Clarifying the Question of Collapse Times on 9/11

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7 August 2021
Version 2*

Abstract

Over the years, several discussions have been raised regarding the fall times of the WTC Twin Towers. Unfortunately, even after years of research, misinformation/misunderstanding continues to persist about how the Towers fell, how long they took to fall, and what all of that means. In this paper, we attempt to clarify these matters by examining both the fall times and fall rates of the Twin Towers and World Trade Center 7. This analysis does not claim to be a definitive description of the collapse mechanics of any building. Rather, the purpose of this analysis is to give a factual account of the Towers' collapse times and fall rates, and to compare them with other building collapses – specifically those that have fallen due to fire, or through controlled demolition. The author bases these findings on publicly available information regarding each structure discussed herein, including videos of the buildings' collapses, which can be studied and analyzed at any interested parties' leisure. We also apply the principal of inductive inference to the question of building fall times and fall rates, comparing the WTC to the various other structures in order to determine whether the Towers more likely collapsed due to the effects of fire/gravity, or controlled demolition with explosives.

"Official" Estimates

Looking to official reports for a definitive estimate of the Towers' collapse times, unfortunately, turns up little of use. The 9/11 Commission Report (2004, 305) states the South Tower collapsed in 10 seconds. NIST (National Institute of Standards and Technology), on an FAQ page and not in their report, states the time it took the first exterior panels to hit the ground was 9 and 11 seconds for the South and North Tower, respectively (NIST, 2006). However, neither of these estimates gives us anything of value, given that (a) the Commission Report is not an engineering report, and thus not an authority on the collapse mechanics, and (b) as the NIST FAQ page makes clear, their statement is in reference to the first debris to hit the ground, not either structure as a whole. Various sources on the web also claim the Towers collapsed in around 10 seconds (or even less), but this appears to be a result of misreading seismographs which recorded the collapses on 9/11 (Hoffman, 2006a). In order to determine more probable collapse time estimates, we must look elsewhere.

Bažant *et al* (2008, 903) also looked at seismic records to determine a plausible collapse time estimate, arriving at mean durations of 12.82 and 10.49 seconds for the North and South Tower, respectively. Although others have challenged the methodology and conclusions drawn in this study and elsewhere (e.g., Szuladziński *et al*, 2013; Schneider, 2019), we will accept these figures as reasonably accurate. Important to note, however, is that these estimates only consider the fall time of the sections below the plane impact points, without the upper sections included. According

to NIST (2005, 87), the collapses of WTC1 and WTC2 started at the 98th and 82nd floor, respectively, meaning the upper sections were 12 and 28 floors. We could then perhaps add one second to the fall time of WTC1, and two seconds to WTC2 (due to the difference in the upper section heights), and this gives us overall collapse times of 13.82 and 12.49 seconds, respectively, resulting in a mean average of approximately 13.1 seconds. Hoffman (2006b) takes a more straightforward approach, and bases estimates primarily on the video records, determining that the Tower collapses took around 15 seconds in either case. For the remainder of our discussion, we will accept this figure of 15 seconds as our time for the Towers, but we consider this an upper bound figure, as the fall times could have been as low as 13 seconds.

Determining the fall time of WTC7 is also subject to some debate, but appears somewhat more straightforward. Jones (2006, 4) estimates the building collapsed in approximately 6.5 seconds. Conversely, NIST estimated the fall of the first 18 stories took approximately 5.4 seconds, 1.5 seconds (40%) longer than free fall (NIST, 2008, 601). However, this estimate was based on the initial movement of the building's roofline, not its downward descent (Gourley *et al*, 2008). Because there is some dispute over the exact moment the start of the fall should be clocked at, we will consider both estimates in this study. Adding in NIST's additional 1.5 seconds to Jones' estimate brings us to a total collapse time of 8 seconds.

Free Fall Collapses?

In order to continue our discussion, we will need to be familiar with a few figures. To calculate an expected free fall time, the calculation is

$$D = 16.08 \times s^2$$

where D is the distance in feet, and s is seconds. Next, the calculation to determine average acceleration is

$$a = \frac{2s}{t^2} - \frac{2u}{t}$$

where a is the acceleration in ft/s^2, u is the initial velocity, s is the height in feet, and t is the time in seconds. Given that u is assumed to be zero in all cases here (since every structure starts at rest), we can disregard the second part of the equation and shorten it to simply $a = 2s/t^2$.

