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

PERFORMANCE ASSESSMENT OF SEISMICALLY-DESIGNED STEEL MOMENT RESISTING FRAMES AGAINST NUMERICAL SIMULATED OF BLAST WAVE

Hamid GHANBARI
Ph.D. Candidate, Shahid Bahonar University of Kerman, Kerman, Iran
ghanbari.sazeh@gmail.com
Eysa SALAJEGHEH
Professor, Shahid Bahonar University of Kerman, Kerman, Iran
eysasala@uk.ac.ir
Ehsan KHOJASTEHFAR
Assistant Professor, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran
e.khojastehfar@vru.ac.ir
Javad SALAJEGHEH
Professor, Shahid Bahonar University of Kerman, Kerman, Iran
jsalajegheh@uk.ac.ir

Keywords: Numerical simulation, Blast shock wave, Passive defence, Nonlinear time-history response, Computational fluid dynamics

One of the important threats for critical structures is the terrorist attacks. Therefore, performance assessment of critical structures, which are designned based on seismic regulations, against effects of blast wave is of great importance to policymakers.

Conventionally, the blast loading is affected to the structures according to the predefined empirical or simplified analytical formulations in the form of triangular or uniform impact loads (Kinney et al., 2013; Kulkarni et al., 2014). Through these formulations, physical effective factors such as reflection, refraction of blast wave, Mach effects and wave suction are not involved. Furthermore, regarding the numerical assumptions, effects of mesh size on the calculated time history of the explosion load are studied for 2-D models in previous researches. The innovation of this paper is to present the explosion load time-history through the realistic modelling of 3-D block of the structure and the surrounded air. Besides, towards the structural performance assessment, the finite element model of the sampled structures are affected by the achieved realistic time-history of the explosion load.

The first part of the present research devotes to the sensitivity of CFD simulation of the blast wave to the mesh size. To achieve this goal, in the present research, numerical simulation of the blast wave is implemented by CFD considering various mesh sizes. To achieve the efficient, yet accurate mesh size, the simulated blast wave is affected to the building block. In order to study the free propagation of blast waves in air, a 28 m by 28 m by 8 m volume of air was numerically modelled with five different mesh sizes: 25, 50, 100, 150 and 300 mm. Building block model, blast-induced pressure contours and pressure gauges are shown in Figure 1. The pressure response on the building block is compared with that of calculated by experimental and empirical formulations. Furthermore, the sensitivity of pressure response to the mesh size is studied for various scaled distances and the suitable mesh size, to simulate the accurate blast pressure on the building, is proposed. In the second part of the present research, the performance of seismically-designed 10-story steel moment-resisting frame is investigated against simulated blast wave pressure. The simulated blast pressure time history is affected to the FE model of the case study.

To verify the numerical model, the responses of FE model are compared with those of presented by a previous reputable publication. Then, the CFD analysis of the building block, to the blast scenario according to the UFC 3-340-02 regulation (UFC, 2008), is implemented by AUTODYN software. The achieved blast load time history is affected to the sampled structure. Firstly, the structure is designed by SAP software. Secondly, to study the performance of the representative frame, the nonlinear time-history response analysis and the related structural performance are implemented by OpenSees finite element tool.

