Fire Research Division Program - Update

September 28, 2017
NCST Advisory
Committee Meeting

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NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Fire Research Program Updates

- Fires in Buildings under construction
  - Pre-occupancy
  - Fuse 47 Reconstruction
- Grenfell Tower Fire

Fires in Buildings Under Construction

Construction related fires (2010-2014) *

- 3750 structures under construction
  - Five civilian deaths
  - 51 civilian injuries
  - $172 M in direct property damage

Causes of fires- under construction

- Cooking equipment – 27%
- Heating equipment – 13%
- Intentionally set – 13%

Series of Large Urban Fires –

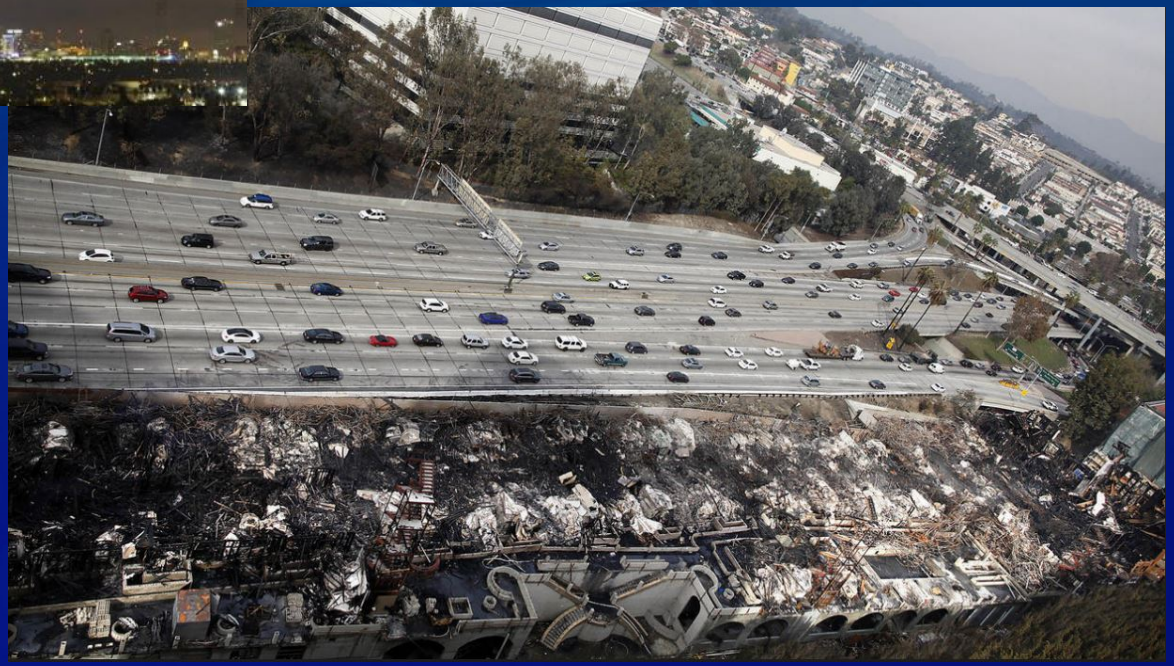
Entire structure destroyed
city block sized – 100,000 ft^2

*R. Campbell, Fires in Structures Under Construction, Undergoing Major Renovation, or Being Demolished NFPA, April 2017

Da Vinci Apartments – Los Angeles, CA

- December 8, 2014
- Seven story
- $30M damage

- 5 stories destroyed
- Upper floors collapsed onto lower floor



Metropolitan Apartments – Raleigh, NC

- March 17, 2017
- Six story
- $12M damage
- PRDC 3.0/1.0

- 5 stories destroyed
- Upper floors collapsed onto lower floor

City Place Apartments – Overland Park, KS

- March 20, 2017
- Five story
- $20M damage

- 22 other homes
- Additional $5M damage

Fuse 47 Apartments - College Park, MD

- Seven-story apartment complex
- Pedestal-type building with a poured-concrete first three levels and several-story wood frame construction on top
- 250 apartments, retail stores, and a parking garage
- occupancy 6/2017 near completion.

