

A layman's open letter to Professor Zdeněk Pavel Bažant

CC: Yong Zhou, Mathieu Verdure, Jia-Liang Le, Dr. Frank R. Greening, S. Shyam Sunder (NIST) and f. ASCE.

Dear Professor,

dear scientific community!

Thank you for taking the time to consider my thoughts on your works “Why did the World Trade Center collapse?” and “Mechanics of Progressive Collapse”.

I am writing to you today because I found your publications* to give the only non-conspirational explanations for the 9/11/01 collapses of the Twin Tower buildings. Based on your work (2002), even NIST concluded in NCSTAR 1 (2005) that no further theoretical or experimental examination of the collapse sequence was needed, because, once the impacted stories began to give in, „the towers were doomed“.

I found this odd ever since I saw the towers collapse for the first time, and although, out of a layman's natural curiosity, I tried to find explanations other than those outrageous demolition theories that have been postulated by a few outsiders in the past years, I have found none that made sense to me; so I find no other way than to ask your assistance in understanding your work. Since this is still a matter of great importance to many all around the world, please accept my sincere apologies for choosing to publish this letter openly on my blog on dugarun.de so other members of the scientific community may join the discussion.

To be honest, those differential equations scared me off a little, but I remembered from high school that an integral describes the area under a curve in a coordinate system, Energy is Force times Distance, Force is Mass times Acceleration, I remembered Isaac Newton's lex quarta and so forth, so it wasn't that hard anymore to decode the equations (1) – (3) in your paper from 2002 and (1) – (6) in 2007.

For better understanding, a copy of Figure. 4 from „Mechanics of Progressive Collapse: Learning from World Trade Center and Building Demolitions“ is included:

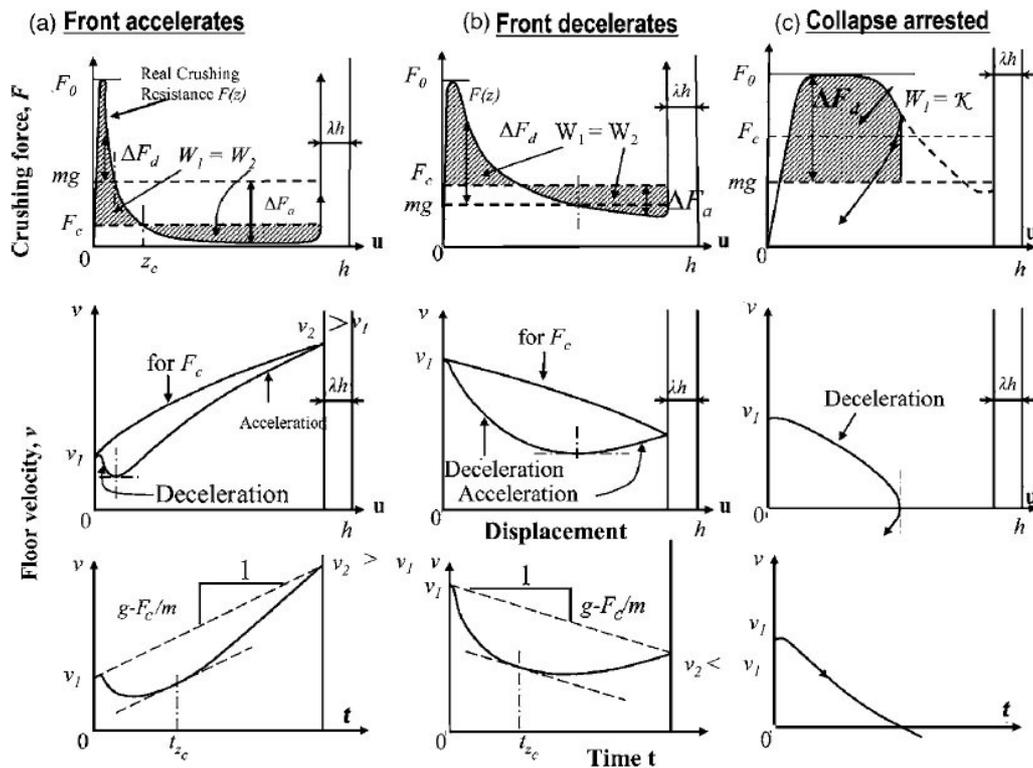


Fig. 4. Typical diagrams of crushing force and floor velocity in buckling and crushing of columns of individual stories