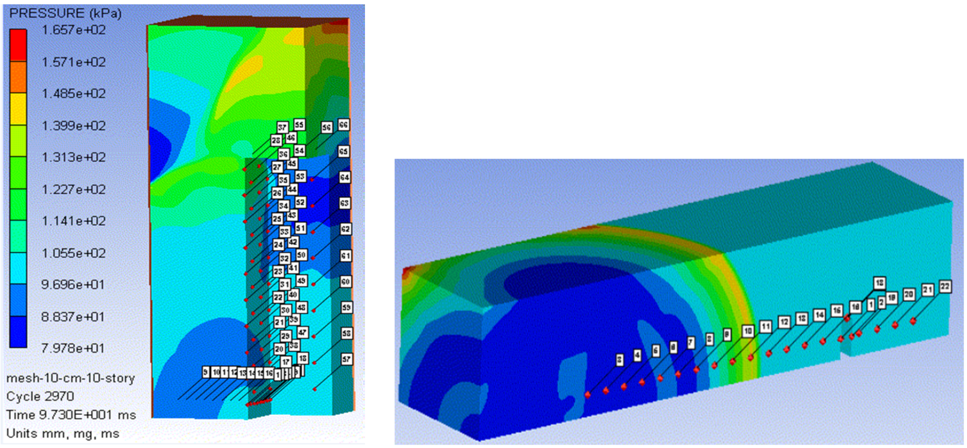
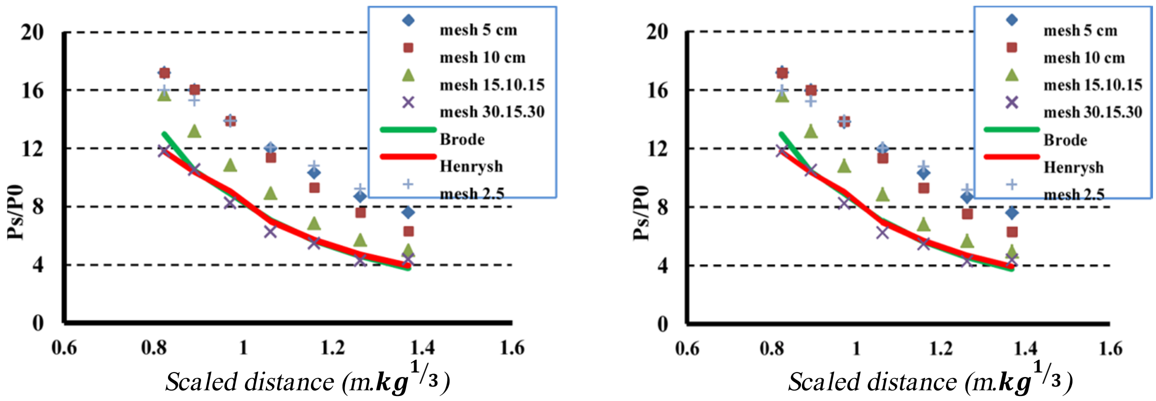


Figure 1. 10-story building block model, blast-induced pressure contours.

As Figure 2 shows, Numerical simulation of the blast wave for various mesh sizes reveals that the difference between the numerical and experimental responses is increased when the scaled distance decreases. Furthermore, the more scaled distance is considered the less will be the relevant sensitivity to the mesh size. The accuracy of the empirical formulations is suitable for moderate and far scaled distances. In Figure 2 the horizontal axis shows the scaled distance (i.e. $R/\boldsymbol{W}^{1/3}$), in which R stands for the explosion distance to the structure location and W shows the weight of explosive material. Besides, the vertical axis shows P_s/P_0 and P_r/P_0, in which P_s and P_r stand for the maximum induced pressure and the maximum reflected pressure, respectively. P_0 is the ambient pressure which is assumed as the atmospheric pressure in the present study.

Mesh size affects the simulated results of reflection and refraction of the blast wave. While the mesh size increases, the reflection effect of blast wave in numerical model is decreased in such a way that for the mesh size larger than 30 cm the reflection effect is vanished.



a) Longitudinal direction   b) Transverse direction

Figure 2. Effect of mesh size on the maximum blast-induced pressure to air pressure ratio for various blast scaled distance.

REFERENCES

Kinney, G.F. and Graham, K.J. (2013). *Explosive Shocks in Air*. Springer Science & Business Media.

Kulkarni, A.V. and Sambireddly, G. (2014). Analysis of Blast Loading Effect on High-Rise Buildings. *Civil Environmental Research*, *6*, 86-90.

Unified Facilities Criteria (UFC 3-340-02) (2008) *Structures to Resist the Effects of Accidental Explosions*, US Department of Defense, Washington DC.