Fuse 47 Apartments - College Park, MD

- April 24, 2017
- Seven story
- $39M damage
- PRDC 3.75/2.0

- Fire started in 6th floor apartment
- Transitioned to attic space

- Durable polymer/fiberglass roof membrane
- 10,000 gallons/min

Fires in Buildings Under Construction

- Building and Fire codes
  - Designed to protect life, not property
  - Protections not “activated” until property occupied
- Revisions to 2015 International Building Code
  - Allows for up to 85 foot tall residential buildings
  - 1-2 floors non combustible (pedestal)
  - 5 floors of wood “stick built”
- NFPA 241 – Standard for safeguarding Construction, Alteration, and Demolition Operations –
- Fire Safety Plan

Fuse 47 Apartments - College Park, MD

Unresolved issues

- How did fire spread to attic space?
  - Did not spread through 6th floor ceiling or walls
- Would fire barriers in attic limited spread?
  - One fire barrier (40k ft2)
- Would operating sprinklers suppressed fire
  - Sprinklers in each apartment
  - Sprinkler in ceiling above apartment
  - Sprinklers in attic space

Plan to use Fire Dynamic Simulator to model fire spread

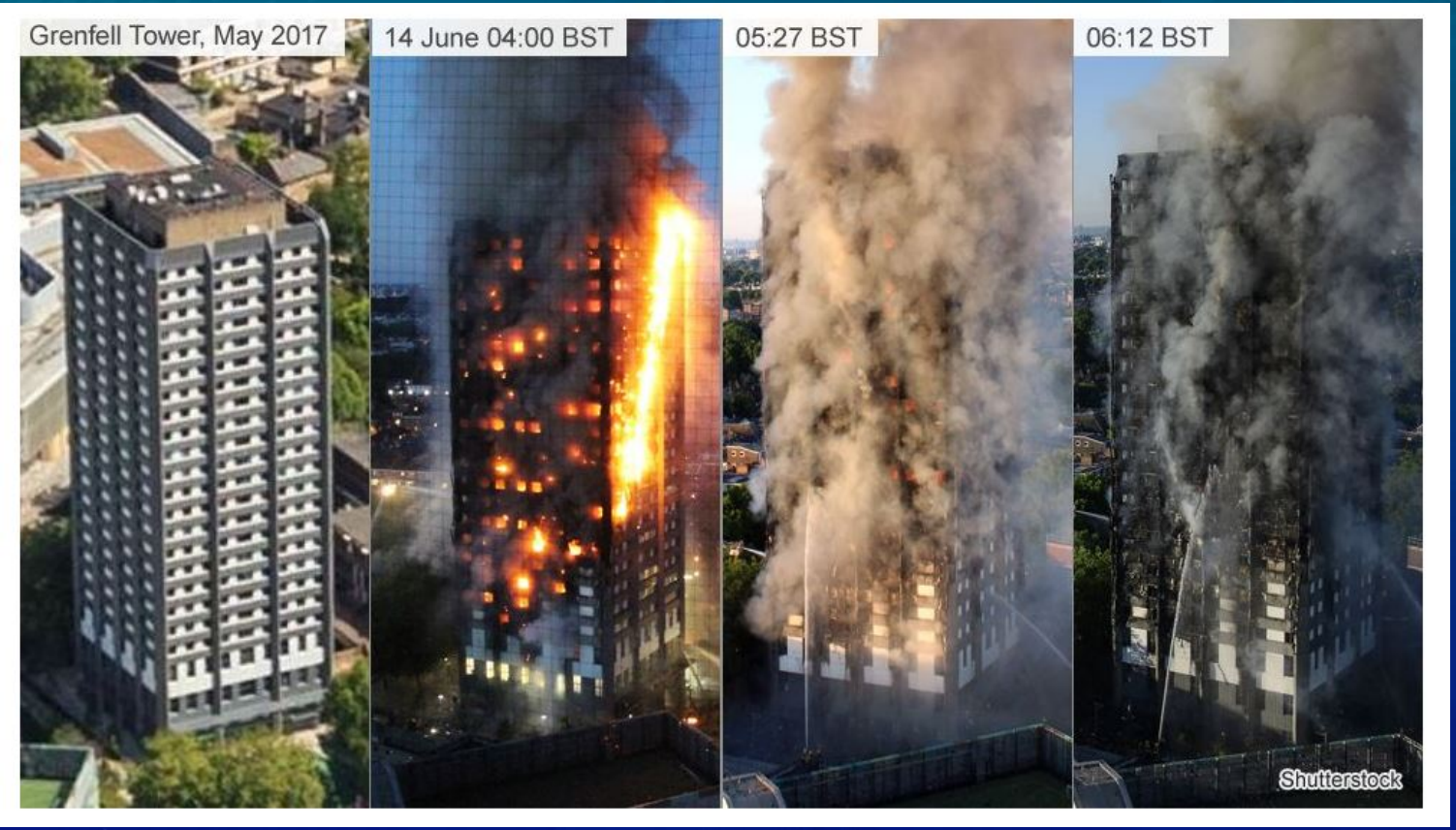
Fuse 47 Apartments - College Park, MD

Townhouses – fire barriers in place during construction

Apartment- few barriers in place during construction

Plan to use Fire Dynamic Simulator to model impact of fire barriers on fire spread

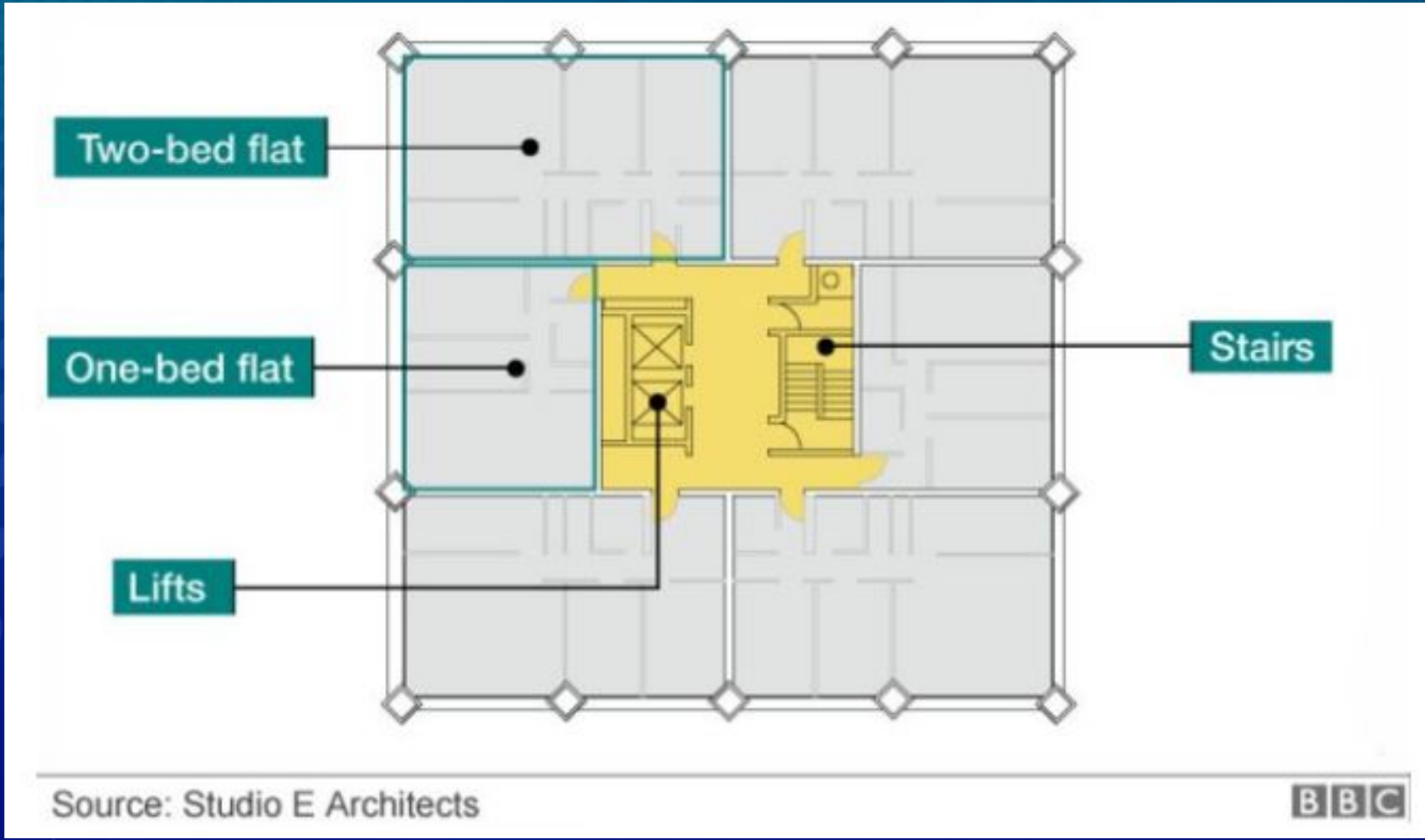
Grenfell Tower, North Kensington, West London