I understand you have proven that the kinetic energy of a 3.7m drop would be sufficient to overcome the peak of the resisting force curve (Fig. 4a) and, after that, continue to buckle. A quick check on Wikipedia shows the four Euler cases and I understand that from a technical perspective, a steel beam can indeed be regarded as four parts connected by three (plastic) hinges. I understand that at first, it's hard to push against a match but once it's broken, it's broken and the fall will speed up again, driven by gravitation or any other pushing force. In any case, F_C , the force needed to crush the story should be much (two or three times) bigger than $m \cdot 9.81 \text{ m/s}^2$ (as you show in Fig. 4b), otherwise, the building wouldn't keep upright in the first place. That's what architecture and engineering is about: putting stuff on top of each other to decelerate gravity's acceleration of everything in and above it to $v=0$, which is guaranteed by an F_C reasonably greater than the weight of what it's supposed to hold upwards.

Only when block C comes down at great velocities and $a = 31 \cdot 9.81 \text{ m/s}^2$ is $m \cdot a \gg F_C$ so the story gets „crushed“ (up or down, you choose) as demonstrated by Fig. 4a. But is global collapse really inevitable, logically?

What about the next story? By now, just some of the potential energy of Block C has been converted to kinetic energy (by the energy the planes brought in (deformation and heat, gets a whole story out of the way for Block C's free fall)), which in turn has been converted to internal energy, because the structure has been deformed. According to what we have learned about the conservation of energy, the sum of all impulses in a closed system stays the same and as we do not assume that any form of energy (as, for example, a lot of unknown mass or gears, levers, momentums or spring energy built in with a watchmaker's precision, or an upside down rocket on the roof, or chemical energy which could be transformed into thermal energy to cut the columns to provide for better "hinges" or even extraterrestrial aliens with superlasers shooting from outer space, which would all serve the same purpose – to assure that $g \cdot m(z) > F_C$) has been smuggled into the towers prior to the attacks to explain why for all stories $g \cdot m(z) = m \cdot a > F_C$ (the case you show in Fig 4a), K , as

converted to $W(u_p)$, should become smaller, i.e. $K'=K-W(u_p)$.

Again: of course, in the beginning, $a=31*9.81\text{m/s}^2$ as you computed from the stiffness C , accordingly, Fig. 4a applies; but g is still only 9.81m/s^2 , so $m*9.81\text{m/s}^2 < F_C$ as in Fig. 4b applies for the whole rest of the building which suffered no damage at all (until then), as everyone including you and NIST (2005) agree. So, in theory, $F(u)$ should *decrease* from story to story, except if someone or something besides earth's 9.81m/s^2 is pulling (or pushing, if you will). Accordingly, the deceleration *should* have resulted in a collapse arrest sooner or later as you show in Fig 4c.

Yet, as we have witnessed on September 11th, 2001, the towers accelerated downwards with an average of $a_{\text{observed}} = 2*h/t^2 = 2*400/(14\text{s})^2 = 4.08\text{ m/s}^2 \approx 0.42\text{ g}$, so the resisting force that accelerated the building upwards was only $F_{\text{totalfriction}} = m*a = 58,000,000\text{ kg} * (9.81-4.08)\text{ m/s}^2 \approx 332\text{ Meganewtons}$.

That is not much compared to the force the topmost floor of the lower building block must have had at least before a plane crashed into it: $F_{\text{load}} = m*g = 58,000,000\text{ kg} * 9.81\text{ m/s}^2 \approx 569\text{ MN}$ (+some little just to be sure). And that's just the topmost floor, in theory, all F_{load} of each of the 110 floors should sum up, according to the superposition principle. Just imagine F_{load} for the columns on ground level!

This, in turn, means, that – against all logic (except that of a few outsiders), but according to your own explanations – indeed Fig 4a does apply so that $m*g > F_C$ during collapse, distributed evenly among all 110 stories, so, essentially, a huge ΔF_a was hidden in the building, ready to be triggered by a relatively small $F(u)$, to make sure that $F_C < m*g$ all the way from the top to the bottom. Ergo, we can conclude that, since we do not want to insinuate that m somehow became greater because a lot of mass has been brought up there, and since we may want to exclude hypotheses explaining how g locally became a lot greater than 9.81m/s^2 during this very hour (or that springs or an upside down rocket attached to the roof accelerated the towers all the way down to Ground Zero) to explain how g (or a , in this case) remains much greater than 9.81m/s^2 for $u_n=400\text{m}$, that the only way to bring down the buildings would be for F_C to drop way below $m*g*$ security factor on each level one after another – for all remaining 108 floors above and beneath the impact area.

