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Technical Note No.31

COLLAPSE OF MULTI-STORY CONCRETE BUILDING DUE TO GROUND LEVEL EXPLOSION

A virtual concrete building used in our simulation is shown in Fig.1. An explosive charge going off at the ground floor causes a shock wave to be applied to the underside of the slab and to the columns as well as sending a stress wave along the height of the building. Two extreme charge sizes are considered and their effects simulated.

Figure 2 shows a disintegration of the structure subjected to explosion of the smaller of the two charges. The basic effect of the pressure pulse is to suddenly relieve the slab from its self-weight, push it slightly up and then let it drop down again. The slab-column connection is the weak area, which breaks under the influence of this loading component. The rest of the slab is relatively uninfluenced and in Fig.2 it is shown well on its way down. The rest of the building is not significantly affected. A minor damage to the level 2 slab did not cause it to fall down.

In Fig.3 there the initial damage is shown as caused by the big charge. The damage to the slab is around the column connections, as before, but there also is some breakage further away from columns. The columns crack at mid-height and at each end.

This first-floor slab breaks up with time and its parts approach the slab above. This is facilitated by the fact that not only does slab No.1 is moving upward due to the explosion impulse, but also slab No.2 is moving downward, due to a free fall of the structure above the first floor. After a collision the pieces of slab No.1 fall down while pieces of slab No.2 move up to collide with slab No.3. (This instant is illustrated in Fig.4) Some fragments of the latter damage slab No.4.

The apparent difference in the manner of disintegration is that the small charge merely disrupts the continuity of the system and allows the gravity to bring down only slab No.1. The big charge, on the other hand, blows up the first story and puts the rest of the structure in a free fall.

DETAILS

The horizontal dimensions are 9x9 m. The ground story is 5.3 m high and each of the remaining five stories is 3.6m high. (These dimensions include 0.3m thick floor slabs.) The corner columns are 0.45x0.45m and the mid-side columns have 0.6x0.6m sections, as they carry a larger load.

The height of the building is divided into only 3 vertical segments and along each segment column strength is kept constant. The slabs are identical. The floors were designed to carry the live load of 300 kg/m².

Gravity was applied to the structure prior to applying blast pressures. The columns are, in general, closer to the explosion source so the pressure impulse is applied earlier. A factor of 1.8 is used to multiply the mass of the explosive on account of exploding on a hard surface (as compared with a suspended charge, for which experimental data are available).

We have used a material model, which is characterized by a clean break. The real reinforced concrete would, upon disintegration, still partially hold together because much of reinforcing rods would remain intact.

As mentioned before, cracking originates at junctions of slabs and columns. This is caused by an abrupt change of shape (discontinuity or stress concentration) on one hand and poor detailing of the building at those locations.

