

Influence of RC Jacketing on seismic vulnerability Bridges

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Abstract - Jacketing as been done for Rc bridges by increasing its columns size with skew angles and comparing its frequency, time period, displacement, acceleration, base shear. Column size from 0.54m*0.54m to 1m*1m and 1.2m*1.2m and also the skew angles are 30°, 45°, 60° as been taken. The models were used to represent bridges located in zone 2 of India. The systemic parameters studied are natural period, base shear, roof displacement, lateral displacement, Joint acceleration of column. Time history analysis has been considered out .the structures has been subjected to a set-off ground motion.

Key Words: RC bridge; Frequency; Natural period; Base shear; Roof displacement; lateral displacement; and Joint acceleration of column

1. INTRODUCTION

The initially bridges were made by environment — by way of simple as a log fallen across a watercourse. The first bridges made by persons were probably spans of woods or planks and eventually stones using a simple sustenance and crossbeam plan. Utmost of these early bridges could not support heavy weights or withstand strong flows. It was these lacks which led to the development of better bridges. The ancient persisting stone bridge in China is Zhao Zhou Bridge, fabricated from 595 to 605 AD during the Sui Dynasty. This bridge is also traditionally significant as it is the world's oldest open-spandrel stone segmental arch bridge. The first book on bridge engineering was written by Hubert Gautier in 1716. With the Industrial Revolution in the 19th century, truss systems of wrought iron were developed for larger bridges, but iron did not have the tensile strength to support large masses. Using the initiation of steel, which has a high tensile strength much bigger bridges were constructed.

Bridges are classified on the source that how the four forces namely shear, compression, stiffness, and moment are circulated in the bridge building.

The current earthquake-destruction to bridges and other buildings located within a few kilometers from a fault separation clearly indicated the importance to consider the near-field ground motion effect. As shown, the amount of acceleration was very high, and was considered by single pulses with large acceleration and long predominant dated. As well as the strong intensity, the directivity of the near-field ground motion is important in seismic project. This is important in considering the effect of bilateral directional

excitation. Perhaps the effect of bilateral excitation for bridges may be measured in terms of difference of ductility capacity of piers [Mahin and Hachem 1999].

Bridge's piers can be damaged by the action of intense quakes. These essentials are the most important component of the structural stability of a bridge system. Later the occurrence of an earthquake or after updates in the design code, the piers may require an intervention to improve their strength and stiffness volumes. For a long time, RC jacketing has been used as a suitable technique to provide additional strength and to improve the ductile behavior of columns under seismic loads. There are number of studies linked to the behavior of bridges retrofitted with RC jacketing, but there is a lack of computable estimations for this technique regarding the seismic susceptibility of a bridge.

1.1 Types of bridges

- 1.1.1 Girder bridges
- 1.1.2 Arch bridges
- 1.1.3 Cable stayed bridges
- 1.1.4 Rigid frame bridges
- 1.1.5 Truss bridges

1.1.2 Arch bridges

Arch bridges posture a typical architecture and the eldest after the girder bridges. Dissimilar simple girder bridges, arches are well suited to the use of stone. Meanwhile the arch doesn't require piers in the center so arches are decent choices for crossing valleys and streams. Arches can be one of the most beautiful bridge types. Arches use a curved structure which provides a high resistance to bending forces. Arches can only be used where the ground or foundation is solid and stable because unlike girder and truss bridges both ends of an arch are fixed in the horizontal system.

2 OBJECTIVE AND METHODOLOGY

2.1 Objective of the study

- To investigate the influence of repair to individual RC bridge columns on the post repair seismic performance of a bridge system.
- To study the performance of the bridge models contains varied number of repaired column was comparable to

that of the bridge only original columns with respect to the target system level performance.

2.2 Methodology

- The bridge considered for study is assumed to be located in zone-2 of India.
- Material and section properties are defined and assigned to the models.
- Base of models are fixed.
- Five seriously damaged Rc columns are with different damage conditions are repaired. Using developed repair method.
- Bridge with skew angle 30°, 45°, 60° has been studied. And it will be analyzed by CSI Bridge software.

