

Maintaining Structural Integrity

- **Stephen S. Szoke, P.E.**
- **Director of Codes and Standards**
- **Portland Cement Association**
- **5420 Old Orchard Road**
- **Skokie, IL 60077**
- **847-972-9078**

Maintaining Structural Integrity

- Strengthening or providing redundancies in structural frames
- Combining performance of various building elements
- Experience total burnout without collapse

Structural Design Loads

Dead + Live + Earthquake
+ Wind
+ Snow
+ Ice
+ Flood
+ Fire

Structural Frame

- **Design the Structural Frame to Resist Collapse (ASCE 7)**
 - Indirect Method - minimum levels of strength, continuity, and ductility throughout the structure
 - Direct Method – Alternative Path Method
 - Direct Method – Specific Local Resistance Method

Construction with Infill

- **Concrete and masonry fire protection**
 - Minimize deflections
 - Transfer loads
 - Additional fire protection
- **Fire protection needs to resist shocks and vibrations due to fire exposure of**
 - Protected elements
 - Elements integrally attached to protected elements

Loadbearing Walls or Frame with Infill

■ Investigation

- Limited resources and defined objectives
- Did not consider successful performing buildings

■ Recommendations

- Analysis of very tall high-rise building
- Applications to 15 to 20 or more

FEMA/ASCE on 130 Cedar

"...is a 12-story reinforced concrete frame structure with setbacks at... Perimeter spandrel beams beneath the windows and interior infill walls of brick, terracotta, or concrete masonry provide additional lateral stiffness... A column section from WTC 2 penetrated the 10th floor roof slab... Fire damage was evident on the 11th and 12th floors... fire temperatures of between 600°F and 1,100°F."

Combining Building Elements



90 West

NIST WTC Workshop

FEMA/ASCE on 90 West

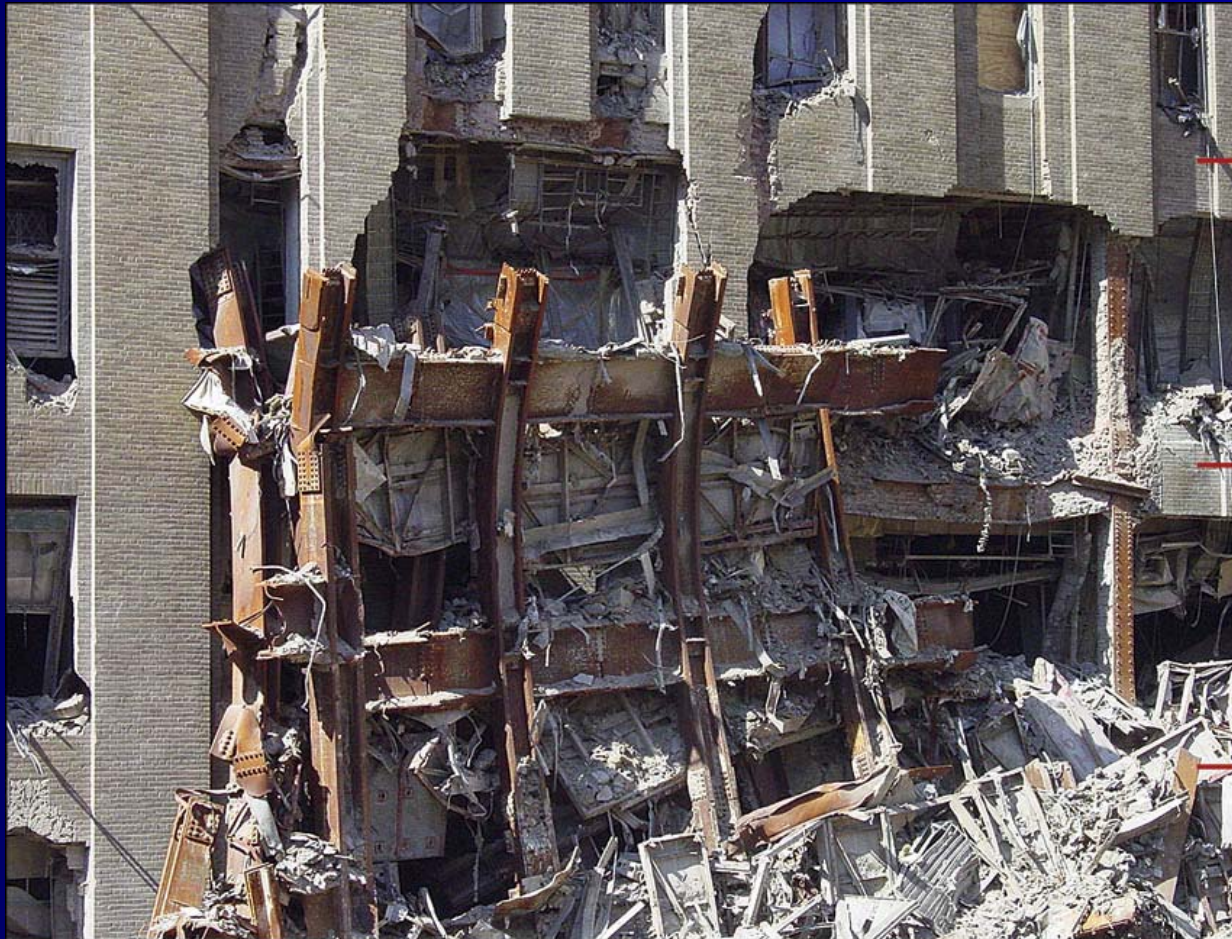
"Older, early century fireproofing methods of concrete-, brick-, and terra cotta tile-encased steel frame performed well, even after 90+ years, and protected the 90 West Street building from extensive structural damage." "This type of construction, with terra cotta tiles providing fire protection...resulted in highly compartmentalized building, which may have helped slow the spread of fire..."