You state that what matters is neither strength nor stiffness, but is energy. So, $E_{\text{kinplaneimpact}} = 1/2 * 124,000\text{kg} * (225\text{ m/s})^2 \approx 3.14\text{ Gigajoules}$. This plus $E_{\text{heat}_{\text{kerosene}}}$ is what, in our 1D-model, causes $E_{\text{pot}_{\text{BlockC}}}$ to be released all of a sudden by displacing all columns (which obviously took several minutes to prepare, for until then, the towers were standing – hurt and smoking from 3GJ of deformation energy and burning from $E_{\text{heat}_{\text{fires}}}$, but upright). $E_{\text{pot}_{\text{BlockC}}}$ now in turn, after falling 3.7 meters and gaining a speed of 8.52 m/s (since $v = \text{sqrt}(2*g*s) = \text{sqrt}(2*9.81\text{m/s}^2 * 3.7\text{m})$), becomes $E_{\text{kin}_{\text{crush}}} = 1/2 * m * v^2 = 1/2 * 58,000,000\text{kg} * (8.52\text{ m/s})^2 \approx 2.1\text{ GJ}$ ($\approx K$ in your paper, I believe).

Compared to the potential energy of each tower, $E_{\text{potential}} = m*g*h = 500,000,000\text{ kg} * 9.81\text{m/s}^2 * 400\text{m} / 2 \approx 981\text{ GJ}$, a very small amount of input energy sufficed to bring down the complete structure, while one would expect that the sum of all $W(u_p)$ to $W(u_{110})$ would be a huge lot greater than K , even greater than $E_{\text{potential}}$, diminishing $a*m(z)*u_n$ along u in Eq. 3 (2007) as $a=31*g$ approaches $a=g$, since usually in a building $\Delta F_d > \Delta F_a$, resulting in an increasing $\Phi(u)$, so that sooner or later $\Phi(u) > K$ (Eq. 5) and the fall is stopped, as with every other static structure we know of.

To be even more precise, $\Phi(u)$ is even bigger because of the area over λh in Fig. 4a-c. The „rubble“ and the softened steel would „dampen“ any force, as indicated by the steep rise in the curve for $F(u)$, and so would the acceleration force needed to overcome the inertia of the next floor slow downwards movement.

As the collapse was not arrested for 110 floors and the downwards acceleration was bigger than the deceleration (=upwards acceleration) for 10-23 seconds, a critical review of your own analysis begs the question why $m*a$ was greater than F_C throughout the whole structure so that $\Delta F_a > \Delta F_d$ and $\Phi(u) < K$ for all u from top to bottom of three buildings (WTC 1, 2 & 7) that have been built to withstand storms and earthquakes and faithfully did so for three decades.

The towers were „doomed“ and collapse was „inevitable“ only under the assumption that for each floor, the rules of Fig. 4a apply. It is hard to see why such a building would be allowed to be built in the first place, as its collapse bears features of a metastable system or a 19th century *perpetuum mobile* mechanism rather than of anything remotely statical; just a small impulse would trigger a huge mechanism that switches from decelerating earth's 9.81m/s^2 to 0m/s to accelerating $500.000.000\text{ kg}$ structure of steel and concrete with 0.42 gs so it keeps moving all the way, folding into itself.

This cannot be the result of some chaotic and random process, but requires meticulous planning, as can easily be verified in experiment by alternately stacking weights and paper rings on each other (as seen in <http://www.youtube.com/watch?v=caATBZEKL4c> and <http://youtu.be/rGw58logz0o>): no model of what looks anything like a „tower“, even with so much m distributed (as m_1, \dots, m_n) over h that F_C is just a little bigger than $m*9.81\text{m/s}^2$ (putting just a little more weight on one paper ring than 1.8 Kg would crush it instantly, an extreme form of Fig. 4a). Choosing a generous drop height and a nice m_C for a good C-block (picking up a third of the 1825g and letting them drop from $0,2\text{m}$) will not result in total collapse. Parts of the „tower“ structure will get „crushed“ between earth and falling object. „Crush-up“ and „crush-down“ appear simultaneously, the impulse runs through the structure, „crushes“ the weakest „hinges“ (right down to floor level, where $m*g$ is closest to F_C with just a tiny ΔF_d), and, as expected, Fig. 4b&c ensue: collapse is arrested (if kept from „toppling“) with most damage where block C and B+A made contact and on floor level, while „rubble“ (crumpled paper rings) dampened the impacting force.