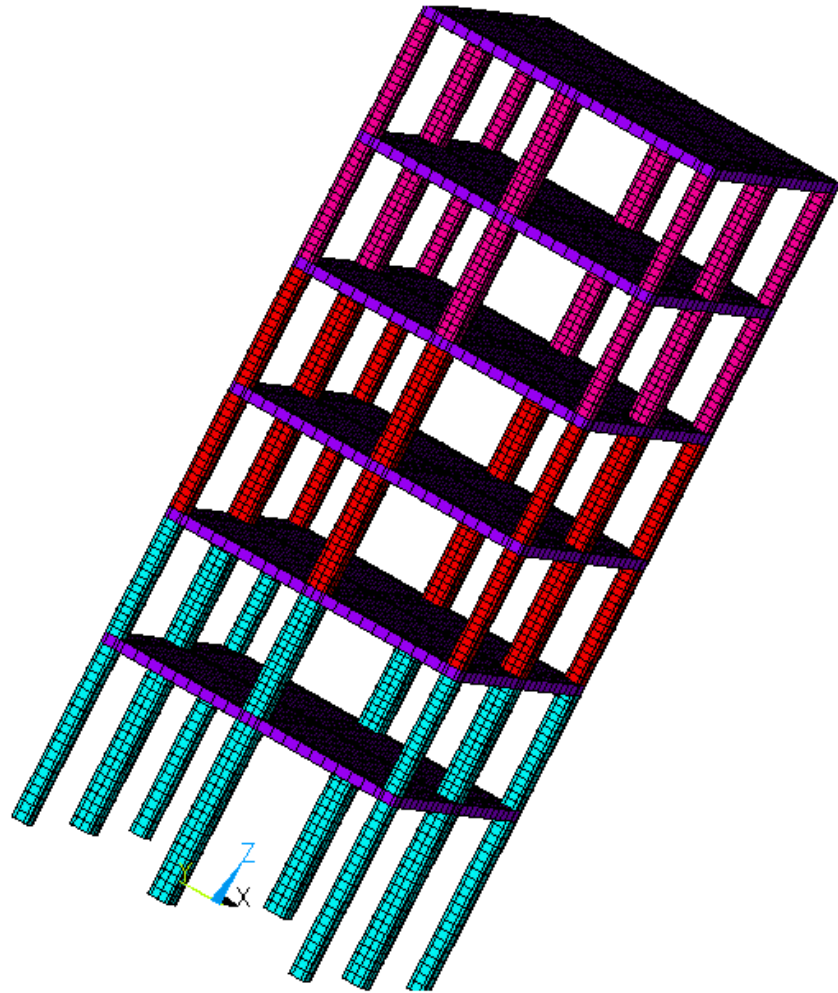


Fig.1 Geometry of virtual building

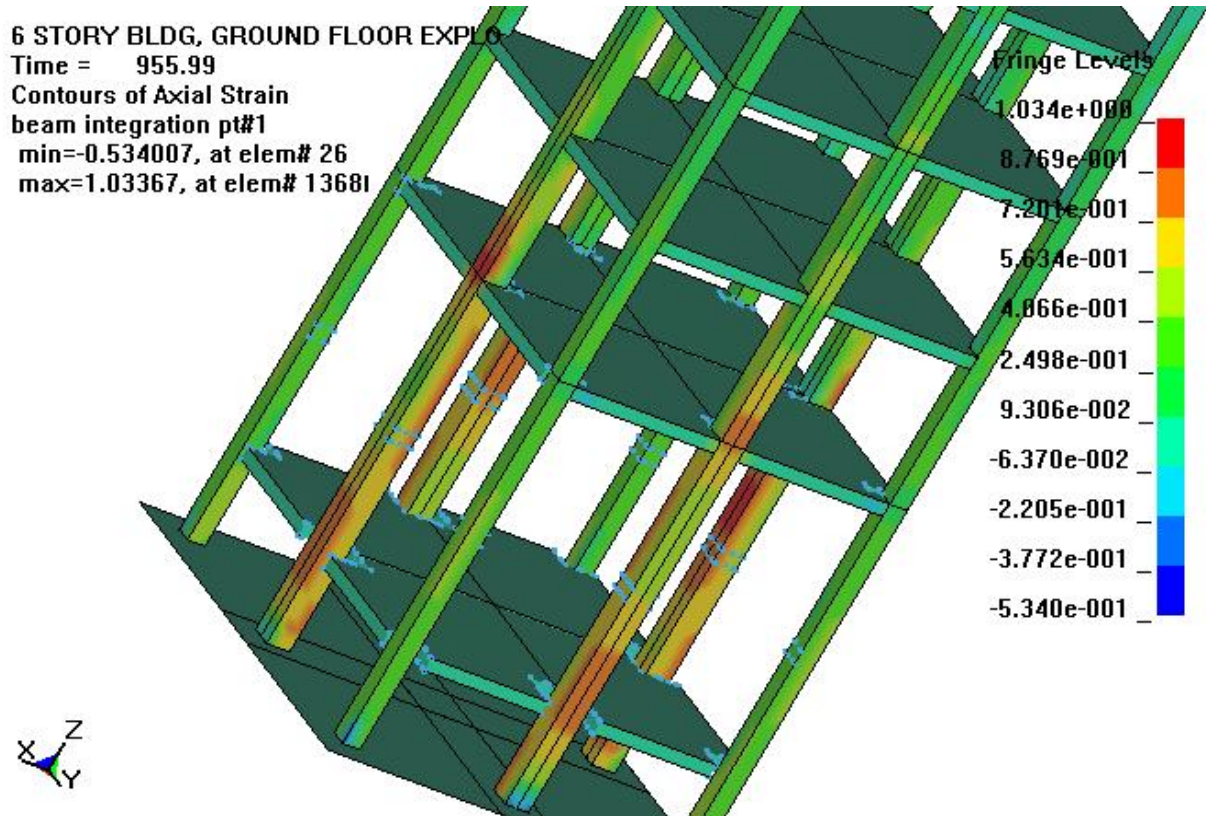


Fig.2 Small charge. First-story slab in a free-fall.

