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

SEISMIC PERFORMANCE EVALUATION OF CODE-DESIGNED GRANDSTAND STRUCTURE OF A ROOFLESS SPORT STADIUM

Mahboobeh PIRIZADEH
Assistant Professor, Department of engineering, Islamic Azad University, West Tehran Branch, Tehran, Iran
pirizadeh.m@wtiau.ac.ir

Farnood SABER NIKOOPASAND
M.Sc. Student, Department of Engineering, Islamic Azad University, West Tehran Branch, Tehran, Iran
farnood.saber@gmail.com

Baitollah BADARLOO
Assistant Professor, Department of Civil Engineering, Qom University of Technology (QUT), Qom, Iran
badarloo@qut.ac.ir

Keywords: Probabilistic seismic performance, Crowd-Structure interaction, Grandstand structure, Sport stadium, Incremental dynamic analysis

Nowadays, special structures such as sports stadiums have become part of the megacity's engineering symbols. Given the significant investments made by the public or private sectors for construction and operation of these specific structures, it is essential to develop appropriate approaches for facilitating decision making in risk management of building financial sectors, especially in the seismic prone areas. Currently, stadiums have considered in the category of buildings with high importance according to the Iranian code of practice for seismic resistant design of buildings (2015). Therefore, no major damages maybe expected for these buildings under the seismic hazard level of 10% probability of exceedance in 50 years and they can be repaired quickly for reusing during the design level earthquake events. However, the adequacy of simplified seismic code design procedures when applied to this type of buildings is questionable in terms of seismic performance by considering randomness and uncertainty in both the seismic loading and building resistance.

In this approach, a performance based assessment approach to the design of grandstand structure of sport stadiums can provide greater insight of designers into the unique characteristics of these structures, such as the crowd-structure interaction, the circular or oval geometrical configuration of frames, the high potential of vertical irregularities' formation along the height of the structure and also, the arrangement of slopping beams under the sitting platform of spectators (Gkologiannis et al., 2010). In this paper, the probabilistic framework is used for the seismic performance evaluation of grandstand structure of a roofless football stadium by using the incremental dynamic analysis (IDA) method (Vamvatsikos and Cornell, 2002), and the interaction effects of various scenarios of population gravity distribution (i.e., living load) on the seismic performance of structure are assessed during different intensity levels of probable earthquakes. The stadium has a symmetric oval shape plan view and will have the ability to host approximately 20,000 spectators (Figure 1). The structure is designed for a very high seismic zone with a site-specific earthquake acceleration of 0.35 g according to the 4th edition of Iranian seismic code (2015). The lateral force resisting system in all structural directions is a special concrete moment resisting frame. The structure are designed based on the linear response spectrum analysis method by applying the orthogonal combination procedure.

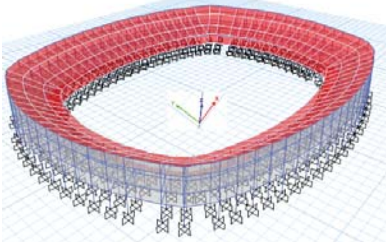

Figure 1. Three-dimensional (3D) view of the reference structure.

In the next step, the relative performance of the structure under two different crowd scenarios is compared by the IDA method (Vamvatsikos and Cornell, 2002) under bidirectional excitation of a set of 10 earthquake records, all of which were recorded on stiff soil and bear no marks of directivity. For this purpose, structure is modelled three-dimensionally for nonlinear analyses. The inelastic behaviour of beams and columns is modelled by formation of lumped plastic hinges at their ends. The simultaneous effects of the orthogonal seismic excitation on the performance of structure are evaluated in two different cases. In these cases, the major principal component of the ground motion accelerations is taken as acting along the X and Y structural axis, respectively. The considered scenarios for crowd-structure interaction included empty and full spectator's seats. Consequently, the IDA curves in the IM-EDP plane (maximum interstory drift ratio, θ_{max}, versus the peak ground acceleration, PGA) are generated for the structure in these two scenarios, as shown in Figure 2. The limit state capacities for two common performance levels namely IO and CP are defined based on the procedures described in Jalayer and Cornell (2003).

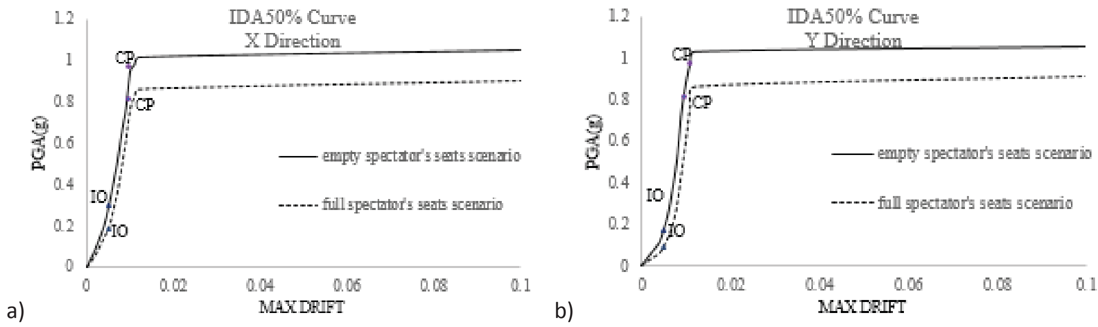

Figure 2. The median IDA curve of code-designed grandstand structure along: a) X-Direction, b) Y-Direction.

The results show that the mean annual frequency (MAF) of exceeding the performance levels are increased in the crowded scenario with respect to the empty scenario. Furthermore, the MAF of exceeding the IO performance level under seismic hazard level having a probability of exceedance of 10% in 50 years (i.e. design basis earthquake (DBE)) did not satisfy the seismic code requirements, even for the empty scenario. However, no major damages is experienced for the building under the seismic hazard level of 10% probability of exceedance in 50 years and it can be repaired quickly for reusing during the design level earthquake events. The seismic performance assessment of the structure during the maximum considered earthquake (i.e. 2% in 50 years) is also demonstrated the reliable confidence level of meeting the collapse prevention (CP) performance level for the structure. However, the median IM capacity of the structure is decreased more than 20% in the crowded scenario with respect to the empty scenario. Therefore, applying more accurate analytical procedures to predict the seismic performance of these special structures via the seismic codes requirements can minimize the loss of life, property damage, and social and economic disruptions caused by any probable earthquakes. The spatial configuration of studioums usually provide the large urban open spaces over the density megacities, and this study shows that they can be considered as an emergency facilities in earthquake events with return periods less than 475 years for emergency evacuation or emergency temporary accommodation.

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