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EVALUATION OF SEISMIC CAPACITY OF PLAIN CONCRETE ARCH BRIDGES BASED ON STRESS INTENSITY FACTOR

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There are numerous old arch bridges in Iran that have been used as railway bridges for more than 80 years. Since most of these bridges are not designed for earthquake excitation, seismic vulnerability of these structures is uncertain. This fact necessitates the investigation of the earthquake resistance of these kinds of bridges. For this purpose, non-linear static analysis (pushover method), non-linear dynamic analysis (IDA method) have been used frequently to assess the remaining capacity of plain concrete arch bridges (Mahmoudi et al., 2018; Marefat et al., 2019). This work is aimed to assess the seismic capacity of plain concrete arch bridges which are suffered cracks based on a new aspect. For the cracked domains it seems the most perfect method to evaluate them relate to fracture mechanics theory. The existence of crack and notch may cause remarkable concerns in the failure analysis of solids and structures. In order to analyze this kind of engineering problems, the stress intensity factors (SIFs) have been used to examine singularity at the crack tips. Previously, the field test of km-23 bridge which is located in the Tehran-Qom old railway revealed important properties such as the initial stiffness, cracking pattern and the primary stages of post-yield behavior. Therefore, for the first time, this study is aimed to assess the bridge seismically based on the fracture mechanics theory. As majority of cracked media problems do not have closed-form solutions, numerical methods are usual approaches to deal with fracture mechanics problems. The finite element method is employed frequently in the analysis of fracture mechanics problems because of its flexibility. Thus, using ANSYS as a finite element package, all the geometrical characteristics of the km-23 bridge as cracks have been precisely modeled in detail, and the stress intensity factors have been calculated. It is necessary to define the crack propagation criteria for computation of the cracked medias capacity based on linear elastic fracture mechanics theory. There are two major criteria for propagation of cracks extending in imperfect linear elastic media: a local criterion and a global approach. In the local criterion, crack propagation often involves the SIFs. In a brittle material, a pure mode-I loading condition is typically used for the fracture toughness which is denoted by K_{IC}. In mixed mode loading, it is needed to compare a combination of K_I and K_{II} with a material critical value of K_{IC}: if $\leq combination(K_I, K_{II})$, then cracking is initiated. In the global approach, the energy release rate *G*, which is calculated from the crack global transfer of energy is compared with critical energy release rate G_C which is a material property. If $G \geq G_C$, cracking is then initiated (Khaji & Yazdani, 2016; Yazdani & Khaji, 2018; Yazdani et al., 2016). The results of static loading tests are used to calibrate a finite element model of the bridge in which a plain strain analysis is carried out. By using fracture mechanics theory, the capacity curves of the structure is calculated and then based on standard 2800 elastic demand spectrum is obtained. Finally, the demand levels of the bridge are determined and compared with traditional pushover and IDA results. By implementing seismic excitations as lateral static loads, crack propagation initiated in springings of the bridge as depicted in Figure 1. The results show that the earthquake resistance of these kinds of bridges which are calculated based on linear elastic fracture mechanics (LEFM) theory is agree very well with the others methods (see Figure 2).

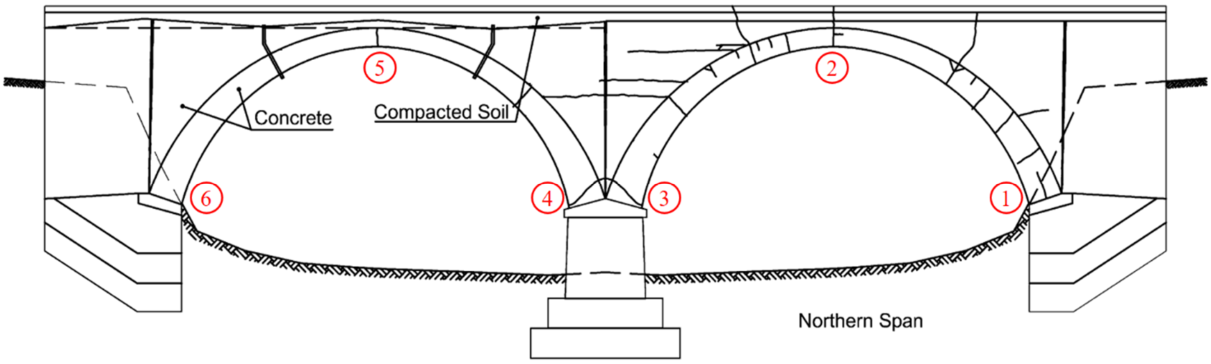

Figure 1. Six initial cracks and crack pattern at final stage of static loading test (Marefat et al., 2004).

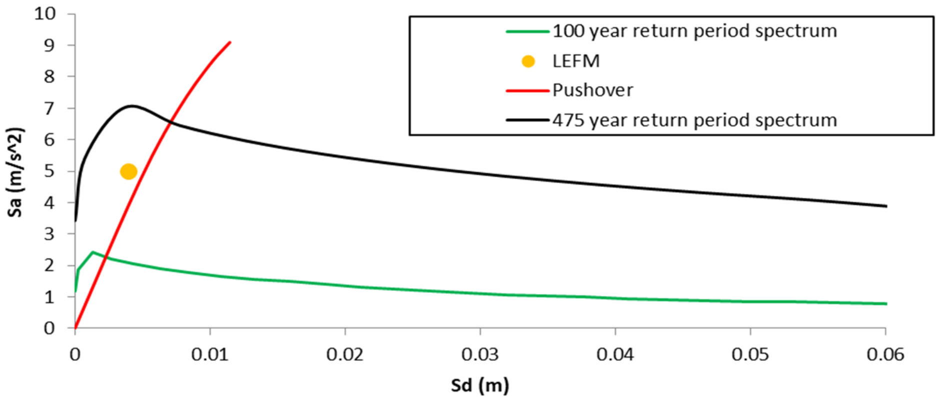

Figure 2. Performances of the bridge in different earthquake levels.

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