6 STORY BLDG, GROUND FLOOR EXPLO
Time = 382

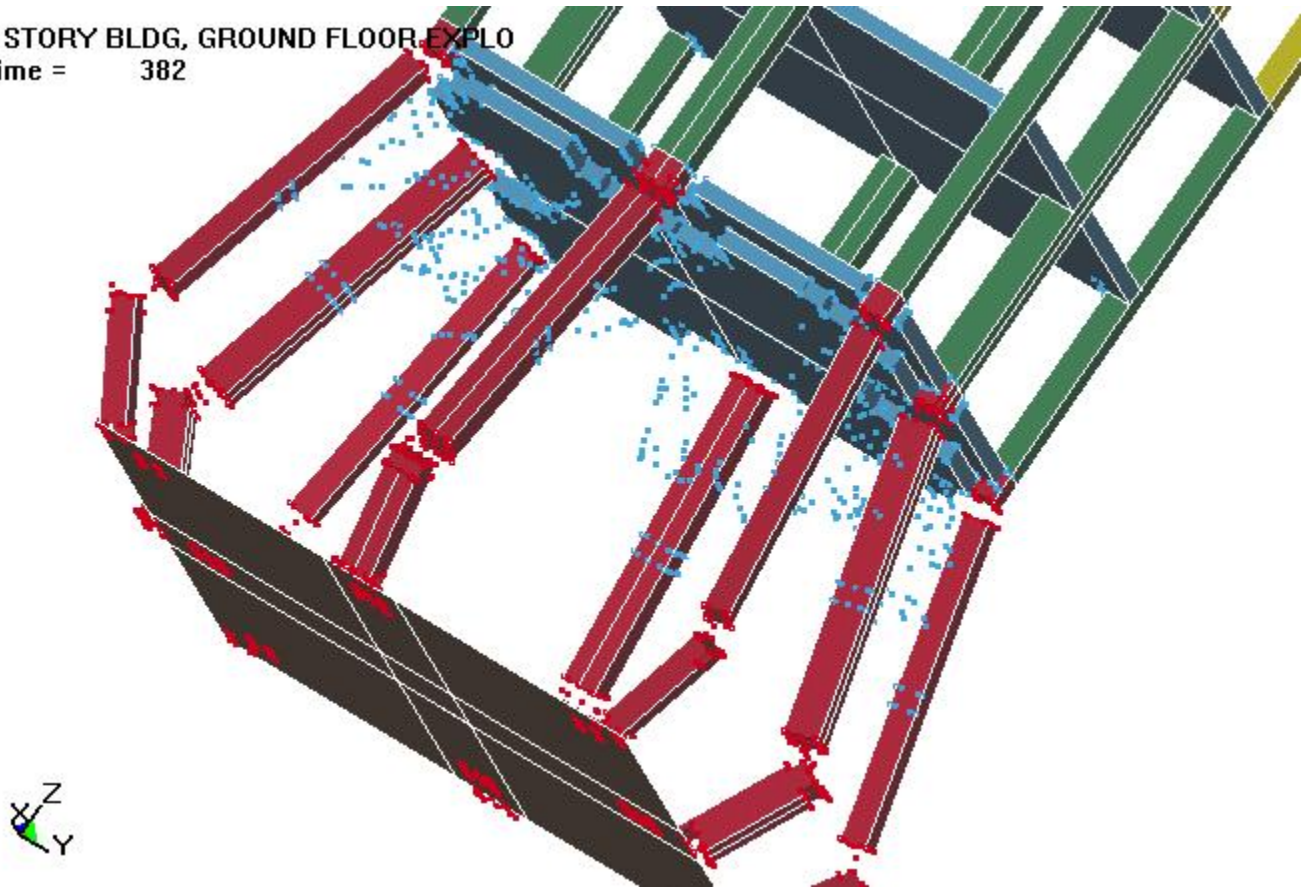


Fig3 Big charge. Initial damage to ground story.

6 STORY BLDG, GROUND FLOOR EXPLO
Time = 723.99
