On Cherepanov's Critique (emailed to USNCTAM Participants on 6/17/06) of Bazant & Zhou's Analysis

2 slides presented in Discussion at Symposium on WTC Collapse, US National Congress on Theor. & Appl. Mech., Boulder 6/26/06

- Misunderstanding of the purpose of showing huge elastically calculated stresses upon impact (merely prove the necessity of inelastic analysis).
- Role of creep –although unimportant for conclusions, the WTC steel shown to lose 20% of yield strength at 300 C, 80% at 600 C (the max. temperature documented by NIST). Marked creep above 450 C.
- Designed for safety factor > 3. Yes, but claiming that the load capacity cannot be overcome by gravity, he overlooks dynamic snapthrough.
- Thinks that stocky columns only shorten plastically but do not buckle Reality — plastic hinges, plastic web buckling, fractures in welds and connections greatly reduce energy absorption capacity.
- Implicitly denies the necessity of gravity driven progressive collapse.
- Free fall? – misquoted!
- Cherepanov's estimate of progressive collapse duration – excessive by far.

Flaws of Cherepanov’s “Fracture Wave” Concept

- Implies a homogenized continuum at the limit of strain softening
  = an ill-posed dynamic problem.
- Nonlocal formulation with a material characteristic length is required but not used.
- Forgot to check for localization instability (with energy release due to unloading) of his assumed initial state, which is at the limit of strain softening. This initial state cannot be reached.
- No characteristic length is present in the entire formulations, and so the size effects, experimentally shown to be strong (e.g. for borehole collapse, rock burst, avalanches, etc.) are not captured.
- Other unrealistic, physically incorrect properties of “fracture wave”:
  - negligible volume compaction,
  - speed equal to elastic wave, etc.
- Rock bursts, avalanches, borehole collapse, etc.
  — are completely explained (incl. size effect) by fracturing and localization instability, with no need for “fracture wave”.

More detailed critique of Cherepanov's "fracture wave" concept:

The steel tower was fragmented by the so –called "fracture wave" in split second into small pieces, and then remained visually intact for several seconds until mass freely falling from the top arrived?— Impossible. The fractured material, on the verge of softening damage is unstable, and so collapse would be simultaneous and immediately visible through the entire height, but it was not. Besides, for structural mild steel, which is very ductile, it is impossible to fragment rather than deform plastically.

Supposedly, the fracture wave occurs in a continuum on the verge of strain-softening damage with fragmentation. But this is in fact an ill-posed dynamic problem, which must be regularized by a nonlocal or gradient approach, while Cherepanov uses the classical local continuum approach. The concept of "fracture wave", which was proposed by Cherepanov some 40 years ago but has never been used by any scientist except himself, is physically meanigless.

Cherepanov's equations for his "fracture wave" are mathematically identical to those for a detonation wave in a chemically explosive gas mixture. But the initial and boundary conditions are very different from a gas mixture. The impending instability is in a gas mixture caused locally, by the possibility of chemical reaction at each point in the gas, but in a solid such a state is produced by boundary displacements or constraint of the surrounding solid rather than locally. This causes that a uniform state on the verge of instability would immediately localize in a small zone and the rest of the solid (or tower) would immediately unload.

This means that a fragmented tower could remain stable for a few seconds only if some external agency restrained every point of the tower. Cherepanov forgot to check for such instability, and if he did he would have had to drop the idea of "fracture wave".

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