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EXTENDED ABSTRACT

The effect of FRP use on the Damage Index, Seismic Performance Levels and Ductility of The Bridges Circular Columns by Using IDA and NSP Analyses

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1. Introduction

One of the purposes of this study is to investigate the effect of the FRP use in order to increase the ductility capacity and reduce the ductility demand under dynamic loads. In this order the maximum ductility demand in the circular columns used in the bridges in the cases of use and disuse of FRP under far field earthquake records has been investigated and the effect of this application on the ductility demands has been determined quantitatively. By using the results of this study, the effect of FRP using in increasing the lateral strength of these columns has been investigated quantitatively.

In the following, the columns damages in the cases of use and disuse of this polymers has been investigated quantitatively using an appropriate damage index and the effect of their use in reducing seismic damages has been studied.

Finally, using incremental non-linear dynamic analyses on these columns considering confinement due to the polymers, seismic performance level such as operational, Immediate Occupancy, life safety and Collapse Prevention limit states has been investigated and the effect of using FRP in bridges circular columns on the improvement of their seismic performance has been evaluated.

2. Methodology

2.1. Column Properties

The under consideration column properties are selected based on one of the models recommended by Hu (2014) and its modeling is performed in Opensees software. The used column for analyses is made of concrete with circular cross section with 365 mm diameter and 1470mm height. The compression strength of the unconfined concrete is considered equal to 40.4Mpa. The yield stress and modulus of elasticity of steel are given as 450 and 2×10^5Mpa respectively.

2.2. FRP modeling

Thickness, tensile rupture strength and modulus of elasticity for FRP polymers are considered to be equal to 1mm, 900Mpa and 2×10^4 respectively. For modeling the behavior of confined concrete materials with FRP, the SZM model is used which was proposed by Shao (2006) for considering the effects of circular cross sections confinement with FRP. For modeling the curve for confined concrete behavior with FRP polymers in Opensees software, concrete01 material was used for which the tensile strength of concrete is neglected.

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2.3. Non-linear static analysis

The under consideration column is under push over analyses in all confinement modes and the diagram of the base shear against the deformation of the column top is obtained. Regarding the obtained results from these analyses, the ductility capacity, yield strength and yield displacement for each column in different confinement modes are acquired and compared to each other.

2.4. Non-linear dynamic analysis

Non-linear dynamic analyses on the considered column in different modes of confinement are performed using the far field earthquake records. The levels of ductility demand and damage index caused in the column in different modes of confinement under earthquake records and their averages are computed and compare to each other.

2.5. Incremental non-linear dynamic analyses

Incremental non-linear dynamic analyses on the considered column in different modes of confinement are performed using 22 far field records. In order to investigate the different performance levels of this columns, the respective spectrum acceleration for each performance level in different modes of confinement for all earthquake records are obtained using interpolation and the median of the results is computed and compared in each case.

3. Results and discussion

3.1. The effect of using FRP polymers on ductility capacity of column

By using FRP polymers even in one layer, the ductility level has been increased approximately 57% compared to the column without polymers. This amount of increase for two and three layer columns is 114 % and 200% respectively. By adding FRP due to confinement and more energy absorption capacity, the displacement that can be endured by the column before its collapse are increased and hence its plasticity will be increased consequently.

3.2. The effect of FRP polymers on column yield strength

The yield strength of this column is increased as a result of confinement increase. This amount of yield strength increase is 40%, 56% and 61% for one, two and three layer FRP compared to the case without FRP.

3.3. The effect of FRP polymers on maximum seismic ductility demand of column peak

With the increase of FRP layers around the column and its thickness, the amount of ductility demand in the column is reduced. This shows the effect of using FRP in different layers in order to increase the column seismic performance under dynamic loads. Thus the use of FRP with more thicknesses will improve the column seismic performance.

3.4. The effect of FRP on column damage index

By using FRP for columns confinement, the amount of damage occurred in the column will be reduced. This amount of decrease is increased by increasing the FRP layers. The amount of damage index reduction under different earthquakes for one, two and three layers FRP is 34%, 54%, 64% respectively compared to the case without FRP.

3.5. The effect of FRP on column seismic performance levels

By increasing the number of FRP layers around a column, the amount of spectral acceleration needed for the column to reach a specified performance level is increased. This amount of increase in OP performance level in one, two and three layers of confinement modes is 2.31, 2.6 and 2.67 times of that of the unconfined case respectively. For IO performance level, this amount of increase is 2.33, 2.48 and 2.56 times of that of the

case without FRP and in the LS performance level it is 2.40, 2.46 and 2.86 times of the corresponding amount in the case without yarn.

4. Conclusions

In this paper, the effect of using FRP fibers in the number of different layers on the seismic performance of circular columns of bridges is evaluated. For this purpose, the circular column recommended by Hu (2014) was modeled in Opensees software and subjected to nonlinear static analysis, nonlinear time history and incremental nonlinear dynamic analysis. The results of these analyzes are as follows:

1) As the columns are confined by different layers of fibers, the lateral yield strength will increase compared to the case where these fibers are not used around the column.
2) The use of fibers around the column and increasing its confinement, the column will endure more displacement before its collapse.
3) The maximum ductility demand of the columns under different earthquake decreases with increasing confinement compared to the state without confinement.
4) The damage caused to the column will be reduced by increasing the confinement.
5) Spectral acceleration such as to reach the performance levels of Operational, Immediate occupancy, Life safety and Collapse limit in the use of FRP fibers compared to the non-use of these fibers around the column has increased significantly.

5. References

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