

How The Towers Fell – Part 3/3
A Plausible Explanation for How the Twin Towers and Seven WTC Collapsed

Joe Englot, PE
 HNTB Corporation

Structural Engineering Webinar Series
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 1:00 PM (Central time)






1

Agenda (Learning Points)

- Author's Experience as Civil Engineer and Knowledge of WTC Structures, Damage Assessment and Personal Evacuation Experiences
- Breaking Down How the Towers Performed the Way They Did
- Comparison to Behavior of a "Conventional" High-Rise Tower Structure
- Fire Protection Engineering in the US and the Difference in Time Temperature Curves for Cellulosic and Hydrocarbon Fires
- How to Create a "Controlled Demolition" of the Towers and Logical Conclusions on the Most Plausible Explanations for the Collapse of the Twin Towers and 7 World Trade Center
- Psychological Impact of 9-11 Terrorist Attack

Photos of Collateral Damage to Buildings Across the Street from the WTC Site after Collapse of the Twin Towers



Source of Photos: FEMA Response Team to 9-11 Attacks

2

Acknowledgement

1. This lecture is intentionally technical in nature to understand the engineering aspects of this monumental tragedy. To do that we must first acknowledge all of the lives that were tragically lost, including innocent people going about their daily business reporting to work or traveling by plane, the heroic first responders who sacrificed their lives to conduct a rapid evacuation of the site, the lower Manhattan residents whose lives and physical health were forever impacted and the construction workers, police, firefighters, and National Guard troops who occupied the hazardous damage zone during the long recovery effort.
2. The technical information and professional opinions presented represent the recollections of the author supported by information collected from published references and are provided in the interest of sharing this information with the audience to make a positive contribution to the public's understanding of events.
3. Much information presented in this lecture comes from members of the ASCE/FEMA WTC Building Performance Assessment Team (BPAT) especially Jonathan Barnett, Professor, FPE, WPI.

3

Author's Experience as Civil Engineer and Knowledge of WTC Structures, Damage Assessment and Personal Evacuation Experiences

- Member of ASCE Met Section Student Chapter at the Polytechnic Institute of Brooklyn (BSCE & MSCE 1972)
- Attended ASCE Student Chapter site visit tour of WTC while under construction in 1971
- Hired as Port Authority Engineering Trainee Upon Graduation in 1972
- First Trainee Assignment: Preliminary Design of "Blast Vault" at JFK Airport to Store Suspicious Baggage from El Al Airlines
- Served as Port Authority Chief Structural Engineer from 1993 to 2003
- Member ASCE Structural Design for Fire Conditions Standards Committee (1991-2005)
- Evacuated WTC during 1993 Bombing and 2001 9-11 Attacks and Supervised Recovery
- AASHTO/FHWA Blue Ribbon Panel for Bridge and Tunnel Security (2002-2003)
- Since 2005: HNTB Corporation National Director of Infrastructure Security
- 2012-2013 ASCE Met Section President
- NIST Disaster Resilience Fellow for 2016 Community Resilience Planning Guide for Buildings and Infrastructure Systems (Chapter 13 Transportation Systems)

4

Experience Evacuating from 1 WTC Tower in 1993

1. I made call home from my office on the West side of 72nd floor, then evacuated without any instructions, experienced heavy smoke effects and fear of walking down the stairs into a raging fire on ground floor.
2. I ran into traffic jam (backup) in exit stairway and exiting to a lower floor with other employees to escape smoke only to return to the stair because the smoke was getting so heavy in the office space it was hard to breathe and see. In addition, all the lights went out and the rest of the trip down was in darkness.
3. Later I understood why some people broke windows to get fresh air. 300 windows were broken in towers due to difficulty in breathing and poor visibility in heavy smoke due to stack effect. The was a feeling of great relief after we saw firefighters coming up the stairs knowing that it was safe to proceed down.
4. PANYNJ Chief Engineer E. Fasullo & F. Lombardi and other PA staff escaped from elevator because they could gradually cut through 4-inch-thick sheet rock walls in the elevator shaft with their car keys.
5. Many others trapped in elevators in heavy smoke and some who passed out and were rescued by firefighters.
6. Class of school children visiting observation deck stuck in elevator in Tower 2.
7. I exited Tower 1 at plaza level door after 2-1/2-hour evacuation trip down and stepped over the upward bulge in the sidewalk at center of Tower 1 and knew then it was raised up from the upward venting of the explosion in the parking garage below.
8. I called my wife and family from the hotel across the Street since they did not hear from me for 2-1/2 hours when I made my first call and then I rode back home on the subway in a car full of many other people who had soot all over their faces like me.



View of occupants in upper floors of Tower 1 shortly after first plane hit on 9-11. They had no exit path down to the ground since all three exit stairs below them were destroyed by plane impact. I speculate that they broke windows to escape smoke from the raging fire below them and to try to seek fresh air, daylight and safety.