The Twin Towers were 1362 (WTC2) and 1368 (WTC1) feet tall. A fall from either height would take approximately 9.2 seconds in complete free fall. In other words, the free fall time of the Towers is calculated as $1362 = 16.08 \times 9.2^2$. Likewise, the average acceleration is calculated as $2(1362)/15^2 = 12.10$ ft/s^2. This also results in a fall time exceeding free fall by approximately 63%. Building 7 was 610 feet in height, resulting in a free fall time of approximately 6.1 seconds. Assuming NIST's estimate of a roughly 8 second collapse, we find the average acceleration to be approximately 19.06 ft/s^2. This results in a fall time exceeding free fall by around 31%. Assuming Jones' estimate, we find an average acceleration of 28.87 ft/s^2, and an excess of free fall by only 6%.

Although claims have often been made that the Towers collapsed at free fall, or "near" free fall, these figures put things in better context. The rate of free fall in a vacuum is 32.2 ft/s^2, so in no sense can either of the Twin Towers be said to have collapsed at free fall. And while studies have

found portions of their accelerations to be anomalous (e.g., MacQueen & Szamboti, 2009; Chandler, 2010), whether the overall fall times of the Towers can be said to have been at near free fall is still debatable. On the other hand, a much better case can be made for Building 7 to have fallen at near free fall, and indeed it has been found that for at least a portion of its collapse, its acceleration was indeed that of free fall (NIST, 2008, 602; Chandler, 2018).

It is this author's opinion that the focus on whether or not the Towers are said to have fallen at free fall was perhaps misguided all along. If the question at hand is to determine if the Towers were felled by explosives, or purely by the combination of fire and gravity, then the focus should squarely be set on analyzing their actual rate of fall, and how they compare to other structures felled by these competing scenarios. This, of course, involves examining real-world examples of each, which we will now proceed to do.

Inductive Inference and Other High-rise Collapses

Inductive inference is the method of inquiry that "involves reasoning from a limited number of observations to wider, probable generalizations" (Baggini & Fosl, 2010, 8). While not definitive in the way deductive inference is, induction is recognized as integral to the scientific method (Rothchild, 2006), a "hallmark of scientific reasoning," and the conclusions drawn from it are considered "warranted," "more likely," or "more probable" (DiCarlo, 2011, 40).

Inductive inference has played a major role in assessing the destruction of the WTC buildings, with researchers noting that before 9/11, fire had never caused the total collapse of a steel-framed high-rise skyscraper (e.g., Jones *et al*, 2016, 22). However, this should not be taken to mean that it is *impossible* for fire to cause such a structure to collapse – indeed, as this paper shows, at least two of the structures we will discuss were high-rises and did collapse from fire. The main point is to assess the ratio of fire collapses versus collapses caused by controlled demolition with explosives. And considering the extreme rarity of fire ever causing a high-rise skyscraper to collapse (Sarns, 2020), initial skepticism that fire caused such a thing three times in one day is warranted.

Adding to this inductive reasoning is the fact that the collapse of the Towers exhibited characteristics that, until 9/11, had only ever been seen in controlled demolitions (Griffin, 2005, 26-27). In addition, before and even after 9/11, no steel structure that collapsed from fire had exhibited every one of these features (Taylor, 2013, 24-25). One such feature is the rate of collapse, and that is the feature we will closely analyze here. To do so, we will compare the rate of fall between structures known to have collapsed from fire, and those that were knowingly felled by explosives.

We will first consider three structures known to have been brought down through controlled demolition with explosives: the Landmark Tower, the Martin Tower, and the Farmers Bank Building. The reasons for choosing these structures are (a) they are all steel-framed high-rises like the Towers (as opposed to masonry structures), (b) they are fairly tall structures, all over 300 feet in height, and (c) they all collapsed more or less as single units, as opposed to collapsing in sections. The specific details of these buildings, in terms of their size and construction, are taken from www.emporis.com.