Even if there's a gradient of FC over h , but so is of m . And of course $F_{C(n)}$ and $F(h)$ is just the weakest points, hinges, connectors and trusses combined, including shearing, buckling and all that which can happen when things go mechanic. However, for a, say, 80% intact steel building, that should be more than just 332 MN resisting a $58,000\text{t}$ -block (distributed over 400 meters and its own load being something between $250,000\text{t}$ to $400,000\text{t}$) vertically; bearing in mind that the structure hardly swayed visibly when it was hit horizontally by a fast-moving plane and even absorbed the huge fireballs that we saw when half of the kerosene exploded. So, even with another 2.1 GJ being triggered by the ensuing office fires and fireproofing being razored off the columns in the impact zone, global collapse should neither be inevitable nor the most logical thing to expect, as documented by the EMS setting up a triage desk in the lobby of the already burning south tower (NCSTAR 1, p. 44) and hundreds of firefighters still making their way upwards to save lives. Those were heroes, not maniacs with suicidal tendencies.

Dave Thomas was kind enough to explain on his website how the stiffness of a spring can be computed and inserts a value of $71,000,000,000\text{N/m}$, as you do for (2002) and (2007) as a basic premise for the rest of your calculations. If, however, $F=-kx$, then, as we observed, the „spring“ was displaced 400 meters by 31 times the force of block C, so $k=-F/x$ and for $F=31*F_{LoadBlockC}$: $K=-31*58,000,000\text{kg}*9.81\text{m/s}^2/-400\text{m}=44095950\text{N/m}$ which is 1610 times smaller than $71\times 10^9\text{N/m}$ – what a „spring“ the towers must have been then that it lost 99.94% of its stiffness!

Although I am not an expert, I'd like to prefer science, empiric studies and sane logic over blind superstition, ignorance and outlandish conspiracy theories as they were common during the dark ages and, as we have learned from history, inevitably lead to oppression, prosecution of minorities and the torture of innocents. This is the 21st century.

As Galileo Galilei said: „in questions of science, the authority of a thousand is not worth the humble reasoning of a single individual“, I herewith would like to offer my 0.02€ to the discussion over why the towers fell and express my hopes that you as the leading expert in the research of scaling the mechanics of solids will propose a model of the towers featuring the same distinct properties during a – however induced – *collapse sequence* to shed even more light on what happened on September 11th, 2001 and which still influences the lives of many all around the world.

Kind regards,
Akareyon

*this letter refers to:

Bazant, Zhou (2002): *Why Did the World Trade Center Collapse?—Simple Analysis*

Bazant, Le, Greening, Benson (2007): *Collapse of world trade center towers: what did and did not cause it?*

Bazant, Verdure (2007/2008): *Mechanics of Progressive Collapse: Learning from World Trade Center and Building Demolitions*

=====
Professor Bazants reply:

Dear Mr. Akeyron: It is impressive when a layman grasps phenomena normally requiring higher level of training. We appreciate your expression of support, but we are too busy to have time to engage in a discourse at this level. For us, the analysis of WTC was a small, unfunded and temporary interest.

Dear Professor Bazant,

I understand that you must be very busy, so thank you very much for your fast reply.

I just wanted to point out that according to your 2007 paper, $m \cdot g$ would have to be greater than F_c as in Fig. 4a for all 110 floors of each tower to guarantee global collapse so, if interpreted correctly, regardless on which level, your work inadvertently SUPPORTS controlled demolition theories instead of refuting them.

What for you may have been a temporal interest, is of great significance to those still riddled with doubt over what happened on 9/11, as policy makers around the world, including those in my country, still base their decision-making mainly on the validity of your work (on which NIST relies, on which, in turn, media rely and shape public opinion), and many suffer from that very policy – for example, when the war against terror is fought in their country.

I must not speak on their behalf, but on my own, for when I went to school (in 1990's Germany), our teacher wanted us to interview our grandparents about their knowledge of the Holocaust. 9/11 being the “American Holocaust” which I have witnessed in my lifetime, I must expect my kids to ask me one day why the WTC collapsed and I would feel ashamed to admit that – even after asking the very experts who proved a global collapse under its own weight feasible – I could only “guess” how and why the towers fell, even if it gives them a bad lesson about science, superstition and conscience.

