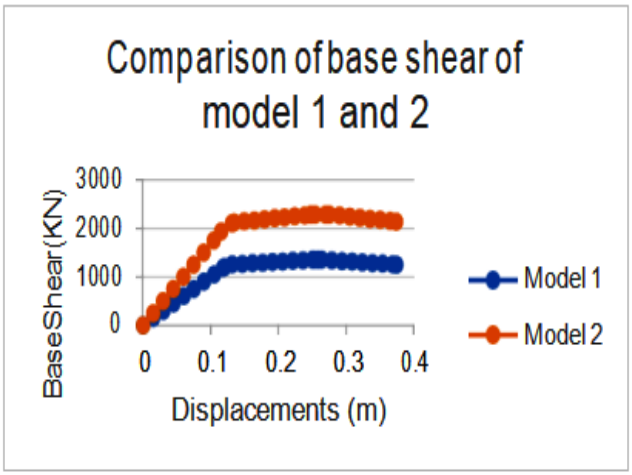


Fig 5. Comparison of base shear of model 1 and 2 in x direction.

Figure 5 show a comparison between Model 1 and Model 2 based on displacement versus base share due to the base shear's dramatic change.

## V. CONCLUSION

The base force required for a short span bridge in the X direction is 4.23% more than that of a bridge with a long span when the span and steel grade stay constant and only the grade of the concrete changes. Similar to this, a bridge with a short span requires 5.44% greater base force in the Y direction than a bridge with a long span.

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The bridge is stronger in the 'Y' direction because the base shear values are higher in the 'Y' direction than the 'X' direction. The base shear capacity of the bridge structure is directly impacted by the change in span length, grade of concrete, and grade of steel, as shown by the results above.

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