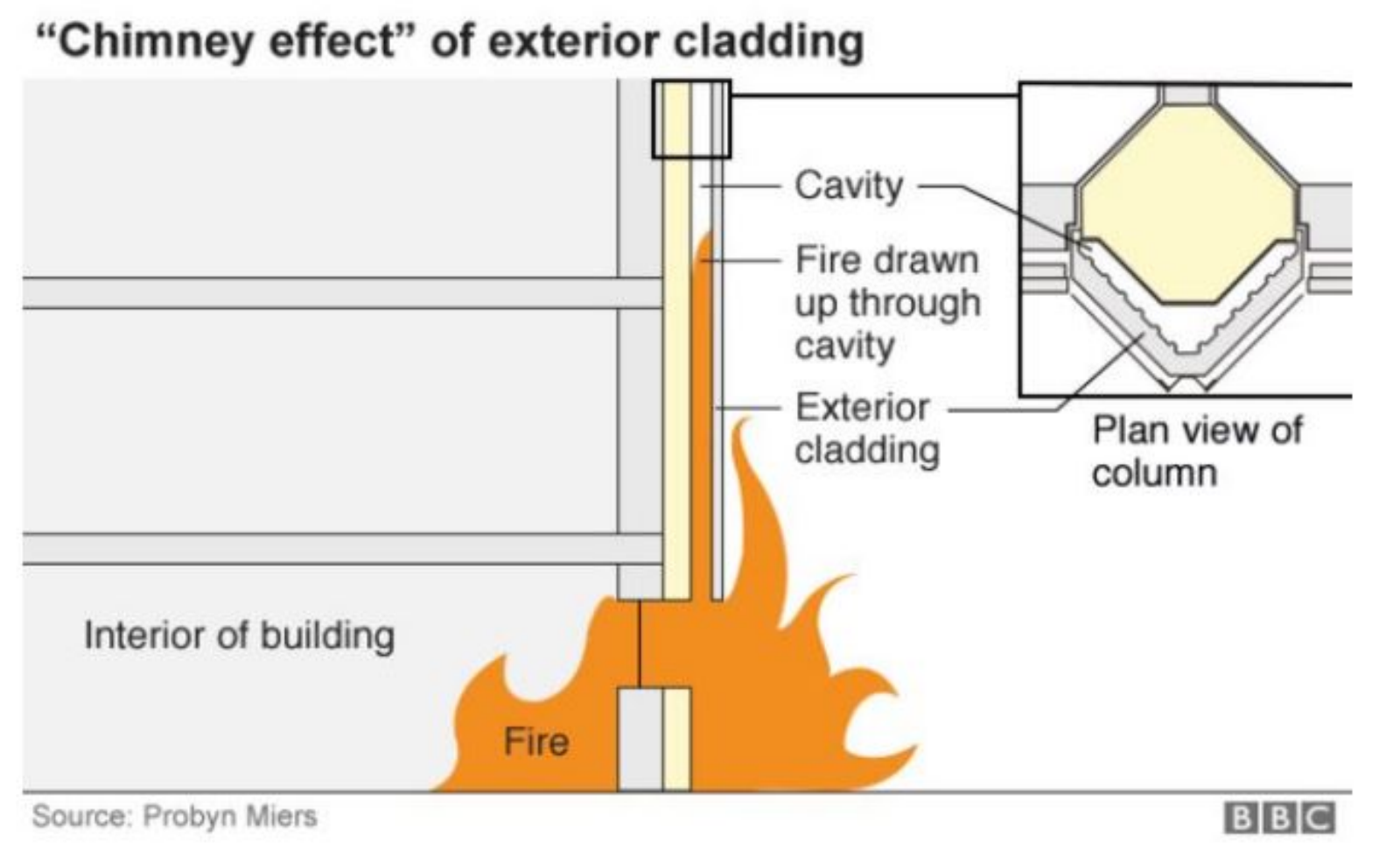
- June 14, 2017
- 24 story / 129 apartments
- 60-80 fatalities / 255 survived
- PRDC 4.1/3.6/0.9