If, perchance, you or your colleagues ever start a new small and unfunded analysis, they may want

to avoid the mistake that I have pointed out in my letter to you, so I thought I better notify you about that pitfall.

Again, thank you for your time and consideration!

Yours sincerely

Akareyon

=====

Professor Bazants reply:

With this I disagree. Briefly, out have to consider dynamic equilibrium (d'Alembert principle). in which all the inertia forces must be superposed on the gravity forces and the resisting forces. You need to look at some elementary text on structural dynamics. Our argument refutes rather than supports the fairy tale of controlled demolition.

Professor,

that's exactly my argument. $m \cdot g$ in Fig. 4 cannot be $31 \cdot m \cdot 9.81 \text{ m/s}^2$ for all 110 floors, because kinetic energy $m \cdot g \cdot u = m \cdot g' \cdot u' + W_{\text{deformation}}$, so g should become smaller and smaller while proceeding through u until $m \cdot g < F_C$ as should be in a static building. The superposed resisting forces of the lower block as a structure that has not suffered any serious damage yet should be much greater than block C's "feeble" $31 \cdot m \cdot 9.81 \text{ m/s}^2$, unless something besides earth's 9.81 m/s^2 keeps accelerating block C+rubble layer.

Sincerely,

Aka

(no reply so far)

=====

Dr. Greenings reply:

Dear Mario,

Perhaps the attached material will help answer your questions:

Frank Greening

(attached was a Word document with chapter 6.2 from [The Pulverization of Concrete in WTC 1 During the Collapse Events of 9-11](#), with the addition of "An Assessment of the Time Delays Involved in the WTC Collapse Events" made which, according to google, hasn't been published yet so I really feel honored :-)

Dear Doctor Greening,

thank you very much for your time and consideration!

However, the attached excerpt from your work "The Pulverization of Concrete in WTC 1 During the Collapse Events of 9-11", riddled me with questions very similar to those in my original letter, even though your approach is slightly different from that of Bazant/Zhou (2002) and Bazant/Verdure (2007).

Let me quote:

"Thus, setting M_n to $5.8 \cdot 10^7 \text{ kg}$, M_1 to $0.39 \cdot 10^7 \text{ kg}$ and with v_i equal to 8.52 m/s , we readily determine that the first impacted floor of WTC 1 moved off with a velocity v_f equal to 5.4 m/s ; that is 3.1 m/s or 36% slower than the impact velocity. Nevertheless, this reduced velocity was more than sufficient to guarantee a self-sustaining global collapse of WTC 1."

With all due respect: non sequitur. You can't just crush one story and say, just like NIST and

Bazant/Verdure do: “after that, the towers were doomed”, “global collapse ensued”, “global collapse was inevitable”. It does not match experimental observation, it is not the most logical thing to happen. We still have another 108 floors to go! (110-1 for the impact damage which causes freefall and -1 we’ve just crushed).

Because, for the next story, the same equation applies:

$$\frac{1}{2} M_n v_i^2 = \frac{1}{2} [M_n + M_1] v_f^2 + Ed$$

This time, with our second v_i only v_f from the first step (first step’s $v_i * 64/100 =$ first step’s $v_f = 5.4\text{m/s} =$ second step’s v_i) and according to the law of conservation of energy, another Ed (603 MJ) must again be subtracted from the second $\frac{1}{2} M_n v_i^2$ to derive v_i for the third step. Only one plane impact, so only one free fall, and of course only one energy input of 2.1 GJ, sorry. Thus, with a total input energy of only 2.1GJ (which I agree upon given a 3.7m freefall of 58.000t near earth’s surface), the collapse should get arrested after crushing three or four floors, if each floor’s $Ed = 603$ MJ, as you calculated.

According to Table 1 in your report, ["An Assessment of the Time Delays Involved in the WTC Collapse Events"] the structure’s “Force action distance” is only 11 centimetres, which might be the case in a perfect scenario given the fact that the impacting forces found their least energy-consuming way through the weakest parts of the structure, i.e. bolts, “plastic hinges” and so on, and afterwards, there’s another small “free fall”. But I checked your numbers according to the equations given [$d = (v^2 - u^2)/(2g - F_y/M)$] and [$\Delta t = 2d/(u + v)$] and found that you must have derived each Δt and d in your table for each story from $F_y = 2 * 10^{10}$ Newtons – while conservation of momentum, Newton’s lex quarta and the d’Alembert principle (which Professor Bazant was so kind to inform me of) and every observation I have made in my lifetime dictate that F_y diminishes with each story crushed, d be 11 centimeters or 3.59 meters!

