TAC UPDATE.

Institution of MECHANICAL ENGINEERS

What Really Happened to Building 7?

First Clues Emerging

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One year ago a Technical Advisory Committee (TAC) was formed to assess the findings of the University of Alaska Fairbanks (UAF) report on the collapse of World Trade Centre Building 7 (WTC7) and to understand what happened to the building. The multi-disciplined team of mechanical, civil and structural engineers was also asked to consider relevance to current building standards. Unusually, the team has the advantage of a video sequence where the East and West Penthouse and upper North and West side collapses are visible. So, whatever theory is offered, it has to explain what can be seen.

Our first task was identify and define the main structural components of the building, the relevant material properties, the composite floor decking, the load paths and then the conditions of the fire in the building during the hours before it fell. A report issued by the TAC in September assesses the capacities of the each of the beam, column, and girder (welded and bolted connections) in the East side of the building, around the 12th and 13th floors. This study used the Eurocode Component Method with calculations performed for both the Elastic Design condition and the Plastic failure load condition. For each connection type, tabular comparison is made with the results obtained from the UAF analysis, Weidlinger analysis, and work by Burgess and Plank - in order to get the widest possible perspective on what the connection capacities are.

A second report focused on the severance of Column 79 at floor 13, which NIST had suggested was the initial point of failure, and considered the catenary supporting forces generated by the building structure from floors 14 to 47. These floors were only minimally damaged by fire.

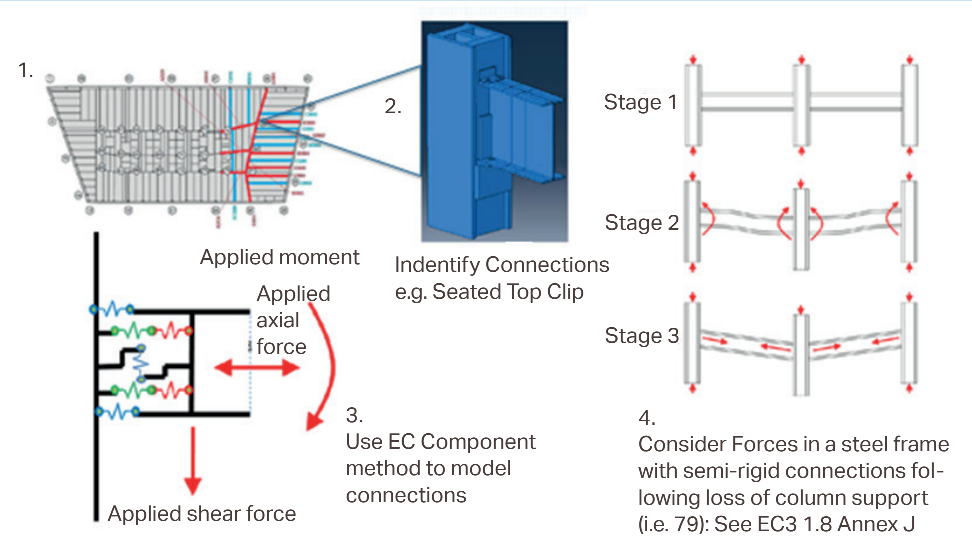


Figure 1. Wp1: East Penthouse Collapse Connections Analysis

Key:

1. Typical frame and column diagram for each floor.

2. Example connection at Column 79.

3. Component model for typical Connection.

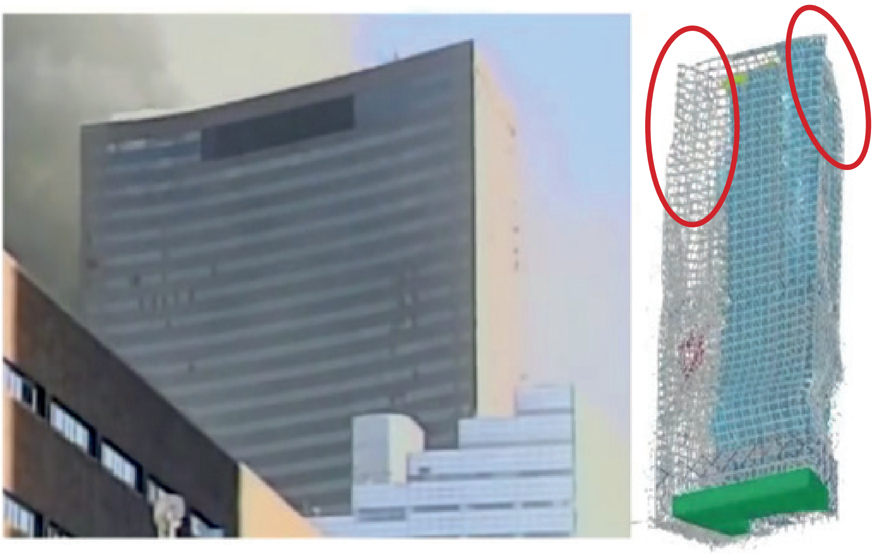
4. Column collapse model showing resultant forces.vv

The UAF study had concluded that column 79 would not fail but descend only 10 feet, however we found that the building's structure only provided 75% of the resistance necessary, and therefore the column would continue to fall. Although the outcomes from both studies are different, both demonstrate that there is significant structural resistance in the building.

The analysis also indicated that if Column 79 collapsed, escalation to core Columns 80 and 81 could occur, but at the same time there would be substantial inward (catenary) forces imposed on the exterior frame.

The next phase of the work will consider why in the 5 seconds after the East Penthouse fell, extensive distortion of the horizontally unsupported North East exterior was not observed.   And further, while the NIST described collapse progresses westwards across to the remaining core columns (confirmed by the fall of the West Penthouse), we will question why the catenary forces caused minimal damage to the entire North and West faces of the building. The evidence shows that, apart from minor window damage and a slight kink in the roof line, the exterior shows little sign of the destruction inside. The video still (taken 8 seconds from initiation and after both Penthouses have fallen) shows the North and West sides of the building just before the global collapse occurs. At this point, according to NIST, all the core columns are destroyed or falling, yet there appears to be no effect from the resultant catenary forces.

8.0 secs



North exterior 8 seconds after collapse initiation.
NIST's LS-DYNA model of the collapse.

Figure 2. Video vs. NIST WTC7 collapse animation comparison

It is noteworthy that according to NIST's own dynamic analysis, a frame of which is shown alongside the video, the distortion of the exterior they predict (see the red circles) is not seen in reality. Such significant differences observed between reality and modelling suggest to the TAC, a different collapse mechanism may be applicable.

Work on the stability of the exterior frame and the building itself continues, and we hope to draw firmer conclusions about alternative collapse scenarios, and the UAF results by end of the first quarter 2022.

David Llewelyn: November 2021

On behalf of the Steel Framed Building Safety TAC