5

Experience Evacuating from 1 WTC Tower in 9-11 Attacks

1. I was standing talking to a co-worker in my office on the east side of 74th floor when I felt the building sway suddenly toward the south and then sway back to the north and quickly come to rest. That co-worker told me later that I said at that moment, "Oh my God, a plane hit the building".
2. I saw lots of papers flying down from the floors above on the North side and South side of the tower.
3. I intentionally did not want to call home until I was out of the building and safely away from it, so I headed to the exit stair telling all the staff on the floor to exit.
4. Almost everyone was through this before and they were very calm. Some staff in fact stayed behind based upon their previous experience in 1993 and barely escaped the building alive before it collapsed.
5. As I began to exit down the stairway, I thought the only reason that an airplane would hit the building on a perfectly clear sunny morning is if it were a terrorist attack. I recalled reading about the recent incident in October 1999 when a co-pilot of a jet plane (Flight 990) flying from NY to Cairo intentionally crashed his plane into the ocean 60 miles south of Nantucket, MA. It was concluded to be a criminal act by NTSB, killing 217 people on board.
6. It took me only 15 minutes to evacuate down to the concourse level.
7. When I reached the plaza level inside the Tower 1 lobby, I looked out to the plaza on the North side and saw scattered piles of burning debris and some of the deceased among the wreckage.
8. I was directed by a police officer to the escalator that goes down to the below grade concourse level.



Above left: After first plane hit on 9-11 Tower 1 occupants on the 91st Floor and below were able to evacuate since there were not many at work in their offices at 8:46 AM. Above right: FDNY firefighter is already on scene going up the stairs to look for any disabled, injured or trapped victims. They had no idea that they only had 102 minutes to evacuate.

6

Experience Evacuating from 1 WTC Tower in 9-11 Attacks

9. When I reached the bottom of the escalator, a fellow employee was standing there telling me that our Chief Engineer wanted me and the other discipline heads to meet in the Marriott Hotel to organize the emergency planning process. I said that I had to get to a phone to call my wife and I left.
10. At that point I realized that a second plane hit Tower 2. It was still standing. A woman police officer calmly instructed me to exit through the concourse and said to keep walking away from the building and do not look back.
11. When I exited the concourse to Church Street I was instructed to keep walking east. After a few blocks I remember turning around and not seeing Tower 2 anymore. It was gone. I was in total shock and my first impression was: Could someone have planted explosive charges in the building to cause it to collapse?
12. I kept walking East and then North looking for a public pay phone. I found one when I reached Federal Plaza. I called my wife to tell her that I was safe, and she told me about the other attacks on the Pentagon and the plane that went down near Pittsburgh PA. I told her that I was going to get on a subway and call her when I was able to.
13. I looked at the Federal Plaza Building wondering if it would be attacked next and decided the safest thing was to go underground and get on the Subway. I got on a train at the Chambers St. Station heading for Brooklyn and Queens.



Above left: At 9:59 AM lower part of Tower 2 is seen collapsing on top of the Marriott Hotel where my co-workers had gathered to start the emergency recovery work. Fortunately, they survived the incident. Above right: Huge debris cloud from the collapse of Tower 1 at 10:28 AM is seen behind people who were evacuating away from the site the WTC site.

7

Experience Evacuating from 1 WTC Tower in 9-11 Attacks

14. The train went elevated over the Williamsburg Bridge to cross the East River and as I was standing in the car with other passengers looking at me, I told them that I had just evacuated the World Trade Center and was in the tower when the plane hit. They asked me if I was OK, and I said yes. I thought about the deceased bodies I saw on the concourse. I turned around to look back at Tower 1 which at that moment collapsed suddenly and I saw the antenna go flying as the building split apart, the floors dropped down in a heap in an instant.
15. When the train reached the Brooklyn side it went out of service. We were told that we had to exit because all subways were being shut down. I exited and borrowed a cell phone to call my wife. I walked a few miles to Jamaica Queens then called her so she could pick me up there.
16. The next day, since I had responsibilities as a manager in the Engineering Department to start the recovery effort and my place of work was destroyed, I reported to the Port Authority engineering construction unit at JFK International Airport, the closest unit to my home.



Above left: The City of NY stopped all mass transit systems and closed all tunnels and bridges to and from Manhattan to vehicular traffic. People are seen trying to get home by walking. Above right: A view of Tower 1 collapsing at 10:46 AM which I watched from the subway train I was on as it crossed the Williamsburg Bridge taking me from Manhattan to Brooklyn. the train stopped at the first station and went out of service.

8

The Impact Force on Tower 1, How it Performed and then Collapsed

Video Collapse of Top of Tower 1 **Video Collapse of Tower 1 Continues**

We will examine in the following slides how Tower 1 survived the plane impact, its magnitude, the way that the loading on the tower changed after impact, how the tower responded, how an alternative type of high-rise tower may have performed, the temperatures generated by the internal fires, and finally the tower collapse mechanism.

Source of Videos: Left: Jonathan Barnett, PhD, BPAT, Right: Open-Source Internet

The Impact Force on Tower 1, How it Performed and then Collapsed

The Basic Building Components:

Fireproofing at core stairwells and elevator shafts:
2" thick gypsum panels covered with 2 or 3 sheets of 5/8 inch gypsum board.

Source of Photos: FEMA 403 WTC Building Performance Study and Jonathan Barnett, PhD

The Impact Force on Tower 1, How it Performed and then Collapsed

The Hat Truss

Design Function of the Hat Truss

- 3-Dimensional Trusswork in the Top Two Floors of the Towers
- Stiffens the Tubular Structure by Resisting Lateral Rotation, Shear Deformation of the Tubular Walls and Torsional Rotation of the Giant Tube Structure
- As Such, It Reduces Displacements and Rotations of the Towers
- The hat truss in Tower 1 was strengthened when it was decided that it would have to support a huge broadcast antenna on top of the tower.

