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Seismic Assessment of Three Generations of Isfahan Bridges Using Fragility Curves

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ABSTRACT: Highway Bridges are a major part of the transportation network and an important part of a country's national economy. Despite numerous studies on their seismicity and fragility, very little research has comprehensively addressed all of their dimensions. In this regard, the purpose of this study is to consider the unique details of the design period of these bridges in Isfahan City. To do so, the bridges of the last 50 years in Isfahan were examined through fragility curves. Considering uncertainties and changes in loading in this study is one of the most important surveys conducted through the non-linear history-time analysis method. The 1971 San Fernando and 1989 Loma Prieta earthquakes revolutionized the philosophy of bridge design. Therefore, the study of the three bridges that were designed and built in the three periods before the San Fernando earthquake, after that and after the Loma Prieta earthquake has been done. The results of this study showed that due to the significant improvements in different seismic codes, the possibility of damage to bridges at different times, under the influence of different earthquake intensities is likely. Also, according to the results of this study, column failure is not the sole criterion of bridge failure and the involvement of different components of a bridge in the probabilistic seismic evaluation of that bridge will lead to greater fragility. Therefore, in order to evaluate the probabilistic seismicity properly, in addition to the column, the involvement of all bridge members must be considered.

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1- Introduction

Highway bridges form a significant part of a country's national economy and serve as a basis for infrastructure development. Earthquake damage in recent years has exposed the bridges as one of the most vulnerable components of the transportation system [1, 2]. To reduce potential economic losses and casualties during a seismic event, it is important for stakeholders to evaluate the performance of existing bridges and strengthen important components. The approach of this study is the performance-based assessment of possible seismic risk, which has been done in order to help the decision-making process and risk reduction of the bridges in Isfahan. This method has been used with the aim of better understanding the risk of unsafe structures, using this knowledge in designing structures to increase the level of safety and reduce economic losses or minimize damage in a seismic event. The main focus of this study is on criteria such as damage probability functions or fragility curves to describe the performance and vulnerability of highway bridges under possible earthquakes.

Accordingly, the purpose of this study is to investigate the bridges of Isfahan city based on structure type and in three time periods before 1350, the period between 1350 to 1374 and after 1374. This paper also presents a fragility method that can predict information about the possible performance of bridges during an earthquake. Considering the similarity of these bridges in terms of the type of construction and climatic conditions, the significant evolution of regulations (such as AASHTO and CALTRANS), and the effects of important seismic events on different seismic regulations [3, 4], this study will examine the method of seismic design of bridges in different time periods.

2- Methodology

In the present study, three bridge samples are modeled in CSI BRIDGE software, the results of their dynamic analysis are used as the seismic demand of members (the main input parameter in the formation of the fragility curve). In this study, all bridges are of high importance and regular, which were modeled by considering the position of the bridge in terms of soil and according to AASHTO 2012 [5]. In order to refine the modeling, the deck supports of the bridges were also modeled and their responses were taken into account in the preparation of seismic fragility curves. In this research, the design of the cushions is based on the ASHTO standard and of Ramanatan (2012).

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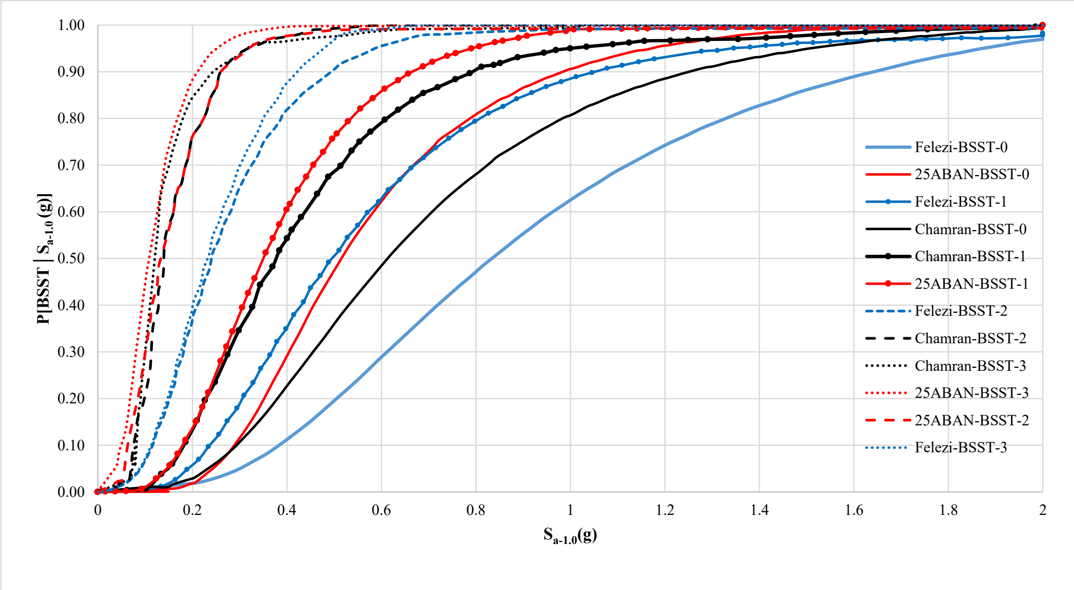

Fig. 1. Fragility curves for the evaluated bridges in three periods and at different levels of damage

Bridge design codes have evolved in response to the weaknesses of earthquakes in recent decades [6, 7] due to considering a greater number of uncertainties in seismic design and assessment. In this study, the uncertainty of various parameters such as elastomeric bearings, concrete and steel characteristics, the seam between deck and backpack, effective hardness of abutment pile, the rigidity of transition and rotational springs of columns foundation, soil resistance of behind abutment, bridge weight, and bridge damping were considered.

3- Results and Discussion

By comparing the fragility curves of the bridges of three different periods with different levels of damage in Figure 1, comparing their vulnerability with respect to each other is possible. As a result, during an earthquake, the least amount of damage to new bridges equals a lot of damage to old bridges, which leads to the loss of efficiency of old bridges and their unusability.

4- Conclusion

This study presents an approach for the development of fragility curves at the regional level for different bridges using the analytical method in which different bridges in three generations with different characteristics are investigated and the results show that:

1)At low and medium damage levels, the synergy of the bridge components makes the probability of damage more critical.

2)Due to the significant changes of new loads in Chamran Bridge, the amount of damage level of the abutment and column as the main members of the structure in extensive and complete damage levels for 2g acceleration, equal to 0.89, 0.69 for the abutment, and 0.96, 0.94 for the column. This is while for the Felezi bridge, it is 0.52, 0.24 in the abutment and 0.94, 0.91 in the column, respectively.

3)The fragility of other components may also indirectly affect other members, either positively or negatively. Therefore, Column failure is not the only criterion for bridge disconnection, and the participation of different components of a bridge in assessing the probable seismicity of that bridge will lead to greater fragility.

4)Considering the characteristics of this type of variability and its combination in fragility formulations makes the resulting fragility models generalizable for other bridges and leads to developing methods in order to improve the transport system infrastructure at the regional level and based on their performance.

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