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STRUCTURAL SEISMIC ASSESSMENT OF THE KASHAN HISTORICAL BAZAAR CONSIDERING THE SOIL-STRUCTURE INTERACTION

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Heritage structures are an important part of the history of each society as well as an economic source. Accordingly, the protection and maintenance of these structures have cultural, economic and social significance. Today, the decision of the responsible organizations and the recommendation of the international reference councils for the monuments are in order to ensure that the identity and the importance of these structures are protected. In most cases, historical structures have very complex geometry, specification of materials, loads, and boundary conditions. Hence, for the modeling of these properties, the Finite Element Method (FEM) is utilized oftentimes. In these structures due to the limited height and rigid sections, the effect of soil-structure interaction (SSI) can have a significant impact (Fathi et al., 2019). This interaction is one of the most important factors affecting the behavior of the structure, which was mainly disregarded in the past. Now it is obvious to us that ignoring this case is only acceptable for lightweight structures on stiff soils because the softness of the soil can reduce the base shear and increase the displacement significantly.

The aim of present article was to assess the structural performance of Kashan historical bazaar, located in the city of Kashan (the center of Iran) that is dating back to the 17th century. With possessing legacy, cultural and social values, Kashan bazaar is a unique monument. The parts of the bazaar with the least remoulding and damage were taken, and then the geometric model of the structure was constructed by using SOLIDWORKS software. For the numerical analysis, ABAQUS finite element software was utilized. In this study, the soil dimensions are based on the previous researches (Ghosh & Wilson, 1969). As shown in Figure 1, for the meshing direction of the bazaar and foundation, an 8-node brick element with reduced integral (C3D8R), and also for meshing the surrounding soil an 8-node brick element (C3D8) were used. The mechanical characteristics and depth of the soil layers are based on the results of the geotechnical tests. Moreover, the bazaar and foundation specifications are assumed according to the Italian code NTC 2008 (Delle Infrastrutture, 2008) for existing masonry buildings, and presuming the LC1 knowledge level (the lowest level). In order to define nonlinear behavior of materials, the concrete damaged plasticity model (CDP) is used. This model is appropriate for simulating nonlinear behavior of brittle materials such as concrete, ceramics, and building materials, and it has been widely used in many studies.

In order to evaluate the structural performance of bazaar, frequency and nonlinear static analysis (push-over) by finite element method has been done in two cases considering the SSI and fixed bearing (regardless of SSI). According to the code NTC 2008, the N2 method is used to examine the global performance of the structure. The required demand spectrum in the N2 methodology is calculated based on the Iranian Seismic Code 2800. Due to the symmetry of the structure, its response to the lateral load on each coordinate axis is examined only in a single direction. Based on the results, the SSI has a great impact on the mode shapes and their frequencies. Furthermore, according to Figure 2, the structure of the bazaar has the load bearing capacity of gravity loads, as well as the stability of the lateral load in the fixed bearing position, but the results of the analysis in the case of considering SSI, has shown the weakness of the structure against the lateral load, as the structural capacity can hardly fulfill the requirement demands that are based on the seismic code 2800.