- The Landmark Tower was 380 ft, and when demolished appeared to collapse in approximately 7 seconds (https://www.youtube.com/watch?v=79sJ1bMR6VQ). A free fall

time from its height would have been approximately 4.8 seconds. This means its fall time exceeded free fall by approximately 45%, and its average acceleration was 15.51 ft/s^2.

- The Martin Tower was 332 ft, and also collapsed in approximately 7 seconds (https://www.youtube.com/watch?v=6QI3VhFXYyw). A free fall time from that height would be 4.5 seconds. It therefore exceeded free fall by approximately 55%, and its average acceleration was 13.55 ft/s^2.

- The Farmers Bank Building was approximately 344 ft, and collapsed in around 8 seconds (https://www.youtube.com/watch?v=60ekZeAtBbU). A free fall time from that height would be 4.6 seconds. It therefore exceeded free fall by about 73%, and its average acceleration was approximately 10.75 ft/s^2.

Now we will compare this with known fire-induced gravity-driven collapses. To the best of this author's knowledge, only three viable candidates exist: the Wilton Paes Almeida Building, the Plasco Building, and the TU Delft building. Each of these were steel-framed buildings which are said to have collapsed solely due to fire. To be sure, other steel structures have collapsed from fire as well, but we are disregarding these, not only because there are no video recordings of most of them to analyze, but also because they are not reasonable comparisons in terms of their size and construction (Taylor, 2013).

- The Wilton Paes Building was 277 ft. It collapsed in approximately 8 seconds. (https://www.youtube.com/watch?v=JxCEpOw2hek). A free fall collapse would have taken 4.15 seconds. Therefore, it exceeded free fall by approximately 92%, and its average acceleration was 8.65 ft/s^2.

- The Plasco Building was 138 ft. It collapsed in approximately 15 seconds. (https://www.youtube.com/watch?v=_MgJTa7SDaY). A free fall collapse would have taken approximately 2.9 seconds. It therefore exceeded free fall by 417%, and the average acceleration was approximately 1.22 ft/s^2.

- The highest point of the TU Delft building was 183 ft. Although this wasn't a total collapse, as only one section fell, this section did so in a progressive top-down fashion, which is also said to have been the case for the Towers. The section collapsed in approximately 9 seconds (https://www.youtube.com/watch?v=bizr86N-4nc). A free fall collapse from that height would have been approximately 3.3 seconds. Therefore, the collapsed section exceeded free fall by 172%, and its average acceleration was 4.51 ft/s^2.