Contours of Maximum Prin Stress
max ipt. value
min=-1.41204, at elem# 124
max=6.01569, at elem# 13511

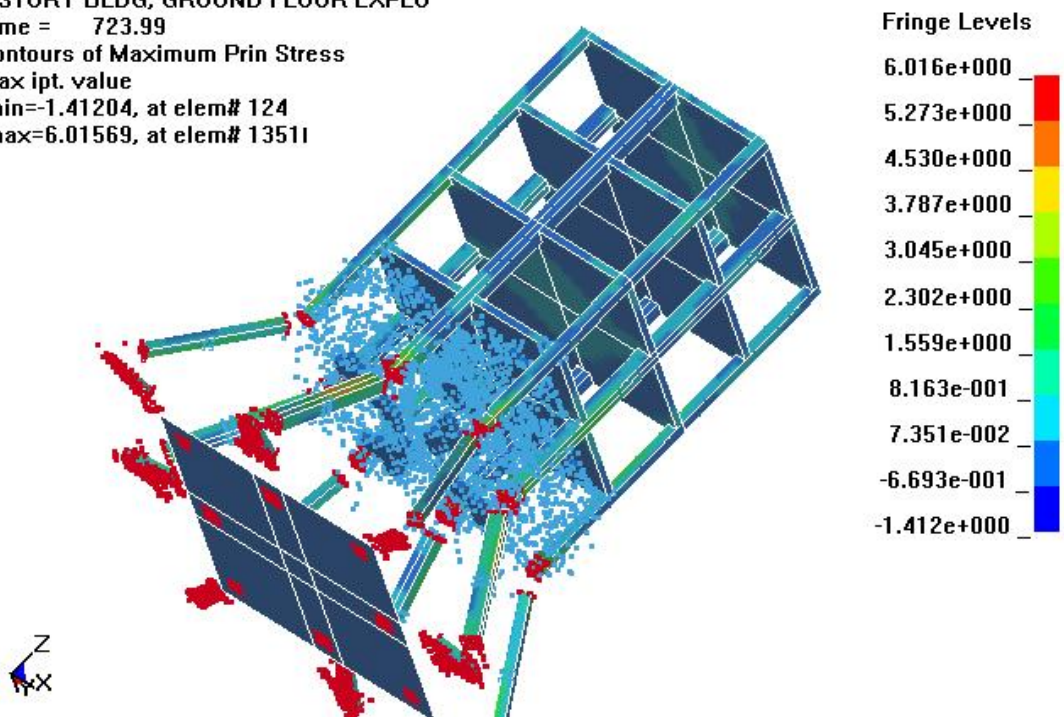


Fig.4 Big charge. Status after collision of the first two slabs.