3. Range of parameters considered

Table 3.1: Parameters

Types of bridges	Box-Girder bridge
Total length of bridge	75 mts
Width of bridge	11 mts
Number of span	5 nos
Span distance	15 mts
No of Lanes	2 nos
No of columns	1 nos
Restraints	Fixed
Pier size	0.54mx0.54m, 1mx1m, 1.2mx1.2m
Bent cap size	1.2m x 0.9m x 9m
Skew angle	30°, 45°, 60°
Type of vehicle	IRC AA tracked

Table 3.2 Material properties

Material Properties	Values
Unit volume	25 KN/m ³
Young's modulus	30000×e ⁶ KN-m ²
Poissons ratio	0.15
Shear modulus	12325.17 Mpa
Co-efficient of thermal expansion	1.17×e ⁻⁵ °C
Co-efficient of concrete	1.17×e ⁻⁵ °C
Compressive strength of concrete	35 N/mm ²

4. Present Study

A 3 dimensional study of a skew bridges before and after retrofitting with different skew angles (30°, 45° and 60°) with fixed based and the base of the modal is subjected to acceleration vs time history of a Elcentro earthquake is presented. The variation of frequency, time period and structural responses for various parameters like base shear, longitudinal stress and drift studied and retrofitting is done for the modal by changing column size to 1m x 1m and 1.2m x 1.2m for different skew angles, all models are subjected to time history.

The typical models layout plan considered in present study as shown in the figures

