

## **A Response from the “Lay Critics” Regarding ‘Mechanics-Based Mathematical Studies Proving Spontaneity of Post-Impact WTC Towers Collapse’**

Jia-Liang Le and Zdeněk Bažant begin their article in EPN 48/1 by claiming that “lay critics” have questioned the cause of the collapse of the World Trade Center “without any meaningful calculations.” As coauthors of “15 years later: On the physics of high-rise building collapses” (EPN 47/4), the article to which they were responding, we must object to that label and point out the fatal errors that are characteristic of their body of work on the WTC failures.

To claim that we are “lay critics” is insulting and unprofessional. Dr. Robert Korol is a professor emeritus of civil engineering at McMaster University in Hamilton, Ontario, and a fellow of the Canadian Society for Civil Engineering and of the Engineering Institute of Canada. Anthony Szamboti is a mechanical design engineer with 25 years of structural design experience in the aerospace and communications industries. We have each published articles in respected journals critiquing these authors’ analysis of the WTC failures.

The errors in the present article are so numerous that we cannot cover all of them in this letter, but we will highlight the most important ones:

- 1) Readers should not be misled by the statement on p.19 that says, “The first simple analysis (2, 3) with a simple mathematical *proof* [emphasis added] of the inevitability of collapse...was published soon after the collapse.” This is simply wrong. There was no verification whatsoever. It was only a *prediction*, and ultimately an inaccurate one at that. The ratio of potential energy to column energy absorption claimed in that “proof” has been shown to be a gross overestimate, which resulted from the authors’ use of:
  - a. Free-fall acceleration during the fall of the first story, instead of the actual, measured 0.5 g acceleration. The latter gives a velocity at impact equal to about 75% of the velocity caused by free fall and thus reduces the authors’ estimated kinetic energy by about 50% (due to the squaring of velocity in the kinetic energy equation).
  - b. Maximum allowable service load of 58 Mkg for the falling upper section, instead of the actual service load of 33 Mkg. The latter further reduces the estimated kinetic energy to about 28% of what the authors predicted.

- c. Column energy absorption capacity, as estimated by the authors, at least 3 times less than it actually was.

The actual ratio of potential energy to column energy absorption would therefore have been about 9% of what the authors predicted, with the 8.4 value shown in reference 3 actually being about 0.75 (meaning that the potential energy would have been *less* than the column energy absorption).

- 2) The authors speculate on fire spread in various floors without citing evidence and then make the outrageous and unsupported statement (second column of p.19): "...a mere half-hour of heating above 150° C would have been sufficient to cause marked viscoplastic creep of the structural steel used." Who has ever heard of steel that loses strength when subjected to just 50 degrees more than the boiling point of water?
- 3) The authors make yet another unsupported statement in the next paragraph: "In consequence, many steel truss girders *likely separated* (emphasis added) from the columns and beams, especially during the cooling phase." When floor trusses, beams, and girders are heated, they expand first and then return to their original lengths afterwards. Unless they buckled, they would simply push their end restraints outwards and return to original length after cooling without separating from their end restraints.
- 4) Structures such as the WTC Twin Towers are designed to have a factor of safety of 3 or more in order to allow for extreme loading conditions and a possible shortfall in nominal strengths of structural members. Le and Bažant, however, omit several facts that are pertinent to understanding the redundancy of these structures and their ability to withstand the loading conditions experienced on 9/11:
  - a. They do not mention that only a relatively small number of perimeter columns were actually damaged (approximately 15% of the 236 in each of the Twin Towers).
  - b. They do not mention the 47 extremely heavy columns in the 135 ft.-long x 85 ft.-wide central core structures, which were some 60 feet away from the impact surface.

- c. They do not mention that the alleged initiating failure of WTC 1 supposedly occurred on the opposite side of the building from the impact.
  - d. And they do not mention that the horizontal propagation of the collapse of WTC 1 occurred across the entire building in less than one second.
- 5) In the article cited in reference 6, Le and Bažant attempted to refute the argument that the lack of measurable deceleration during the fall of WTC 1 indicates that it was not a natural collapse. In that paper they used an average 14-inch square box column for all 287 columns, with a common yield strength of  $0.248 \text{ GN/ m}^2$  (36 ksi), and they say the total column cross sectional area is  $6.05 \text{ m}^2$ , which puts their 14-inch square columns at a 15.5mm wall thickness. They then show the axial yield capacity is 2.84 times greater than the static load, which would provide for a factor of safety close to 3. However, when doing the calculation for column energy absorption, they err by using a yield moment value of 0.32 MNm, which is that found for a 14-inch square box column with a much thinner 6.75mm wall thickness. This markedly decreased the column energy absorption they used and is inaccurate.
- 6) The mathematical model that Le and Bažant present is based on two differential equations that refer to articles cited in references 3, 4 and 5. We have shown in our own work that the plastic hinging assumed and the pulverization of concrete result in energy dissipation that far exceeds the values that they use in their equations involving force  $F_c$ .

The above points provide some insight as to why the simple explanation given by Le and Bažant is inaccurate and thus non-explanatory, and why additional investigation into these collapses is needed.

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