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SEISMIC EVALUATION OF A RC BRIDGE WITH MONOLITHIC CONNECTION OF MULTI-CELL CIRCULAR DECK AND PIERS

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ABSTRACT

Recent devastating earthquakes have shown that bridges are one of the most vulnerable components of transportation systems especially in urban regions. These seismic events have emphasized that there is need to mitigate the risk resulting from the failure of the bridges. Many of vulnerable bridges have been retrofitted in the United States and Japan after San Fernando (1971), Loma Prieta (1989), Northridge (1994) and Hyogo-ken Nanbu (1995) earthquakes. Lessons learned from these earthquakes have developed new versions of seismic design and retrofit codes of bridges. In the United States, AASHTO[1], FHWA[2] and Caltrans[3] have published too many guidelines and codes about new techniques for seismic design of new bridges and seismic rehabilitation of existing transportation structures. Unfortunately there were no regular programs for rehabilitation of bridge structures in other countries such as Iran in 3 last decades.

After Bam earthquake (2003) Iranian government defined different projects for evaluation, screening, prioritization and retrofit of important and vital structures in seismic areas. Tehran as capital has the most number of the highway bridges that some of them have been used since 40 years ago. Most of these bridges should be accessed after moderate to severe ground motions because of emergency. Failure of these important structures after an earthquake may be catastrophic. Unfortunately, many of old bridges in Tehran have no technical documents and structural drawings in municipality archives.

Because of lack of information, the Iranian consulting engineers tried to explore the structural details of these structures by Non-destructive and destructive methods. Strength of materials has been determined by field and experimental tests. Also geotechnical and geo-seismic field investigations and experiments have done for foundation analysis and soil specifications.

Keywords: vulnerability, seismic rehabilitation, concrete bridge, non-prismatic section, C/D ratios, retrofitting.

METHOLOGY AND RESULTS

Seismic hazard analysis of site was an important part of the study just for essential bridges. After completion of the data, screening and prioritization of the bridges have been performed. The structures categorized into 2 groups: The first group had no structural vulnerability and

[1] American Association of State Highway and Transportation Officials
[2] Federal Highway Administration
[3] California Department of Transportation

there is no need for retrofitting them. The second group was the bridges that detailed evaluation showed that they have to be retrofitted. For the latter group, the deficiencies have been detected and retrofit strategies, measures and approaches proposed.

In this study an urban highway bridge in Tehran which is accounted for as life line structure is evaluated. This bridge has four continuous support spans. The superstructure system is reinforced concrete slab with circular cells that is seated directly on concrete column without cap beam and bearing. The superstructure has a skew angle of 23°. The substructure involves reinforced non-prismatic piers that connect to the deck monolithically. The abutments are open type and there are six reinforced concrete columns and a cap beam for each of them. 3D finite element model of the bridge is developed using SAP2000 software. The dead and live loads assigned to structural elements according to Iranian Standard Loads for Highway & Railway Bridges (Code No.139).

For seismic loading, Iranian Road and Railway Bridges Seismic Resistant Design Code (Code No.463) has been used. Multi-mode spectral method has been chosen for seismic analysis of bridge. Structural analyses have been performed with cracked section consideration of reinforced concrete elements. For determination of effective specifications of cracked sections, moment-curvature analysis has been used. Detailed evaluation of the bridge is performed according to the FHWA-2006 rules (C/D Method).

In this approach, demands and capacities of structural members are calculated using linear elastic analysis. C/D values are calculated for bents, abutments, foundations and seat width. This is a force based method that assumes that elastic seismic forces (without R factors) are applied to the members. Capacities of members are calculated using no decreasing factor of strength ($\phi=0$) and increasing ductility factors (μ). After calculation of C/D values, the vulnerable members are detected

CONCLUSION

The results reflect the vulnerability of the main structural elements of the bridge during design earthquake and the necessity of retrofitting for improving its seismic behavior.