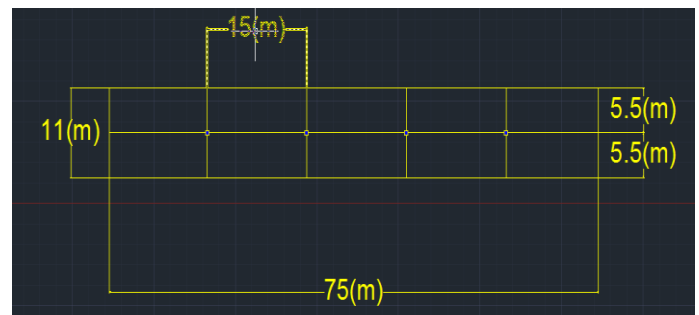


Fig 4.1: Shows the layout plan of 2 lane box girder bridge

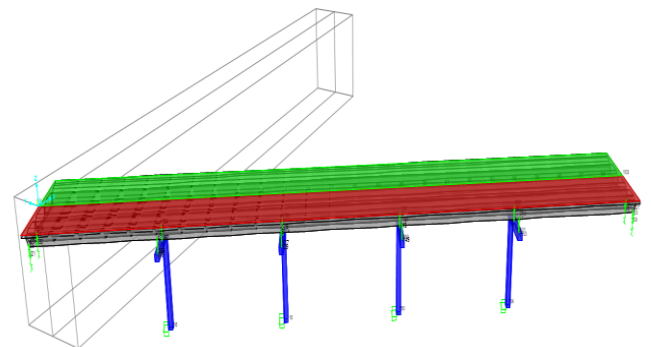


Fig 4.2: Shows the front view 0.54m size of a column with skew angle 30°

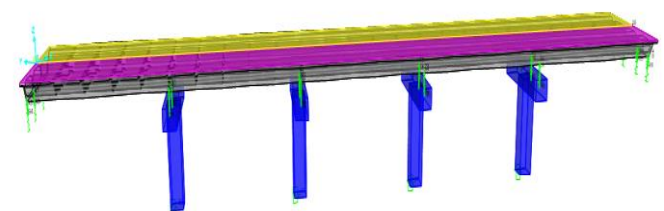


Fig 4.3: Shows the front view 1m size of a column with skew angle 30°

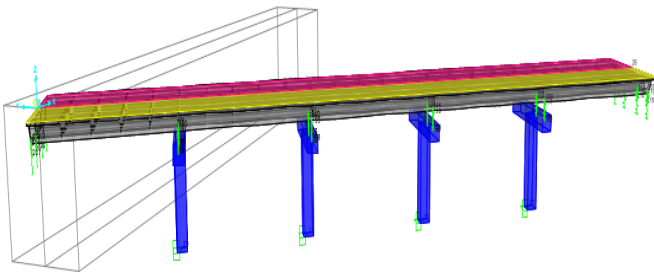


Fig 4.4: Shows the front view 1.2m size of a column with skew angle 30°

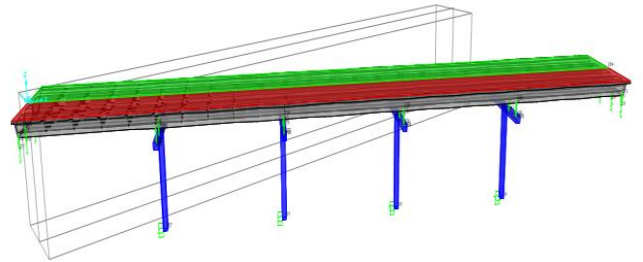


Fig 4.8: Shows the front view 0.54m size of a column with skew angle 60°

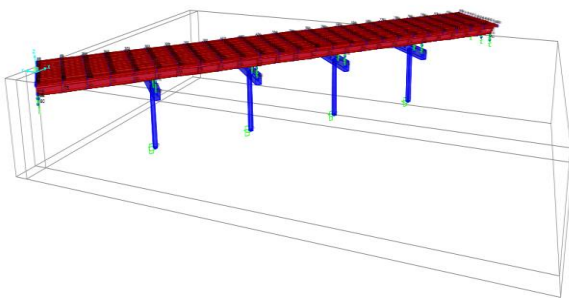


Fig 4.5: Shows the front view 0.54m size of a column with skew angle 45°

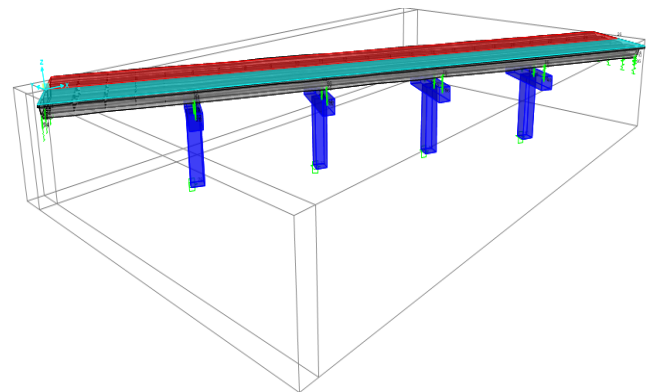


Fig 4.9: Shows the front view 1m size of a column with skew angle 60°

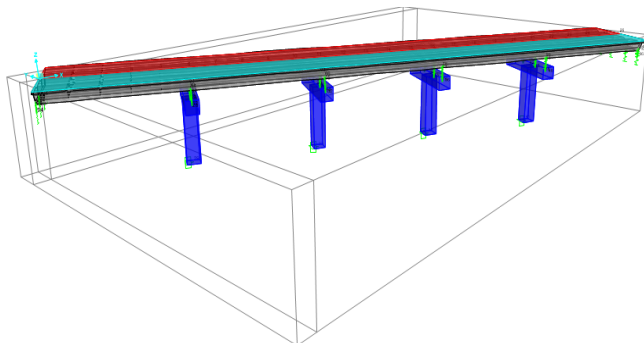


Fig 4.6: Shows the front view 1m size of a column with skew angle 45°

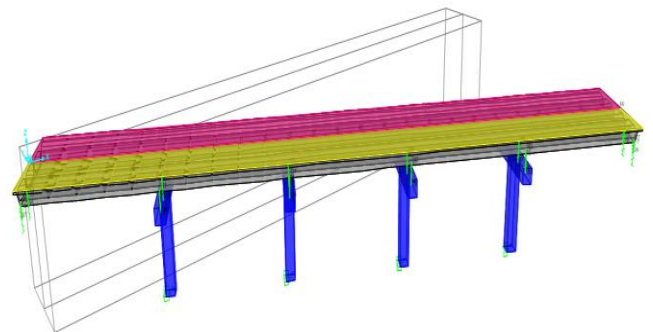


Fig 4.10: Shows the front view 1.2m size of a column with skew angle 60°

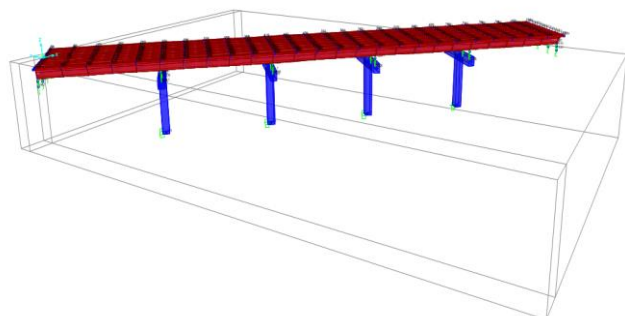


Fig 4.7: Shows the front view 1.2m size of a column with skew angle 45°

5) Result and Discussion

5.1) Variation in frequency

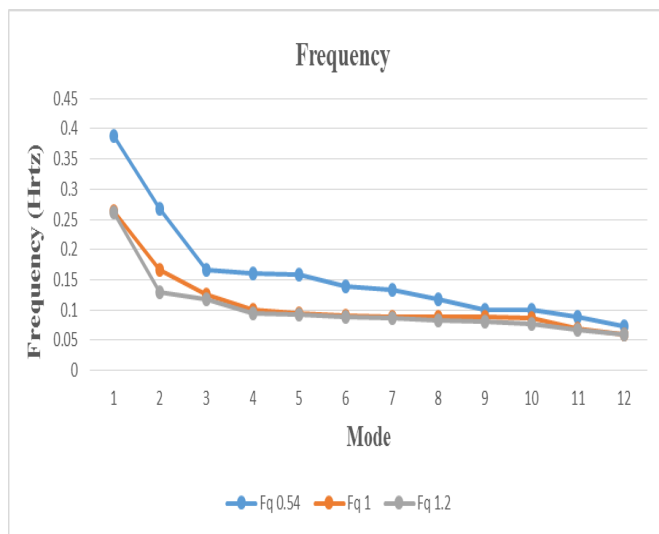