Breaking Down How Tower 1 Performed

Note: If we were to assume the building was infinitely rigid, with stopping distance of 32.5 ft. (plane body crushes), the impact force would be 5 times as high

Initial Velocity = 470 mph

Eq.: $v_f^2 = v_i^2 + 2 \cdot a \cdot d$
 $a = -(689.49 \text{ fps})^2 / (2 \times 168') = -1,414.9 \text{ ft/sec square}$
 Stopping Force = $M \times a = (283,600 \text{ lb.} / 32.17 \text{ ft./sec sq.}) \times -1,414.9 \text{ ft/sec square} = -12,473,000 \text{ lb.}$

12.5 million pounds of applied impact force to Tower (6,250 Tons)

Approximate Stopping Distance is 103' + 65' = 168'
 Aircraft decelerates from 470 mph to zero mph.
 Take off weight of plane is 283,600 lb. per NIST Report due to half full loading.
 Initial velocity = 470 mph = 689.49 fps per NIST Report

Breaking Down How the Towers Performed

Multi-Story Vierendeel Truss Building Framing System

A Simple Vierendeel Truss (No Diagonal Members)

▲ The north tower of New York's World Trade Centre on September 11 2001. Photograph: Richard Drew/AP

Tower 1 Façade Panels Supported the Exterior Floor Joist Reactions from the 21 Floors Above the Severed Panels Both in Tension (Red Arrows) Hanging from Hat Truss and as a Vierendeel Truss (Yellow Grid Lines) Spanning the Gaping Hole in the Tower. The Façade End Plate Connection was Designed for Bearing and not for Pure Tension.

Comparison with an Alternative High Rise Tower

An alternative to the WTC twin Tower Design in Steel is a Truss-Tube with Interior Columns

(a) Steel

(b) Concrete

Figure 2. Classification of tall building structural systems by Fazlur Khan [5,11,12].

Comparison with an Alternative High Rise Tower

WTC Perimeter Tube Design:

- Structural Stability comes from the outer tube
- It takes lateral shear forces and bending forces
- The core columns resist mostly vertical load and rely on the outer tube for stability
- The WTC core column fire rating was achieved from multiple layers of sheet rock
- It had a hat truss at the roof to tie the tower core and outer tube together and control lateral drift
- The hat truss on Tower 1 was also strengthened to support the antenna
- The WTC Towers also had damping units at every exterior bay joist connection to the perimeter tube columns

Braced Tube with Interior Columns:

- Efficiently resists lateral loads by axial forces in the braced tube members.
- Wider column spacing compared with framed tubes.
- Reduced shear lag.
- Diagonal bracings obstruct the view.
- Trussed tube acts as an exoskeleton.

TYPICAL OFFICE FLOOR

Comparison with an Alternative High Rise Tower

Assumptions/Postulations with Braced Tube tower with Interior Columns:

- With this alternative three exterior columns may be destroyed
- There is no Vierendeel mechanism to structurally support the impacted façade so it will locally collapse along with the supported floor bays.
- Diagonal exoskeleton bracing will also be impacted (damaged) but remaining elements will likely provide global stability.
- It is likely that the aircraft engines and body will penetrate the building, but the wings may break apart, due to the heavier exterior columns.
- Ruptured fuel tanks in wings may shower fuel onto the collapsing façade below it.
- The stopping distance of C.G. of aircraft will be shorter, and therefore deceleration (a) will be higher and total impact force ($f = m \times a$) will be greater than WTC Tower 1 due to the higher lateral rigidity of the façade elements that are impacted by the colliding aircraft.

Estimated Minimum Zone of Damage and Collapse

Comparison with an Alternative High Rise Tower

If Tower 1 of the WTC was an alternative high-rise tower design how would it have performed during the 1993 bombing?

Look at the attack of the Alfred P. Murrah federal Building attack and collapse (Oklahoma City Bombing).

- April 19, 1995 case of domestic terrorism.
- Ryder Box Truck loaded with 4,000 lb. of ANFO (Ammonium Nitrate and Fuel Oil). Also referred to as a fertilizer bomb.
- Did the bomber benefit from the knowledge that the 1993 WTC Bomber used 1,000 Lb. plus of explosives and failed to achieve a collapse? Maybe.
- The charge placed near one of the exterior tower columns led to a progressive collapse that destroyed 1/3 of the building and killed 168 people including 19 children.

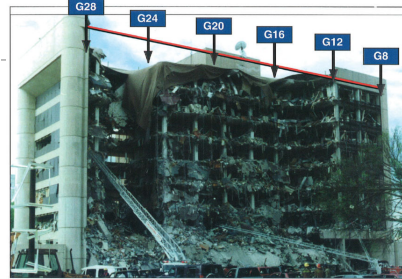


Figure 1-14 Damage to north and east sides of Murrah Building.

Example of Vertical and Lateral Progressive Collapse: 1995 Oklahoma City Bombing Progressive Collapse (Reinforced Concrete Structure)

Cellulosic vs. Hydrocarbon Fires

UL 263 - "Fire Tests of Building Construction Materials," and ASTM E119 - "Standard Test Methods for Fire Tests of Building Construction and Materials," were developed to simulate building fires, often referred to as 'cellulosic fires.' This heating regime was developed to simulate the type of fires that occur in commercial buildings with a simulated exposure based on a post flashover room fires utilizing wood, cotton and paper-based combustibles.