30 West Broadway



NIST WTC Workshop

Verizon

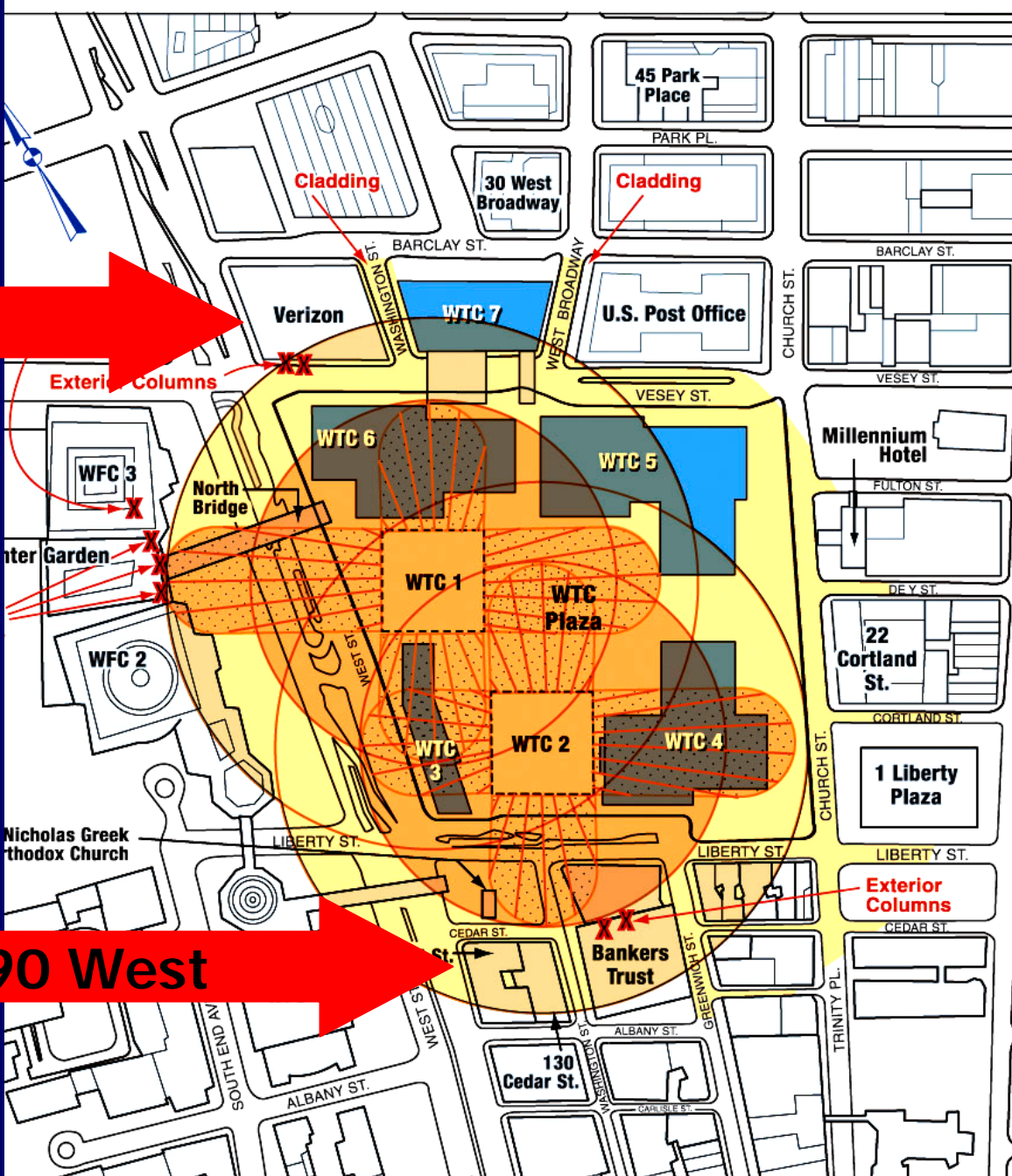


FEMA/ASCE on Verizon

"In general, the Verizon building performed well, especially given its close proximity to WTC 7... Several factors may have contributed to the performance of the Verizon building. The thick masonry walls, brick-encased columns, cinder-concrete encased beams and girders probably absorbed much of the energy of the impacts while also providing additional stiffness and strength to the building frame."

Verizon

90 West



Major Burnout Without Structural Collapse

- 2004 LaSalle Bank Building, Chicago (1930s)
- 1993 New York City Bank, New York (1960s)
- 1991 One Meridian Plaza, Philadelphia (1973)
- 1988 Interstate Bank Building, Los Angeles (1973)

Interstate Bank

- 62 stories
- Built in 1973
- Fire on 12th floor and spread to 16th
- Fire burned for 4-1/2 hours

USFA on Interstate Bank

- "In spite of the total burnout of four and a half floors, there was no damage to the main structural members and only minor damage to one secondary beam and smaller number of floor spans."
- "The effects of this magnitude of fire on a less protected structure must be considered in plan reviews, inspections during construction, and developing codes."

One Meridian Plaza

- 38 Stories
- Built in 1973
- Started on 22 and spread to 30th
- Burned for 19 hours

USFA on One Meridian Plaza

“The degree of structural damage produced during the fire at One Meridian Plaza suggests that the **requirements for structural fire resistance should be reexamined.** Floor assemblies deflected as much as three feet in some places.”

New York City Bank

- 42 stories
- Built in the 1960s
- Fire spread from 7th to 8th

USFA on New York City Bank

“If a compartment of this size [15,000 sq. ft.] becomes involved, particularly modern buildings of “lightweight” construction, there is a significant risk that fire may spread to higher floors or adjacent compartments.”

LaSalle Bank Building

- 45 Stories
- Built in 1930s
- Fire lasted 5-1/2 hours
- Temperatures in excess of 2000°F
- Fire on 29th floor spread to 30th
- No Sprinklers and No Deaths!

Summary

- Buildings can or at least used to be designed and constructed to experience burnout without collapse
- Recommendations should to be holistic and not just for structural frame buildings or structural frame acting alone
- If collapse resistance not achieved than impact on adjacent buildings should be considered

Thank you!

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