The variation in natural frequency due to the effect of retrofitting studied on a 75 mts span skew bridges with different skew angles (30°, 45° and 60°) and column sizes (0.54m x 0.54m, 1m x 1m and 1.2m x 1.2m) with fixed base. The retrofitting is done by changing the column sizes to 1m x 1m, 1.2m x 1.2m.

5.1.1 Effect of change in column size for Frequency:

From the below table it as been observed that there is a decrease in frequency after retrofitting that is after changing column sizes to 1m x 1m and 1.2m x 1.2m. A percentage decrease of 31.78% to 51.54% is observed when compared with column size of 0.54m x 0.54m respectively. For the frequency for mode 1, mode 2 and mode 3. From table 5.1

Table 5.1: Variation in frequency for different column size

Frequency (Hertz)	Before retrofitting		After retrofitting		% Variation	
	0.54x0.54 (m)	1x1 (m)	1.2x1.2 (m)			
Mode 1	0.387	0.264	0.260	31.78	32.8	
Mode 2	0.268	0.165	0.130	38.4	51.4	
Mode 3	0.165	0.125	0.117	24.20	29.09	



Graph 5.1 Variation in frequency for different column size

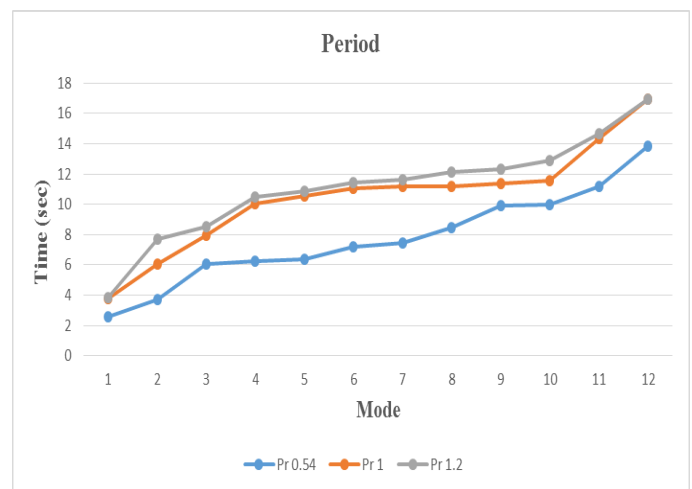
From the above graph we can observe that decrease of frequency after retrofitting that in change in column size to 1m x 1m and 1.2m x 1.2m. A orange and a gray line indicates frequency after retrofitting and blue line shows before retrofitting.