At 5 minutes into the fire test, the temperature within the furnace reaches 1,000°F. The temperature gradually increases during the test and, at 4-hours, the temperature within the furnace reaches 2000°F. This is considered to be the 'standard' time/temperature heating regime for buildings.

However, for installations which include oil, gas and petrochemicals fuels, an alternative 'Hydrocarbon' time/temperature regime may be more appropriate. The test method designed to simulate fires using hydrocarbon fuels employing greater energy input is ANSI/UL 1709 - "Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel".

Note: The calorific value of Jet Fuel is 42.8 MJ/kg vs. 19.5 to 23.0 MJ/kg for wood pallets

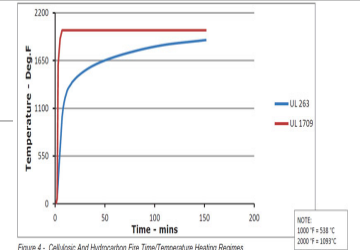
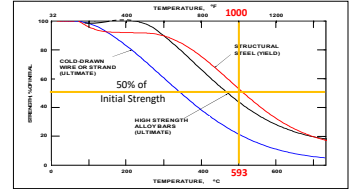
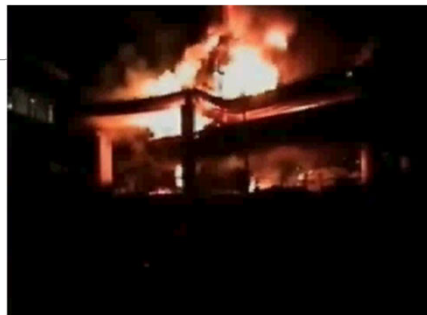


Figure 4 - Cellulosic And Hydrocarbon Fire Time/Temperature Heating Regimes



Source: Best Practice Guide for Passive Fire Protection for Structural Steelwork FIRE RESISTANCE AND EXTERNAL EXPOSURE CHARACTERISTICS 1st Edition: October 2018

Oakland, CA Highway I 80 Interchange Bridges Collapse From Fuel Tanker Truck Fire

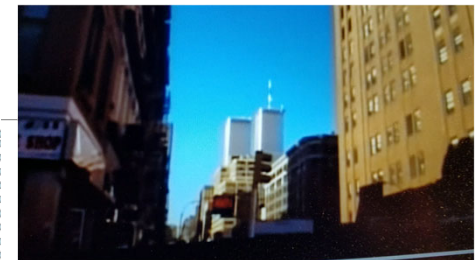
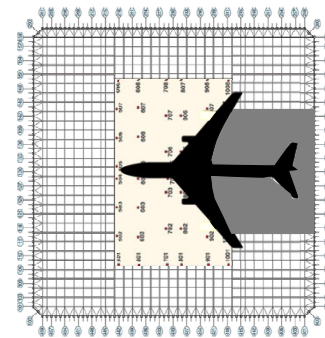


Video Collapse of Highway Interchange Bridges

Timeline:

- 3:41am - Tanker overturns
- 3:55am - Oakland FD arrives at scene
14 minutes
- 4:02am - I-580 overpass collapses
21 minutes
- Approx. 5:30am - fire under control

