University of Tabriz

Journal of Civil and Environmental Engineering
Volume 47 (2017), Issue 1 (Spring), 1-12.

EXTENDED ABSTRACT

Investigation of the Simultaneous Effects of Seismic and Explosive Loading in RC Frames

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Received: 05 February 2016; **Accepted:** 10 April 2016

Keywords:
RC Frame, Seismic Load, Blast Loading, Simultaneous Loads, ABAQUS.

1. Introduction

In this research, a two-dimensional three-spanned RC frame with three floors (one-third scaled model) was modeled and analyzed using ABAQUS/Explicit finite element software. Twelve different scenarios of concurrent earthquake and blast loads were considered and the most critical state was identified here. The important variables of the models included the explosion before or during the earthquake, blast loading orthogonal to or align with the earthquake direction, and the location of the explosion center located in the front face, side face, or inside the frame.

2. Methodology

2.1. Considered Structure

A 2-D reinforced concrete frame was modeled and analyzed using ABAQUS FE software. Geometric and structural characteristics of the building frame can be found in Fig.1 and tables 1 and 2 (Choi & Park, 2011).

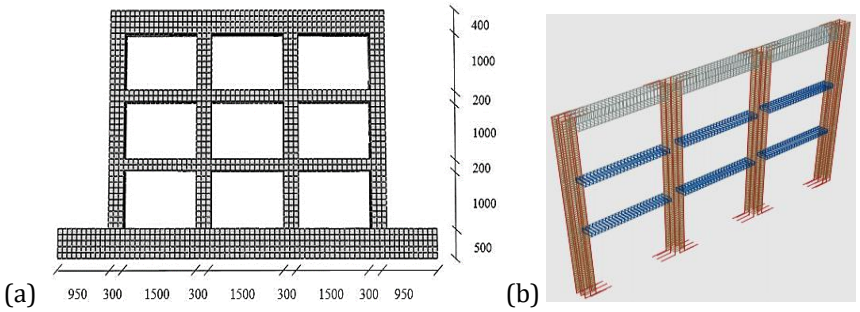

Fig. 1. Considered RC frame: (a) Geometric dimensions, (b) Steel reinforcement

Table 1. Characteristics of the concrete material

Material model in ABAQUS	Constitutive model in pressure	Constitutive model in tension
CDP model	Popovics's model (Popovics, 1973)	Shima's model
Density	Compressive strength	Young modulus
$2.4 \times 10^{-9}\ ton/mm^2$	30 MPa	25743 MPa

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Table 2. Characteristics of the steel reinforcement

Position		D (mm)	No.	Yield stress (MPa)	Density
Columns		22	6	430	7.83×10^{-9} ton/mm^2
Beams		16	4	471	
Stirrups	Columns	10	@50mm	486	
	Beams	10	@60mm		

2.2. Loading scenarios

Twelve different simultaneous earthquake and blast loading scenarios were considered here. The tree diagram of those scenarios is illustrated in Fig.2.

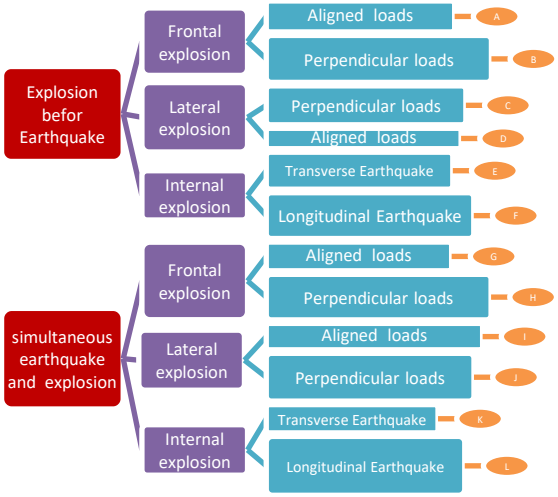
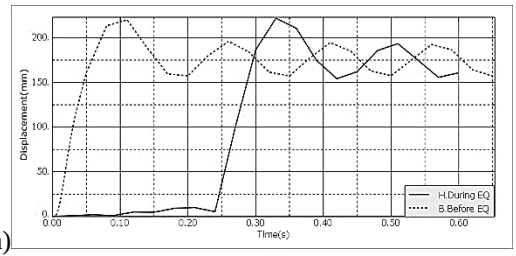


Fig. 2. Tree diagram of the defined loading scenarios in this study

3. Results and discussion

The maximum displacements of the roof and stories of the frame under the effect of the frontal blast loading before and simultaneous with the earthquake are illustrated in Fig.3. The results show that the maximum displacements and deflections of the frame are governed by the blast loading under the frontal explosion conditions.