5.2) VARIATION IN TIME PERIOD:

The variation in time period due to the effect of retrofitting studied on a 75 mts span skew bridges with different skew angles (30°, 45° and 60°) and column sizes (0.54m x 0.54m, 1m x 1m and 1.2m x 1.2m) with fixed base. The retrofitting is done by changing the column sizes to 1m x 1m, 1.2m x 1.2m.

Table 5.2: Variation in time period for different column size

Time Period (sec)	Before retrofitting	After retrofitting		% Variation	
	0.54x0.54 (m)	1x1 (m)	1.2x1.2 (m)		
Mode 1	2.580	3.780	3.831	31.74	32.65
Mode 2	3.726	6.032	7.690	38.22	51.54
Mode 3	6.044	7.972	8.501	24.18	28.90



Graph 5.2 Variation in time period for different column size

From the above graph 5.2.1 we can observe that increase in time period after retrofitting that in change in column size to 1m x 1m and 1.2m x 1.2m. A orange and a gray line indicates period after retrofitting and blue line indicates before retrofitting.

5.3) Effect of ground motion:

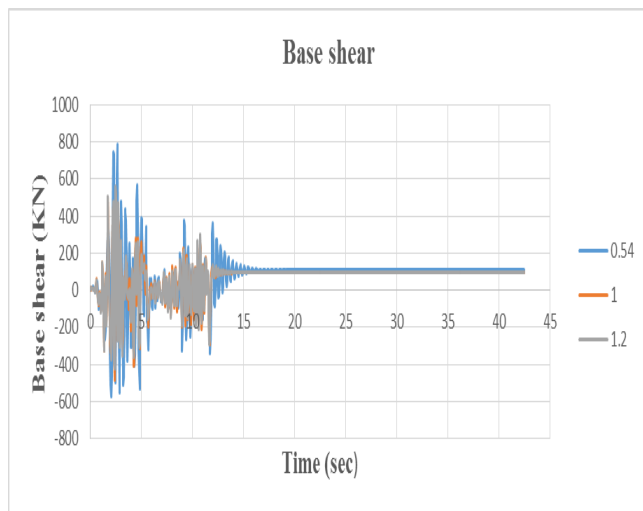
Here the bridge is subjected to earthquake ground motion of bhuj and response of 3d structure (In terms of base shear) is studied with different column sizes and skew angles.

5.3.1 Effect of change in column size for Base shear for different skew angles:

The effect of change in base shear of a column before and after retrofitting studied on a 75 mts span skew bridges with different skew angles (30°, 45° and 60°) and column sizes (0.54m x 0.54m, 1m x 1m and 1.2m x 1.2m) with fixed base. The retrofitting is done by changing the column sizes to 1m x 1m, 1.2m x 1.2m

5.3.1 (a) Base shear for skew angle 30°:

In the discussion comparison is carried for the model with different column size with skew angle 30°. It is observed that base shear decrease in column sizes as after retrofitting with size (1m x 1m and 1.2m x 1.2m) is done. The variation for different size of columns with skew angle 30° is shown in graph 5.3.1 (a)

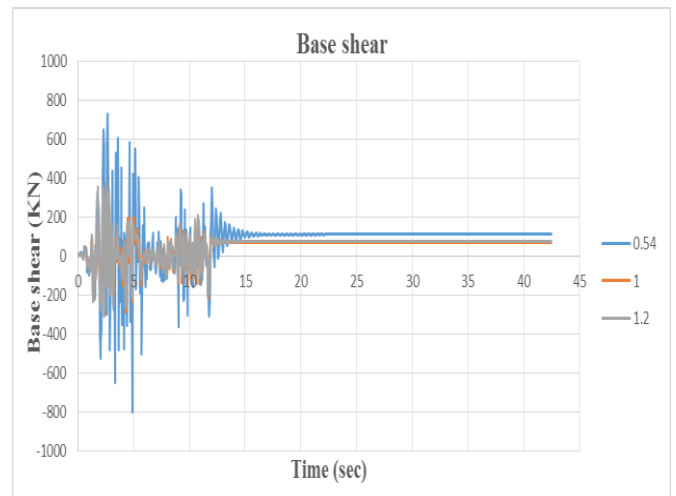


Graph 5.3.1(a) Variation in base shear for skew angle 30° for different column size

From the above graph 5.3.1 (a) it is observed that there is a decrease in base shear after the retrofitting for the column for box girder Bridge with skew angle 30° respectively and maximum decrease in base shear as occurred after retrofitting from (0.54m x 0.54m) column to(1m x 1m and 1.2m x 1.2m) columns.