Explain how Tower 1 Collapsed

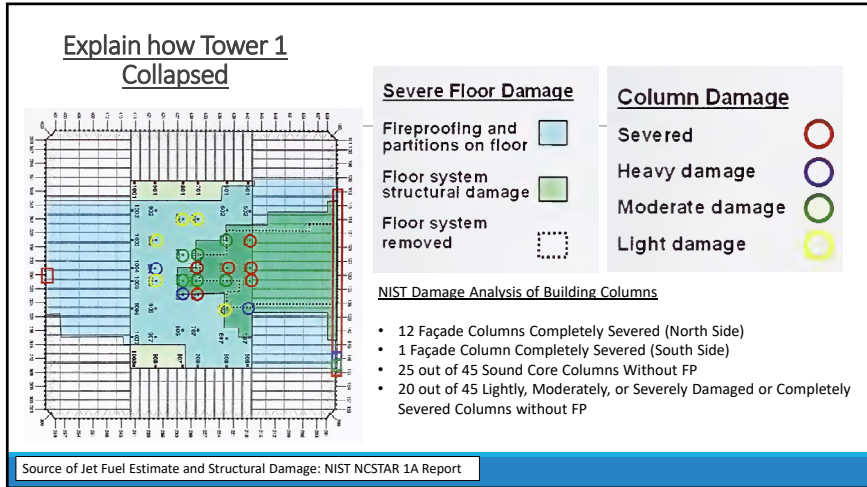


Video First Plane Strikes Tower 1 Slow Motion

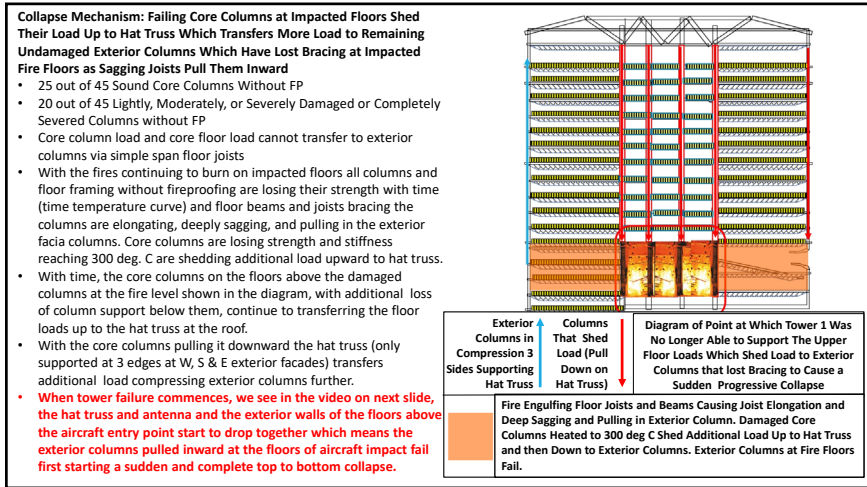
767-200ER Jet Fuel Estimate

- Plane that struck Tower 1 had 10,000 gallons of fuel that flight
- Less than 15 percent burned in the spray cloud outside the building
- Comparable amount (15 percent) was consumed in the fireballs outside the building
- Well over half the jet fuel (7,000 gallons) remained in the building, splashed onto office furniture, shot up and down the elevator shafts

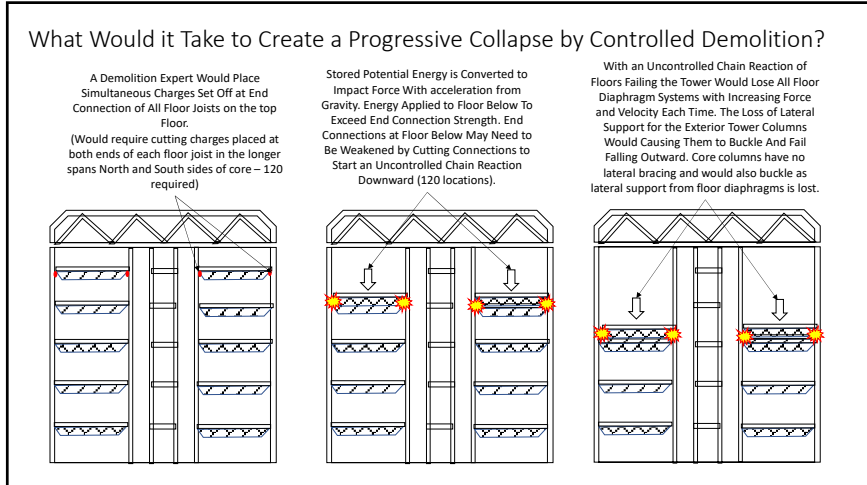
Source of Jet Fuel Estimate and Structural Damage: NIST NCSTAR 1A Report