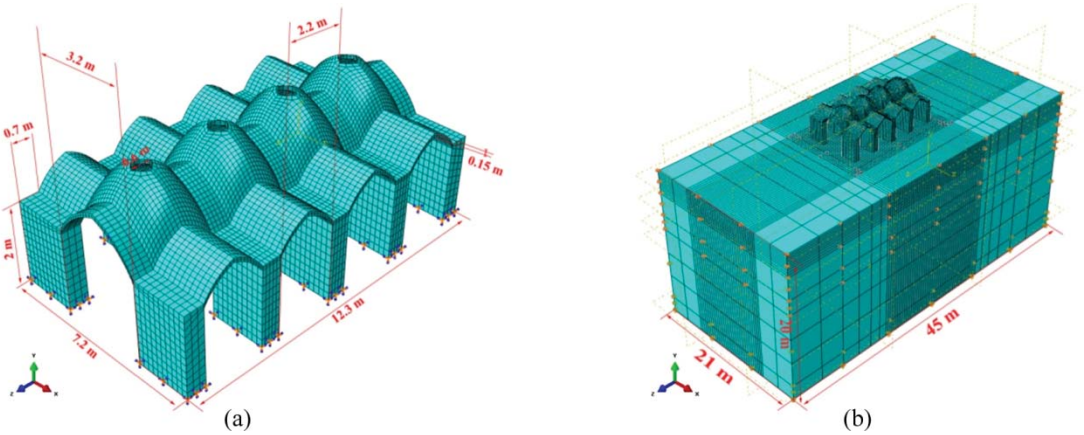

Figure 1. 3D view of the meshed Model and boundary condition: a) Without SSI, b) With SSI.

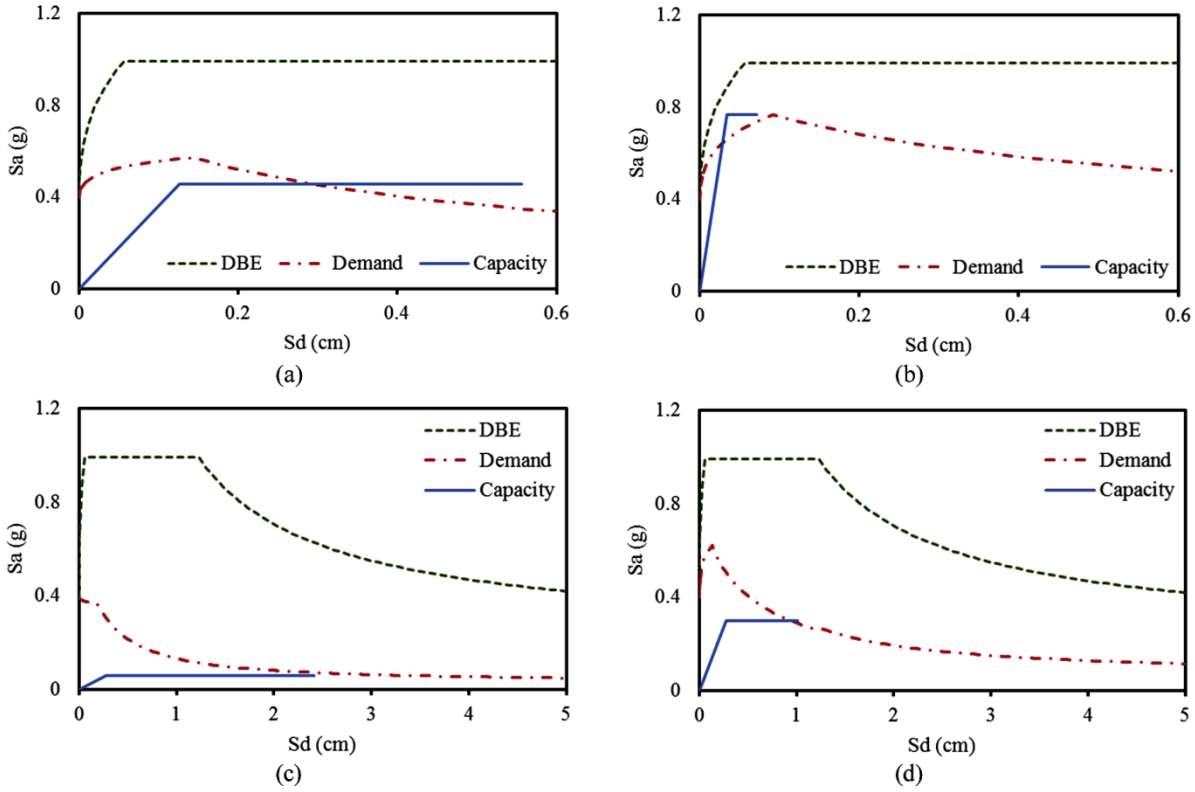

Figure 2. Results of bazaar seismic assessment: a) Z direction without SSI, b) X Direction without SSI, c) Z Direction with SSI, and d) X Direction with SSI.

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