Altogether, here are the results we arrive at:
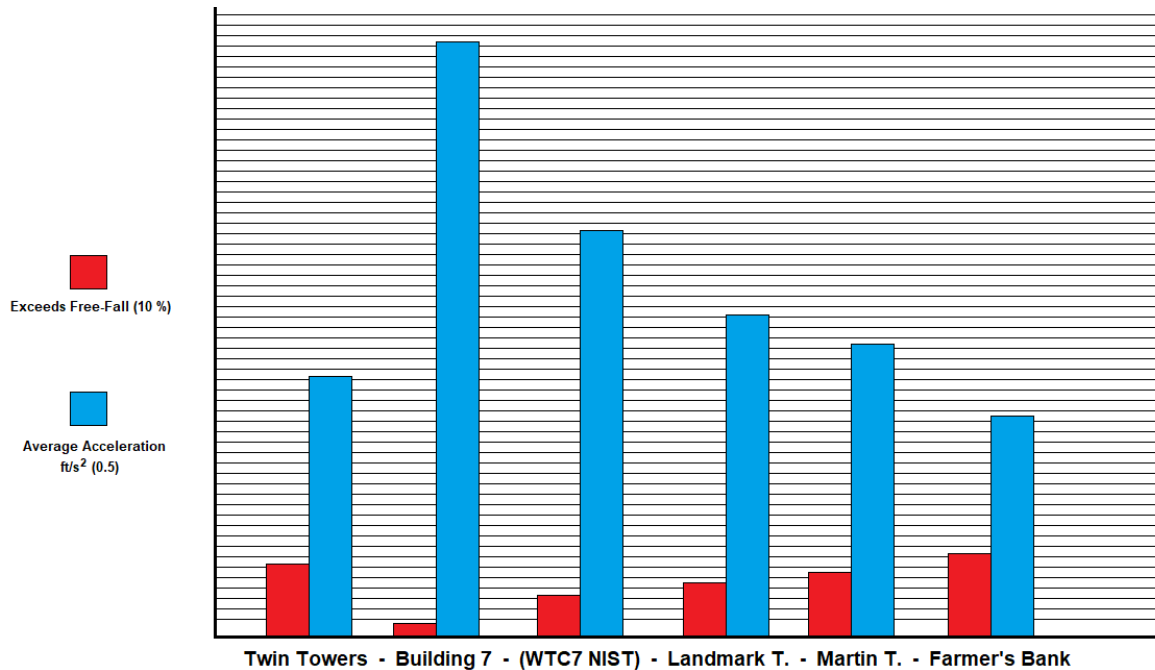
Figure 1: WTC Towers and Controlled Demolition Acceleration/Free Fall Excess Comparisons
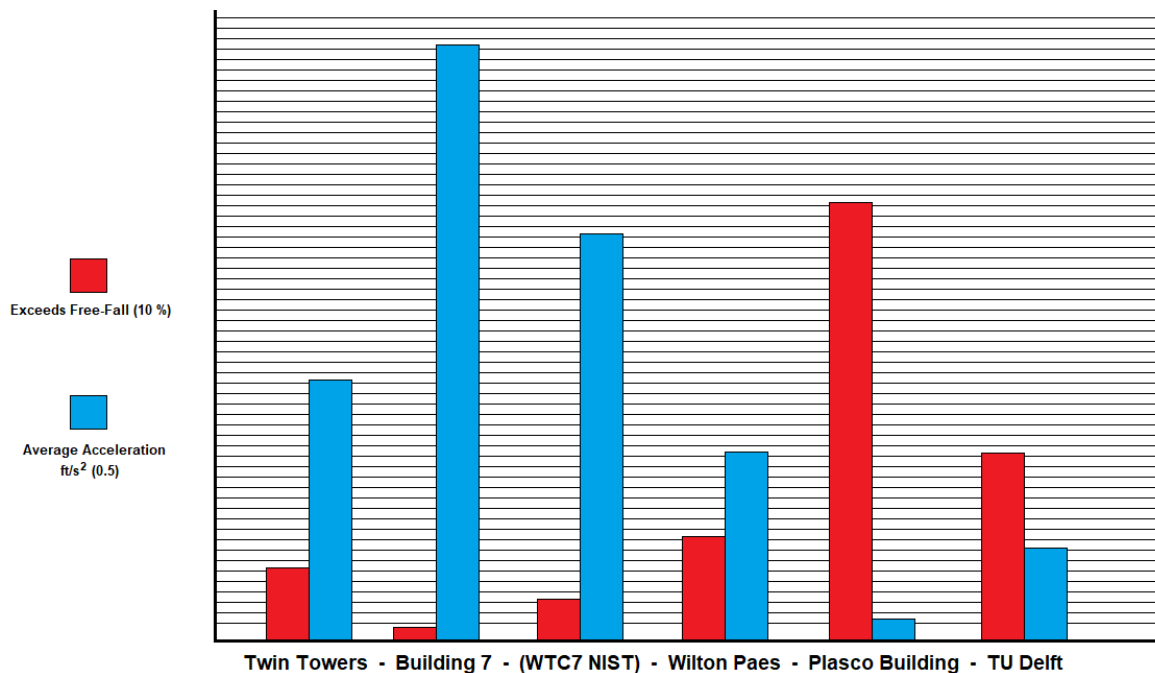
Figure 2: WTC Towers and Fire/Gravity Acceleration/Free Fall Excess Comparisons

These results show that the fall rates of the Towers and Building 7 appear much more in line with structures destroyed with explosives, rather than those felled by fire. The three known controlled demolitions examined showed a mean average excess of free fall of approximately 57%, close to the Towers' 63% and Building 7's 31% (for NIST's estimate). Likewise, their mean average acceleration was found to be approximately 13.27 ft/s^2, again very close to the Towers'

estimated 12.10 ft/s^2. Taking either NIST or Jones' estimate as correct, the acceleration of Building 7 was found to be even greater.

