

PAPER REF: 7202

## **DEVELOPMENT OF ALTERNATE LOAD PATHS IN STEEL FRAMES WITH COMPOSITE BEAMS SUBJECT TO ACCIDENTAL EXPLOSIONS**

**Florea Dinu<sup>1</sup>, Ioan Marginean<sup>1(\*)</sup>, Ioan Petran<sup>2</sup>, Mihai Senila<sup>2</sup>, Calin Neagu<sup>1</sup>, Dan Dubina<sup>1</sup>**

<sup>1</sup>Department of Steel Structures and Structural Mechanics, Politehnica University Timisoara, 300224, Romania

<sup>2</sup>Department of Structures, Technical University of Cluj-Napoca, 400114, Romania

(\*)*Email:* ioan.marginean@upt.ro

### **ABSTRACT**

Buildings' structural components are sized for anticipated actions that can occur during their lifetime. However, for unforeseen loading events, like accidental explosions produced at close distance, the forces imparted to the structure can be only approximated. Therefore, the local failure of some members is most likely to occur. Providing alternate load paths can prevent propagation of collapse and preserve the global structural integrity. In case of multi-storey buildings, the contribution of the floor system and beam-floor interaction to the load redistribution capacity can be significant if properly accounted for in design. The study presented in the paper investigates the response of a multi-story steel frame building at the direct effect of a close-in explosion. The main parameters are the degree of interaction and the capacity ratio between steel beams and concrete slab.

**Keywords:** accidental action, progressive collapse, composite floor, alternate load path.

### **INTRODUCTION**

Building structural components are designed to meet specific requirements in terms of strength and deformation capacity. To ensure proper behavior and maintain the integrity, especially under exceptional loading events, the failure of an element should not lead to a generalized collapse (progressive collapse). This can be assured by providing the system with the capacity to redistribute the loads upon removal of an element. Some structural features, for example two-way floor systems and the interaction between concrete floor and steel beams can improve the load redistribution (Astaneh-Asl *et al.*, 2001; Stevens, 2008; Demonceau and Jaspard, 2010). The consideration of the beam-floor interaction can be very effective in providing resistance to progressive collapse particularly for less redundant structural systems. This paper presents the results of a study that aimed at investigating the contribution of the floor system to the load redistribution capacity following the removal of a column under direct effects of a close-in explosion. For this purpose, a 3D steel frame structure was designed and detailed using several configurations, i.e. first with beams designed as bare steel elements and then with different degree of interaction between steel beams and concrete slab. The capacity ratio between steel beams and concrete slab was also considered as a parameter.

### **RESULTS**

The steel frame structure has two story, two bays and two spans and is extracted from a six story reference building, see Figure 1. The structure was designed for permanent and seismic

design situations. The protection against progressive collapse was considered by applying the tie force requirements. Loading conditions involve different levels of gravity loads and pressure loads due to close-in explosions. The numerical models were calibrated using relevant tests, see Figure 2.

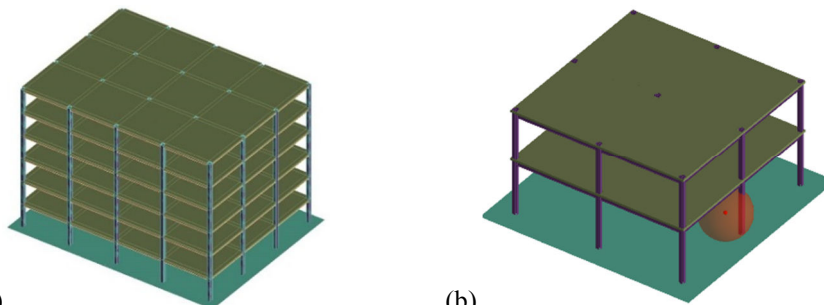


Fig. 1 - Reference building (a) and model used in the parametric study (b) (position of blast charge varies)

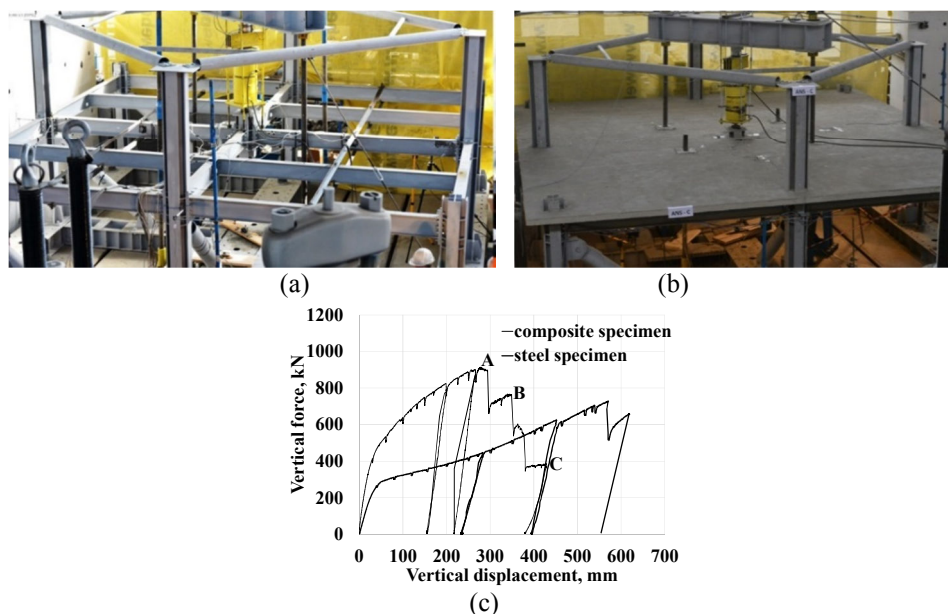


Fig. 2 - Calibration of numerical models: (a) steel specimen; (b) composite specimen; (c) force-displacement curve for internal column removal, steel vs. composite

## ACKNOWLEDGMENTS

The authors gratefully acknowledge the funding by Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI - UEFISCDI, under grant PN-III-P2-2.1-PED-2016-0962, within PNCDI III FRAMEBLAST (2017-2018).

## REFERENCES

- [1] Astaneh-Asl, A., Jones, B., Zhao, Y., & Hwa, R. "Floor catenary action to prevent progressive collapse of steel structures", (Report No. UCB/CE-Steel-03/2001). Department of Civil and Environmental Engineering, University of California, Berkeley, USA, 2001.
- [2] Stevens, D, "Assessment and Proposed Approach for Tie Forces in Framed and Loadbearing Wall Structures". Final rep., Prepared for Security Eng. Working Group, 2008.
- [3] Demonceau, J. F., Jaspard J. P. "Experimental test simulating a column loss in a composite frame", *Advanced Steel Construction*, 6, pp. 891-913, 2010.