SEE 8
8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

INVESTIGATION OF PARAMETERS AFFECTING THE SEISMIC BEHAVIOUR OF REINFORCED CONCRETE ARCH BRIDGES

Adham GHOLIPOUR
Ph.D. Candidate, Babol Noshirvani University of Technology, Babol, Iran
a.gholipour@stu.nit.ac.ir

Mohammadreza DAVOUDI
Associate Professor, Faculty of Civil Engineering, Babol Noshirvani University of Technology, Babol, Iran
davoodi@nit.ac.ir

Hossein YOUSEFPOUR
Assistant Professor, Faculty of Civil Engineering, Babol Noshirvani University of Technology, Babol, Iran
hyousefpour@nit.ac.ir

Keywords: Arch bridges, Nonlinear time history analysis, Drift, Chord rotation, Unseating

Arches are primarily compressive members that have been extensively used as the main load-carrying elements in bridges. According to prior studies, a number of arch bridges have sustained noticeable damage during past earthquakes, such as the Wenchuan earthquake in China in 2008 and the Kobe earthquake in Japan in 1995. However, despite the significant use of arch bridges in the seismic prone areas of the world, limited studies have been performed on their seismic behavior.

This paper is focused on evaluating the sensitivity of the seismic behavior of reinforced concrete (RC) arch bridges to the variability in mechanical properties of concrete and reinforcement. The Siahbisheh Arch Bridge in Iran was used as the main case study. The 11-years-old bridge is a reinforced concrete deck-type arch bridge with a span length of 35 m. Three-dimensional models of the bridge were developed in SAP 2000 (Figure 1) and were subjected to nonlinear time history analyses using the ground motions listed in Table 1. The sensitivity of bridge response to the compressive strength of concrete, yield strength of reinforcing bars and earthquake orientation was also investigated.

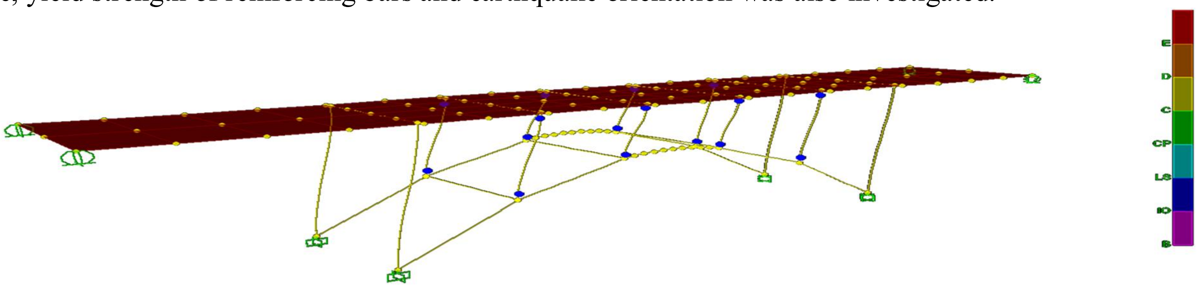


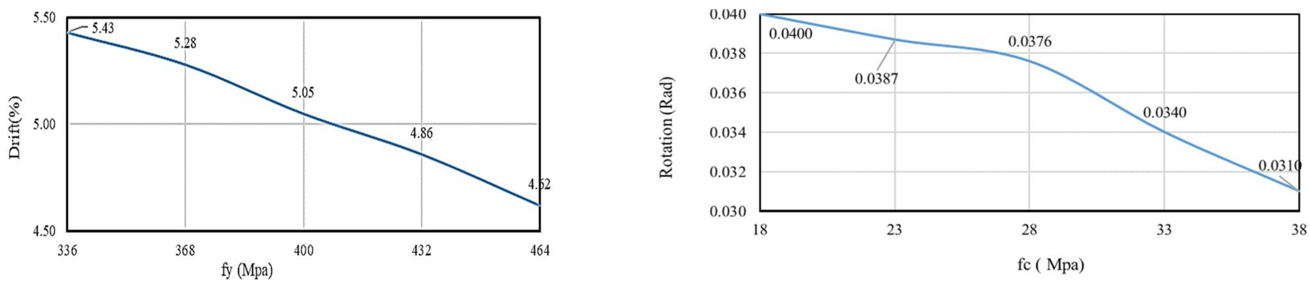
Figure 1. Formation of plastic hinges in nonlinear dynamic analysis.

Table 1. Ground motions properties.

No.	Station	Year	Duration (s)	Magnitude (Richter)	Focal Distance (km)	Soil Class	PGA (g)	Scale Factor
1	Manjil	1990	53	7.4	19	3	0.49	0.95
2	Bam	2003	66.54	6.6	8.5	3	0.62	0.63
3	Tabas	1978	32.98	7.7	70	3	0.71	0.83

For sensitivity analysis, the compression strength of concrete was varied by 5 MPa towards higher and lower compressive strengths. This range of variability was selected based on the provisions of the Iranian National Building Code (2013). The variability of the yield strength of reinforcement was based on suggestions by Ellingwood and Hwang (1985). According to these suggestions, a log-normal distribution, with a mean of 415 MPa and a coefficient of variation of 0.08 was used. The uncertainty in the orientation of earthquake was considered by changing the angle of the application of earthquake following a uniform distribution ranging from 0 to 360 degrees, as suggested by Nielson (2005), Padgett (2007), and Ramanathan (2012).

Results of the analyses showed that chord rotations and drifts associated with columns and unseating at abutments were more likely to govern the seismic behavior of arches compared with the chord rotation at the ends of the arch. Representative charts showing changes in drift as a function of yield strength of reinforcement and changes in chord rotation as a function of compressive strength of concrete are shown in Figure 2. It was also observed that maximum drift and maximum chord rotation during an earthquake are very sensitive to the yield strength of reinforcement and compressive strength of concrete. The results provide valuable insights that can be used for fragility analysis of concrete arches.



(a) Critical column's drift to yielding strength of bar (b) Critical column's chord rotation to compressive strength of concrete

Figure 2. Sensitivity of parameters to material uncertainties.

REFERENCES

American Society of Civil Engineer (2017). *Seismic Evaluation and Retrofit of Existing Buildings*. ASCE/SEI 41-17, Reston, Virginia.

Ellingwood, B. and Hwang, H. (1985). Probabilistic descriptions of resistance of safety-related structures in nuclear plants. *Nuclear Engineering and Design*, *88*(2), 169-178.

Iranian National Building Code (2013). Chapter 9: Design of Reinforced Concrete Buildings.

Nielson, B.G. (2005). *Analytical Fragility Curves for Highway Bridges in Moderate Seismic Zones*. Ph.D. Dissertation, Georgia Institute of Technology.

Padgett, J.E. (2007). *Seismic Vulnerability Assessment of Retrofitted Bridges Using Probabilistic Methods*. Ph.D. Dissertation, Georgia Institute of Technology.

Ramanathan, K.N. (2012). *Next Generation Seismic Fragility Curves for California Bridges Incorporating the Evolution in Seismic Design*. Ph.D. Dissertation, Georgia Institute of Technology.