Conversely, the mean average acceleration of the structures felled by fire/gravity alone is found to be approximately 4.8 ft/s^2, and an average excess of free fall by 227%. Neither of these figures appear in line with the figures arrived at for the Towers or Building 7. But if the fall rates of the Towers are inconsistent with what is seen from fire/gravity induced collapses, the question still remains: how long should it have taken for them to collapse, if unassisted by explosives?

Estimations of Expected Tower Fall Times

Several published studies, acting as critiques of the conclusions drawn by Bažant *et al* (2008), conclude that the upper section should have been arrested early on in the collapse (e.g., Szuladziński *et al*, 2013; Szamboti & Johns, 2014; Schneider, 2019). However, suppose we grant the collapses were allowed to progress – how long should they have taken to fall? To the best of the author's knowledge, only one detailed study has been put forth to determine the expected fall time of WTC7 (Kuttler, 2006). However, this study examined a hypothetical model of the collapse wherein the fall progressed from the top to the bottom. Since the collapse of Building 7 clearly started from the bottom, this model is of little value in assessing a realistic collapse time. Studies of the Towers' collapses, however, prove far more valuable.

According to a study by Kuttler (2007), the expected fall times of the Towers, assuming they were purely gravity-driven collapses, should have been in excess of 25 seconds. This is consistent with an analysis by Szuladziński (2012), who found the Towers realistically should have collapsed somewhere between 23.53 and 30.19 seconds. According to him, "the pancaking mode is not a realistic proposition, as the calculated fall time becomes much too long." In the same paper, he estimates the lowest possible fall time to be approximately 15.33 seconds, assuming perfectly frangible columns. This is also consistent with studies published by Němec *et al* (2018), Chandler (n.d.), and Mitteldorf (n.d.), who found the lowest possible collapse time to be approximately 15 seconds. Again, these studies assume variables that would favor shorter collapse times, such as perfectly frangible columns and purely inelastic collisions between floors. Interestingly, as we've established, this is the approximate collapse time of the Towers, suggesting their supports were significantly weakened throughout the structures during collapse. The study by Němec *et al* arrived at a calculated expected fall time of approximately 20.42 seconds, somewhat shorter than Kuttler and Szuladziński, but still in the same general ballpark, and it is noted by the authors that this is a conservative estimate.

If we assume the figures provided by Němec, Kuttler, and Szuladziński – fall times of 20.42, 25, 23.53, and 30.19 seconds – this results in average accelerations of 6.53, 4.36, 4.91, and 2.98 ft/s^2, respectively. These times would have also exceeded free fall by 121, 171, 155, and 228%, respectively. We arrive at the following results:
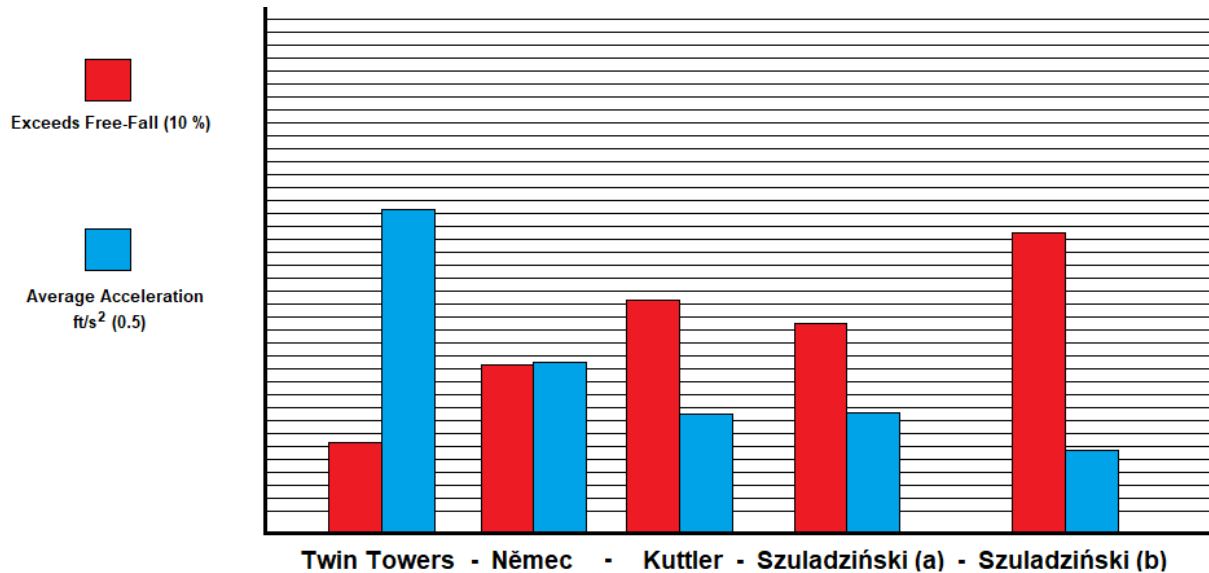
Figure 3: Twin Towers and Estimated Expected Collapse Rates/Free Fall Excess