(a)



(b)

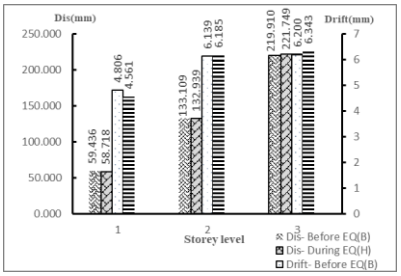


Fig. 3. Results under the frontal explosion for: (a) Roof maximum displacement, (b) Maximum displacements and drift of the stories

Damage contours of the elements are illustrated for different blast event positions in Fig.4. It could be implied from the Fig.4(a) that the columns' face and their connections to the foundation have the most vital damages under the blast loading in front of the frame. For the case of the lateral blast loading, beam to column joints and base of the columns show more damages. Finally, for the explosion inside the frame span, the adjacent beams and columns of the span have the most essential damages.

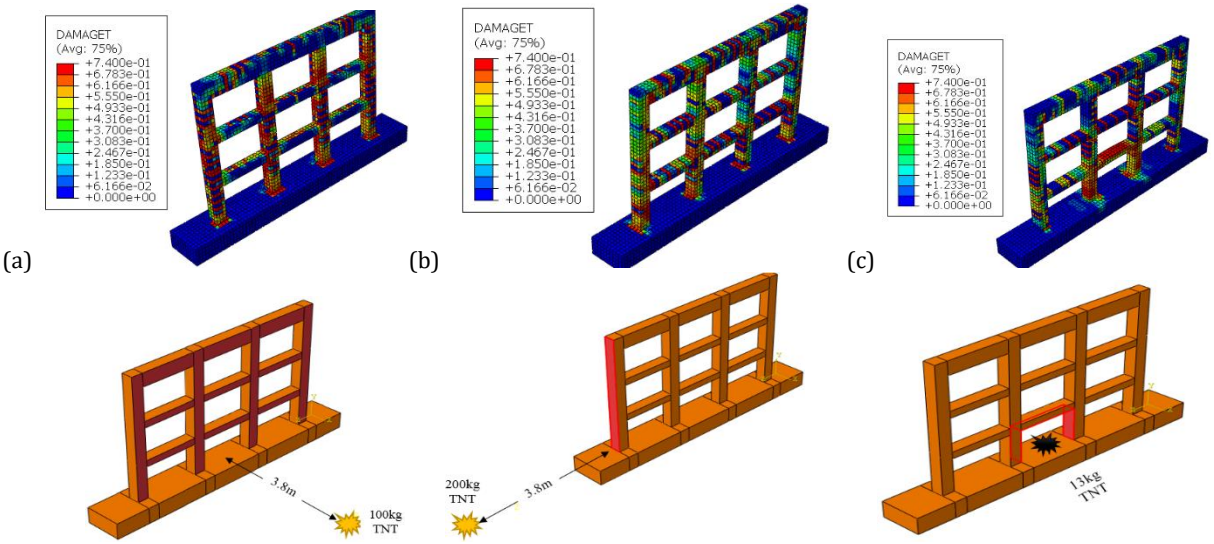


Fig. 4. Damage of the frame under: (a) The frontal explosion, (b) lateral explosion, (c) inside explosion

4. Conclusions

Based on the most important findings of the present study, in the case where the seismic and explosion loads were orthogonal to each other, more damage was observed in the structure comparing to the state of aligned loading for all the three cases of the explosion location (including in front of the frame, lateral explosion and internal explosion). Damages caused by frontal explosions mainly affected the columns and their connections to the foundation. Nevertheless, the lateral blast loading mostly affected the beams. Finally, the internal explosion affected the beams and columns of the span where the explosive was located. Among the studies scenarios, when the explosion occurs during the earthquake's strong motions were more critical than the scenarios in which the explosion occurs before the earthquake.

5. References

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