NUMERICAL SIMULATION OF 3D ASSEMBLY MODELS UNDER LARGE DEFORMATION CONDITIONS

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ABSTRACT

Progressive collapse resistance is a measure of the structural robustness and relies primarily on resistance of key elements, continuity between elements and ductility of elements and their connections. Some structural features may improve the load redistribution capacity and thus, may improve the robustness. One example is the floor system that considers the interaction between concrete slab and steel beams. In the experimental study [1], the ability of a typical steel structure to resist progressive collapse in the event of the loss of a column due to a blast was investigated. The findings suggested that a retrofit scheme in which cables are added to the side of beams could be used to develop larger catenary action with a higher factor of safety. The increase in capacity achieved by this scheme was confirmed by a different test in which horizontal cables were placed in the floors and on the top flange of the girders along the exterior column line [2]. Other studies were conducted to consider the ability of the floor system to provide the necessary load redistribution [3], [4], [5]. In the present study, we investigated using FEM program, Abaqus, the behavior of 3D assembly models under large deformation conditions that result after a column loss event. The models were extracted from a multi-story steel-frame building. The interaction between concrete slab and steel beams was modeled in detail. The case study building has a four-bay, four-span, and six-story steel structure with moment frames in both directions. The bays and spans each measure 8.0 m and the stories are 4.0 m high each. The structure was designed with non-composite and composite steel beams for the effect of gravity loads (permanent and variable actions) and lateral loads (wind and seismic actions), using the Eurocodes. For the first structure, there was no interaction between the steel beams and the concrete slab (*steel model*). For the second structure, only secondary beams were designed as composite section (*composite model I*), while in the third model, also composite, shear connectors were used for main beams and secondary beams (*composite model II*). 3D assemblies were extracted from the reference building and scaled down to 1:2.5, see Fig. 1.

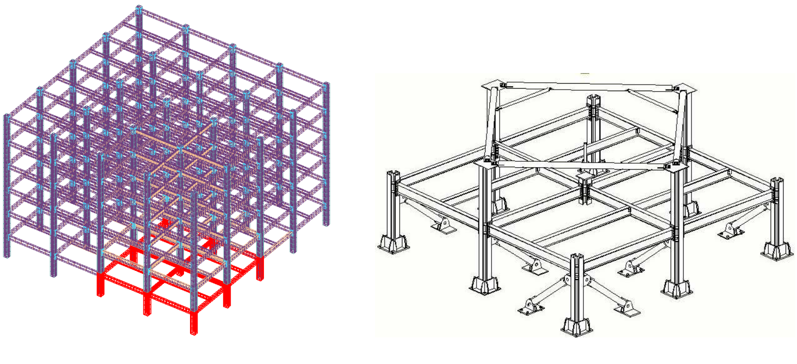
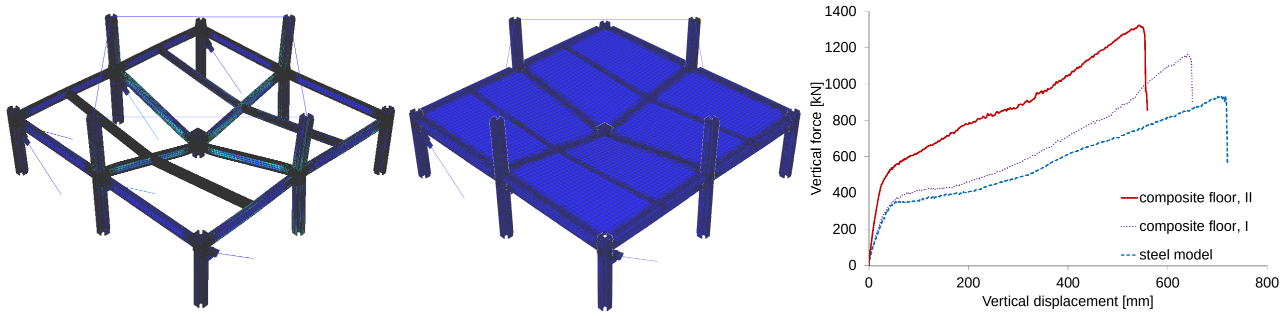


Fig. 1. Extraction of 3D assembly model (right) from the reference multi-storey frame building (left)

Thus, the scaled assemblies are two-bay two-span structures with the total size of 6.0m x 6.0m and 1.5m height. The columns were made with cruciform shape from two HEB 260 profiles but with flange widths reduced to 130 mm. The main beams were made of IPE 220 and the secondary beams of IPE 200. Columns were designed with rigid base connections. The bolted end plate beam to column connections were designed as rigid and full strength. A reinforced concrete slab of 8 cm was considered with a 1.5m span between the floor beams. The slab reinforcement includes welded wire mesh of Φ6/200mm x Φ6/200mm. A non-linear static analysis was employed for the evaluation of the structural behaviour following the removal of a column. The load was applied at slow rates to push the central column down until failure. Fig. 2.a displays the deformed shape for the *steel* model and for the *composite floor II* model. Fig. 2.b plots the vertical force - vertical displacement curves for the three models. It may be seen the model with shear connectors on secondary beams only (*composite floor I*) has the same initial stiffness and yield capacity as the *steel* model, then, after the plasticity starts to develop, the capacity increases up to the failure. The ultimate capacity is almost 25% larger than for the *steel* model. The model with shear connectors both on secondary and main beams (*composite floor II*) has a larger initial stiffness and yield point, and the ultimate capacity is 40% larger than for the *steel* model, and 15% larger than for *composite floor I*. The increase in capacity results in a reduction of the ultimate displacement.



a) b)

Fig. 2. a) Deformed shape of the structure for *steel* model and *composite floor II* model; b) force-displacement curves

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