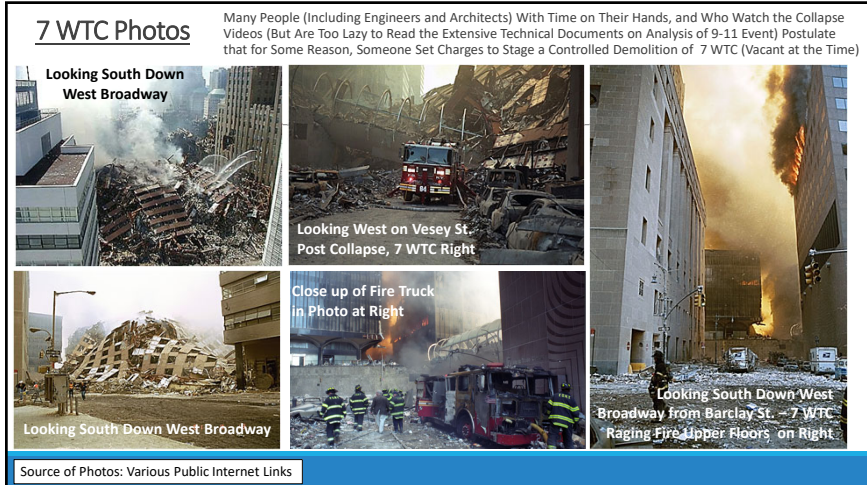
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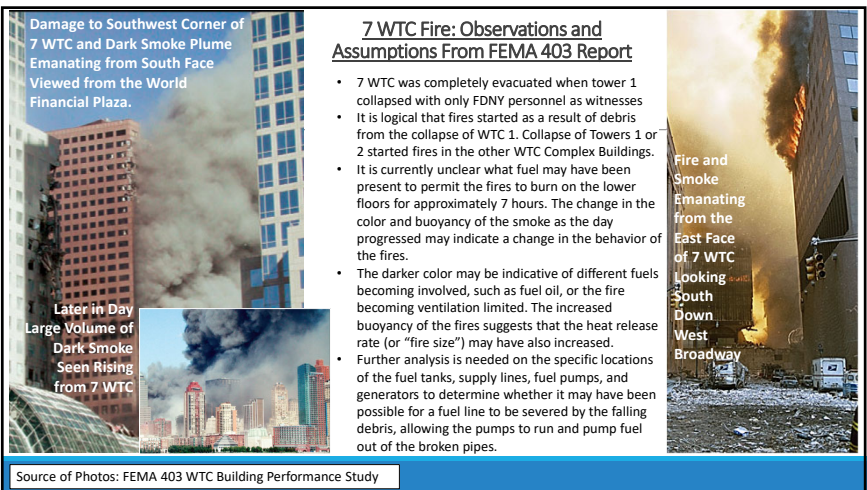
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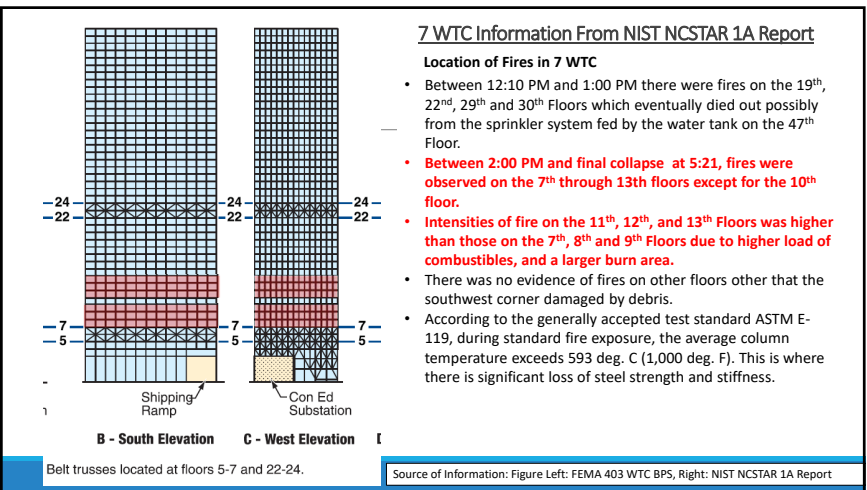
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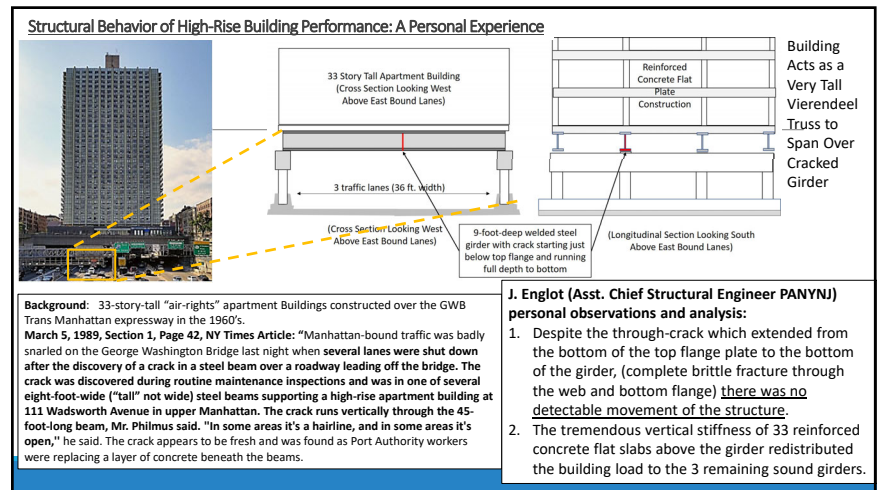
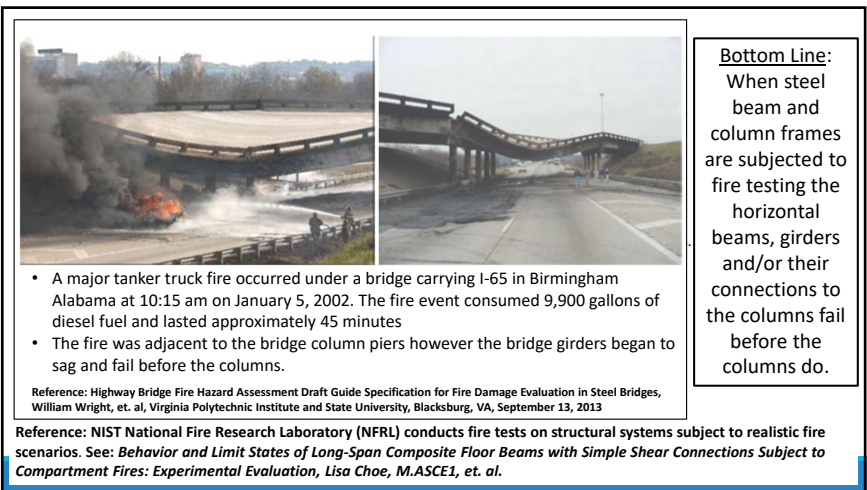
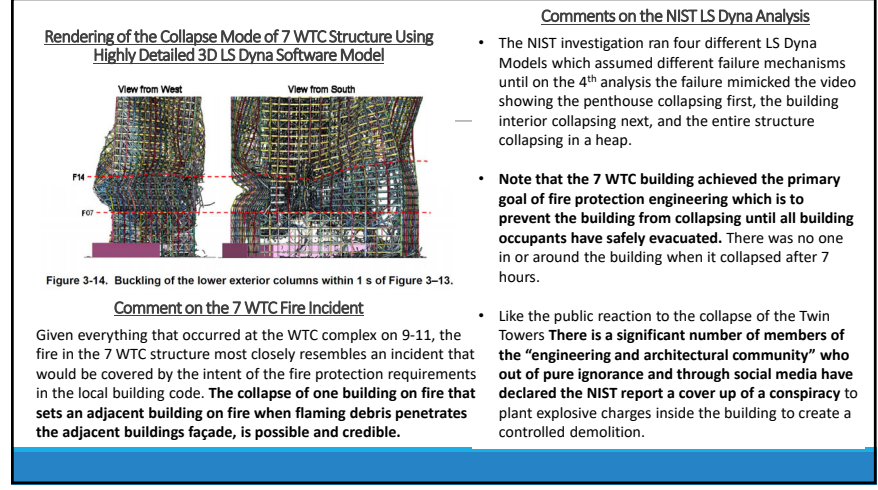
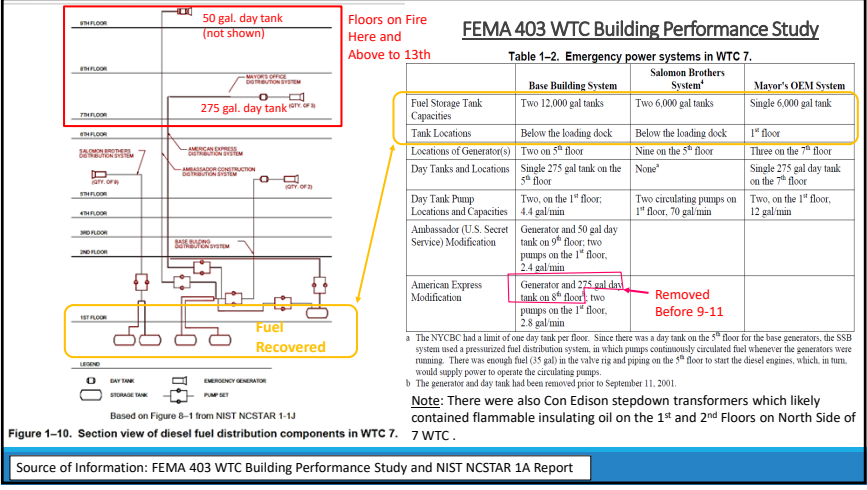
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27