5.3.1 (b) Base shear for skew angle 45°:

In the discussion comparison is carried for the model with different column size with skew angle 45°. It is observed that base shear decrease by increasing column sizes as after retrofitting with size (1m x 1m and 1.2m x 1.2m) is done. The variation for different size of columns with skew angle 45° is shown in graph 5.3.1 (b)

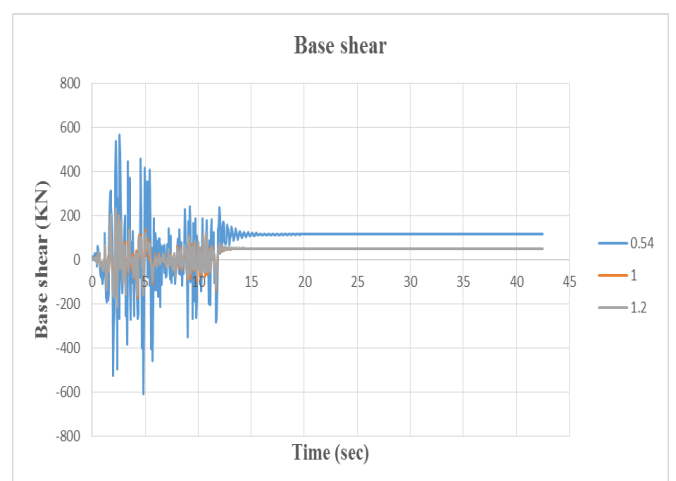


Graph 5.3.1(b) Variation in base shear for skew angle 45° for different column size

From the above graph 5.3.1 (b) it is observed that there is a decrease in base shear after the retrofitting for the column for box girder Bridge with skew angle 45° respectively and maximum decrease in base shear as occurred after retrofitting from (0.54m x 0.54m) column to (1m x 1m and 1.2m x 1.2m) columns.

5.3.1 (c) Base shear for skew angle 60°:

In the discussion comparison is carried for the model with different column size with skew angle 60°. It is observed that base shear decreases by increasing column sizes as after retrofitting with size (1m x 1m and 1.2m x 1.2m). The variation for different size of columns with skew angle 60° is shown in graph 5.3.1(c)



Graph 5.3.1(c) Variation in base shear for skew angle 60° for different column size

From the above graph 5.3.1 (c) it is observed that there is a decrease in base shear after the retrofitting for the column

for box girder Bridge with skew angle 60° respectively and maximum decrease in base shear as occurred after retrofitting from (0.54m x 0.54m) column to (1m x 1m and 1.2m x 1.2m) columns.

CONCLUSIONS

- The Frequency decreases as the column size increase and the system resonance effect will become least after retrofitting bridge.
- In comparison to the before retrofitting bridges and after retrofitting bridges, the Frequency decreases up to **24.2** to **51.4** % for after retrofitting bridges compared to before retrofitting bridges.
- The natural time period increases as the column size increase and the system will response less against lateral load in case of after retrofitting bridges.
- In comparison to the before retrofitting bridges and after retrofitting bridges, the time period increases up to **24.18** to **51.54** % for before retrofitting bridges compared to after retrofitting bridges.
- Maximum % variation of frequency and time period is observed with skew angle 45° and column size 1.2×1.2 m.
- For analysis and numerical study bhuj earthquake data is considered .from the results concludes that as skew angle increases responses of displacement, acceleration and base shear also increases.
- The increased structural of skew bridges is controlled by the influence of RC jacketing.
- Maximum decrease in base shear, joint acceleration and displacement is observed is observed for all skew angles with column sizes 1.2×1.2 m.
- Study concludes that RC jacketing is an effective technique to control seismic response and enhances the life span of an old bridges.

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