THE MECHANICS OF COLLAPSE OF TOWERS OF WTC: WHAT CAN WE LEARN?

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ABSTRACT:

No experienced structural engineer anticipated the towers of World Trade Center to collapse as a result of aircraft impact and the subsequent fire. Therefore, it is important to understand the mechanics of collapse and try to learn from its observation as much as possible. The lecture focuses on the mechanics of rapid progressive collapse of the towers, but leaves aside the initial damage by impact and fire, which triggered the collapse and has been thoroughly examined with extensive simulations at the National Institute of Standards and Technology. The author's early early mechanical analysis of collapse is briefly reviewed, various subsequent studies and hypotheses are discussed, and some conclusions are offered. Extension of the author's early analysis to calculate the precise downward motion of the mass of the building after the initial trigger is described. A mathematical model is presented to describe the propagation of collapse fronts from the critical floors into the lower and higher portions of the tower is presented, taking into account the energy dissipation at the collapse fronts. By considering the inverse initial boundary value problem with advancing collapse fronts, it is shown that if the displacement history of the floors of the tower can be precisely tracked, one can extract valuable information on the energy dissipated in individual floors, and on their mode of collapse. This model is of more general interest for progressive collapse of building. Some previous examples of progressive collapse are discussed in this context. It is shown that the inverse analysis can be applied to extract useful information on the energy dissipative potential of various structural systems from the tracking of displacement histories in the demolition of buildings. In closing, some ways to advance the understanding of progressive collapse are pointed out.

Reference:

Bazant, Z.P., and Zhou, Y. (2002). "Why did the World Trade Center collapse?---Simple analysis." J. of Engrg. Mechanics ASCE 128 J. (No. 1), 2--6; with Addendum, March (No. 3), 369--370.