28



Joe's Explanation for the Uniform Collapse of 7 WTC

- All four sides of the tower had a fascia supported by full height perimeter moment frame (PMF). It acted like an exterior tubular structure and Vierendeel truss that for the most part was not physically damaged and confined the interior structures. The square footage of floor area on each floor typically supported by the PMF is shown (below right) shaded in green. Being on the exterior of the building significant member heat is released through radiation into the air.
- The core columns 58 through 81 are connected to each other by girders forming rigid frames in each direction: 7 bays long in the east-west direction and 2 bays long in the north-south direction. On the floors shaded in red (building elevations below left), these columns and girders experienced the most intense heat.

Floor 14 to 47 were not on fire and the stiffness of 34 floors of steel beams, girders and concrete slab would resist any individual column collapse below them. A steel column below 14 reaching failure to carry its load would shed the load to any adjacent columns not yet overloaded.

Figure 1-5. Typical WTC 7 floor showing locations of the columns, girders, and beams. Based on structural drawings (Cantor 1985)

33

How High-Rise Building Columns Fail From Fire in the Real World vs. Fire Testing

Building Core Framing:
The upper building core acts as a huge Vierendeel truss to bridge over individual failing columns below. Floors 14 through 47 are sound without any significant fire damage. If columns below these floors start to fail individually, they cannot induce either a local or a global failure of the building above. Load will be redistributed to more sound adjacent columns. The core cannot fail until a majority of adjacent columns reach a failure mode leading to a uniform failure of the core.

- These logical assumptions and postulations support the way 7 WTC was observed to collapse after 7 hours.
- The core columns could only fail (no longer support their load) when a sufficient number in the core failed in column buckling due to loss of bracing since the collapsed floors were no longer providing lateral support on consecutive floors.
- The observation that the penthouse in the core began to fail first supports this behavior. The building's exterior moment frames remained stable, supported their share of the floor loading and guided the core downward.
- The floor beams connecting the core to the moment frames pulled them inward and down gradually in a heap.

7 WTC Building Exterior Moment Frame Lies in a Heap After Collapse

Section Through Core Bent

If any single steel column, or a pair, or even three adjacent columns within stories 11 to 13 in the tower starts to buckle under their load due to an increase in unsupported length over consecutive floors it cannot buckle downward so it will shed its load to adjacent columns. When multiple columns start to buckle together in the core, a uniform failure starts. The load redistribution results in an interior sequence of failures that progresses vertically and horizontally.

34

Comparison of Analysis for Cause of Collapse of 7 WTC

- NIST Report: "This was a fire-induced progressive collapse, also known as disproportionate collapse, which is defined as the spread of local damage, from an initiating event, from element to element, eventually resulting in the collapse of an entire structure, or a disproportionately large part of it."
- U. of Alaska Report: "the fires in WTC 7 could not have caused the collapse recorded on video," said Professor Hulse. "We simulated every plausible scenario, and we found that the series of failures that NIST claimed triggered a progressive collapse of the entire structure could not have occurred. The only thing that could have brought this structure down in the manner observed on 9/11 is the near simultaneous failure of every column in the building below Floor 17."
- Joe's analysis: "The core columns could only fail (no longer support their load) when a sufficient number in the core were left laterally unsupported and reached or passed their buckling load. The observation that the penthouse in the core began to fail first supports this behavior. The building's exterior moment frames remained stable, supported their share of the floor loading and guided the core downward. The floor beams connecting the core to the moment frames pulled them inward and down gradually in a heap.
- I think we are all pretty much in agreement how it failed. As they say, "the devil is in the details".