In essence, what you have done, mathematically, is just what Bazant/Verdure (2007) had to do in their report to make the towers collapse as fast and as completely as they did in reality. In your report, $F_y = 33 * F_{st}$ for all 110 floors. In their work, $m * g > F_c$ (where $g = 31 * 9,81\text{m/s}^2$) as shown in Fig. 4a applies to all 110 floors (and as I have explained in my open letter and which is no mistake, as Professor Bazant insists). 500.000.000kg of mass distributed over 400 metres’ height, yet the retarding force acting against earth’s acceleration of 9.81m/s^2 is only $m * a = 58.000.000 \text{ kg} * (9,81-4,08) \text{ m/s}^2 \approx 332$ Meganewtons where $a = 2 * h/t^2 = 4,08 \text{ m/s}^2 \approx 0,42 \text{ g}$. for $h=400\text{m}$ and $t=14\text{s}$.

In other words, *your math is correct*, as the graphs in your Figure 1 show, but begs for a different interpretation, as it also proves an “inside job” for the collapse of the Twin Towers – literally: there must be a lot of force, i.e. $110 * F_y$, that is, a lot of energy hidden *inside* the buildings (other than that of the planes and the fires and the resulting 3.7m freefall) to ensure global collapse. I am desperately out of jokes by now about what that could have been – springs, gears, levers, martians with superlasers or an upside down rocket on the roof, there are many forms of energy around – so I must suggest in all seriousness, for this is not a laughing matter, that you and your colleagues rethink the official “gravitational collapse” hypothesis, blow the whistle and inform the public about your – inadvertent – findings.

Otherwise, one would have to explain how an input energy of 2.1 GJ could trigger $110 * Ed + E_{potential} > 1 \text{ TJ}$ [where $Ed = 603 \text{ MJ}$, as you calculated, and $E_{potential} = m * g * h = 500.000.000 \text{ kg} * 9,81\text{m/s}^2 * 400\text{m} / 2 \approx 981 \text{ GJ}$] UNLESS the towers were built as amplification machines (with gears, springs and levers in them) rather than good old *buildings*, as those working in it for 30 years believed and as we know them ever since our forefathers erected the first pyramids.

Yours sincerely

(Akareyon)

=====

Dr. Greenings reply:

Mario,

No amplification machine required! That's why it's called **disproportionate collapse.....**

Dr. Greening,

Frankly, what it's called is not of primary interest because it has been pancake, card house, crush-up-crush-down, trusses, global collapse, progressive collapse, gravitational collapse, piledriver, controlled demolition, implosion, explosion and telescope mast already. In religion, opinions may differ about how to name things, in science, two plus two make four. When science says that bumblebees can't fly, bumblebees don't stop flying. Instead, science seeks to explain and found that bumblebees have those wings to actually *flap* them. If $F_y = 33 * F_{st}$, as you say (or $g*m=31*9,81m/s^2*m$, as Professor Bazant demonstrates), and if $F_y = 20,000,000,000$ N and $h=110*0.11m$ (your "force action distance") then $W=242GJ$ – that's not unlike our $2,105$ GJ *110 floors = 231 GJ. But there was only one plane, one fire and a 80-90% unhurt solid structure. So mathematically, you're dropping Block C again and again and again. Or pulling. Or pushing. Or getting something out of the way. Please re-read my original letter, third-to-last paragraph: "If $F=-kx$, then, as we observed, the 'spring' was displaced 400 meters by 31 times the force of block C, so $k=-F/x$ and for $F=31*F_{LoadBlockC}$: $K=-31*58,000,000kg*9.81m/s^2/-400m=44,095,950N/m$ which is 1610 times smaller than $71 \times 10^9 N/m$ " – where are those 99.94% of its stiffness gone and whence come those additional > 230 GJ?

Aka

=====

Dr. Greenings reply:

The "spring" you refer to was not compressed 400 meters! *It was broken into a million pieces long before that*, so your calculation is meaningless. Try calculating how much a column can be compressed before it reaches its elastic limit. If you work with Prof Bazant's values you will see his k is for one floor height, but the pile-driver model is not to be taken too literally because the building ceases to act as a spring after a few milliseconds.....

(emphasis mine)

Thank you, Doctor, now I understand what I've been trying to say. Have a nice 11.11.11 :-)