Just like the comparisons with known fire/gravity-driven collapses, the calculated expected fall times of the Towers appear totally at odds with what was actually observed during the WTC collapses. Most of them exceed free fall by over 100% (and even 200% in one case), and the expected average accelerations are far more consistent with what would be expected from a fall unassisted by explosives. And this conclusion is further supported by a study done by Korol *et al* (2011), which looked at the collapse mechanics of hypothetical ten-story structures. The results were that in 90 percent of the examined cases, the collapse was arrested. For the remaining 10 percent, the fall times exceeded free fall by 57 to 228%.

Table 1: Comparison of WTC Buildings with Controlled Demolitions and Fire/Gravity Collapses

Building Collapse	Free Fall Time (in seconds)	Actual Fall Time (in seconds)	Exceeds Free Fall	Average Acceleration (ft/s²)
World Trade Center				
Twin Towers	9.2	15	63%	12.10
Building 7 (Jones)	6.1	6.5	6%	28.87
Building 7 (NIST)	6.1	8	31%	19.06
Demolitions				
Landmark Tower	4.8	7	45%	15.51
Martin Tower	4.5	7	55%	13.55
Farmers Bank	4.6	8	73%	10.75
Fire/Gravity Collapses				
Wilton Paes	4.15	8	92%	8.65
Plasco	2.9	15	417%	1.22
TU Delft	3.3	9	172%	4.51

Table 2: Calculations of Expected Fall Times/Rates/Accelerations of Twin Towers

Study (Twin Towers)	Calculated Fall Time (seconds)	Exceeds Free Fall	Average Acceleration (ft/s²)
Němec	20.42	121%	6.53
Kuttler	25	171%	4.36
Szuladziński (a)	23.53	155%	4.91
Szuladziński (b)	30.19	228%	2.98

Conclusion

The author concludes that the collapse of the Towers, based on their average accelerations and fall times, appears far more in line with what is seen from demolitions. Collapses induced by fire and driven by gravity, as expected, produce collapse times far higher, and result in much lower average accelerations compared to what was seen on 9/11, and from known controlled demolitions. Furthermore, calculations for the expected fall times for the Towers, assuming a purely natural, gravity-driven mechanism, produce fall times that appear more consistent with other structure collapses known to have been caused by fire. This analysis hopefully also brings clarification to the discussion of the Towers' fall times, showing that while free fall is not a necessary element to focus on, comparisons with other known collapses caused by a variety of mechanisms can contribute to the discussion of what may have caused them to collapse.

Admittedly, this analysis is limited by the fact that it considers so few examples – only three in each case. But on their own, these results should cause us to seriously reconsider the mechanism which was ultimately responsible for the destruction of the WTC buildings on 9/11. For all the reasons cited herein, the author calls for further investigation into the collapse of the Twin Towers and World Trade Center 7, one that will seriously consider the kind of evidence and analysis presented here.

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*Version 1 of this paper available at https://911docs.files.wordpress.com/2021/02/clarifyingcollapsetimes1.pdf. Updates to this version include: Corrected typos, additional reference (Mitteldorf, n.d.) added.