35

7 WTC Collapse Sequence Times From FEMA Report

(Times are registered by a seismic recording)

- ~5:20:33 p.m. WTC 7 begins to collapse.
- ~5:21:03 p.m. Approximately 30 seconds later east mechanical penthouse disappearing into the building.
- ~5:21:08 p.m. Approximately 5 seconds later, the west mechanical penthouse sinks into WTC 7.
- ~5:21:09 p.m. The whole building starts to collapse.
- ~5:21:10 p.m. WTC 7 collapses completely after burning for 7 hours.

Video of Controlled Demolition of 39-Story Building

Watch and **listen** to the controlled demolition of 39 story former Trump Plaza Hotel and Casino in Atlantic City On February 17, 2021

- Used 1,900 pounds of explosives in 2,300 locations on 14 floors
- Performed by Controlled Demolition Inc., Phoenix, MD.

Source of Photos: FEMA 403 WTC Building Performance Study

36

Psychological impacts from 9/11 (Left) and Remedies (Right)

- In the weeks after the 9-11 attacks citizens in the City of Los Angeles were fearful about their safety in the many tall buildings there and hired Rand Corporation to perform a study of potential threats and policy changes.
- Immediately after the Sept. 11, 2001, terrorist attacks, Americans were afraid to fly and took to the nation's highways instead. Domestic air-passenger miles fell that October, November and December by 20%, 17% and 12%, respectively.
- The initial plan for the new 1 WTC (initially called Freedom Tower) was to have the upper floors to be a skeleton structure framework thinking that they would not be able to lease them due to the fears of tenants to occupy higher floors.
- Eleven days after the September 11, 2001, terrorist attacks, Pennsylvania Governor Tom Ridge was appointed as the first Director of the Office of Homeland Security (DHS) in the White House. The office oversaw and coordinated a comprehensive national strategy to safeguard the country against terrorism and respond to any future attacks.
- The TSA was created by the Aviation and Transportation Security Act, which was passed by Congress and signed into law by Pres. George W. Bush on November 19, 2001. It was mandated with developing and implementing policies to ensure the safety of the nation's transportation systems.

37

Changes to the International Building Code as a Result of 9/11 Studies

- Elevators are required in high-rise buildings more than 120 feet tall, so firefighters do not need to walk up from the ground floor with heavy equipment;
- An additional stairway for high-rises that are more than 420 feet tall;
- In lieu of the additional stairway, an option to provide enhanced elevators that can be used by the building occupants for emergency evacuation without waiting for assistance from emergency personnel;
- A higher standard for fire resistance in high-rise buildings more than 420 feet tall;
- More robust fire proofing for buildings more than 75 feet tall, which will be less likely to be dislodged by impacts or explosions;
- Shafts enclosing elevators and exit stairways that have impact resistant walls;
- Self-luminous exit pathway markings in all exit stairways that provide a lighted pathway when both the primary and secondary lighting fails; and
- Radio coverage systems within the building to allow emergency personnel to better communicate within the building and with emergency staff outside the building supporting the response.

Source: Fire Prevention & Protection 8-29-2011

38

Key Professional Site Safety, Ph

Report Editor:
Therese McAllister

Chapter Leaders and Authors:
Executive Summary: Gene Cooley
Donald Hamberger
Therese McAllister
Jonathan Barnett
Chapter 1: Therese McAllister
John Cooley
Donald Hamberger
Jon Magnusson
Chapter 2: Ronald Hamberger
William Baker
Jonathan Barnett
James Miller
Harold "Bud" Nelson
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Note: List does not include

NSPE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Code of Ethics

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

Support, Worker on Reports

NIST NCSTAR 1A Report

(In addition to many of those already listed under FEMA Report)

H.S. Lew, Ph.D., P.E. (NIST)
Richard W. Bukowski, P.E. (NIST)
John L. Gross, Ph.D., P.E. (NIST)
Therese P. McAllister, Ph.D., P.E. (NIST)
Harold E. Nelson, P.E.

Lelie E. Robertson Associates, R.L.L.P.
William J. Fischer* William C. Howell
Richard B. Garlock* Raymond C. Lai

39

Assessment of Learning 1 of 2

1. What type of structural truss system has no diagonal members?
Vierendeel Truss
2. Name three examples in the presentation where this type of truss was discussed?
 1. Tower 1 Floors above the plane damaged facia were partially supported by one
 2. An apartment building over a highway that was able to span over a cracked support girder
 3. The upper floors of 7 WTC were held up by one when the columns below were weakened by the fire and lost their strength
3. Two types of time temperature curves were discussed in the presentation. The ASTM E119 Test/UL 263 Curve and the ANSI/UL 1709 curve.
 - What category of fuel is used in the ASTM E 119 test and UL 263 Curve? Cellulosic
 - What category of fuel is represented by the ANSI/UL 1709 Curve? Hydrocarbon

40

Assessment of Learning 2 of 2

1. What is unique about the 7 WTC collapse that set a precedent?:

First high rise building to completely collapse from a fire

2. How did 7 WTC catch on fire and how long did it take to collapse after it caught fire?

1. It caught on fire from being hit by pieces of Tower 1 when it collapsed.
2. It burned for 7 hours

3. Based upon the NSPE Code of Ethics would we expect a PE to withhold the truth about their analysis of building failure from the public, support a conspiracy to hide the truth from the public, or think that other PEs would participate in a cover up of facts?

The answer is obvious.

41

How The Towers Fell – Part 3/3 Twin Towers and Seven WTC Collapse from the 9-11 Attacks

Questions?

HNTB

42