Numerical Framework for Evaluating Debris Loads on Underground Structures

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This paper presents a comprehensive methodology for analyzing static loads acting on underground structures due to debris accumulation following the progressive collapse of above-ground, multi-story reinforced concrete buildings. A large set of frame-slab type structures was parametrically generated and numerically collapsed using Abaqus/Explicit. The simulations accurately reflect real-world rubble behavior by selecting optimal debris element sizes and distributions. Figure 1 shows an example of the collapse process of a 16-story building. It can be observed that the majority of debris fragments accumulate in the zone near the base of the building and in the surrounding area.

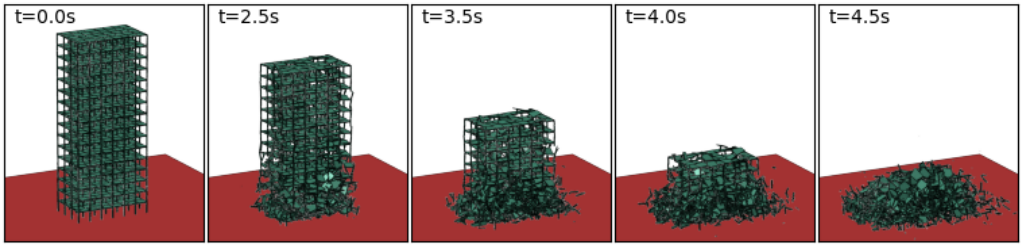

Figure 1. Snapshots of the 16-story building collapse process. Each columns shows selected frames in time.

The presented cases were further compared with the Polish notional guidelines to assess the dependence of rubble-induced pressure on building height. Figure 2 shows the obtained results, where it is clearly visible that the numerical simulations predict lower pressure values for each case compared to the notional guidelines.

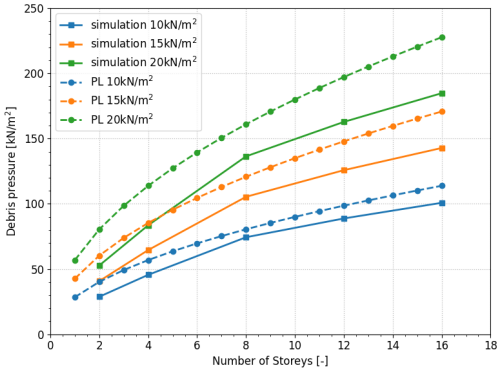

Figure 2. Comparison of obtained loads according to PL notional guidelines.

The results provide a robust foundation for ongoing updates of the international guidelines addressing rubble-induced static loads on buried structures, particularly in the context of progressive collapse or warfare scenarios.