- Built 1974
- Renovated 2016

Grenfell Tower, North Kensington, West London



Grenfell Tower, North Kensington, West London



Grenfell Tower, North Kensington, West London

- Fire started on 4th floor, about 1:00 am
- Spread rapidly up exterior cladding
  - Flammable core of exterior cladding
  - “chimney” effect
  - Possible role of vinyl window frames
- Declared under control after 24 hours
- Fatalities – occurred on 11, 14, 15 – 23 floors
- Criminal Investigation and Public Inquiry
- Commission to review regulatory process

Grenfell Tower, North Kensington, West London

- Building regulations –
  - Single stairwell
  - No sprinklers
  - Exterior cladding
    - Polyethylene core between two aluminum sheets
  - At least 400 similar structures

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Questions?

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Fires in Buildings Under Construction

- Series of fires
  - —Da Vinci Apartments – Los Angeles, CA; December 8, 2014
    - Seven story, $30M damage
  - —Metropolitan Apartments – Raleigh, NC; March 17, 2017
    - Six story, $12M damage
  - —City Place Apartments – Overland Park, KS; March 20, 2017
    - Five story, $20M damage, 22 other homes, $5M damage
  - —Fuse 47 Apartments - College Park, MD; April 24, 2017
    - Seven story, $39M damage

Fires in Buildings Under Construction

Construction related fires (2010-2014)

- 3750 structures under construction
  - Five civilian deaths
  - 51 civilian injuries
  - $172 M in direct property damage
- 2560 structures under major renovation
  - Four civilian deaths
  - 65 civilian injuries
  - $108 M in direct property damage
- 2130 structures being demolished
  - Four civilian deaths
  - 16 civilian injuries
  - $30 M in direct property damage

R. Campbell, Fires in Structures Under Construction, Undergoing Major Renovation, or Being Demolished NFPA, April 2017

Fires in Buildings Under Construction

Causes of fires

- under construction
  - Cooking equipment – 27%
  - Heating equipment – 13%
  - Intentionally set – 13%
- under major renovation
  - Heating equipment – 15%
  - Intentionally set – 13%
  - Torch, burner or soldering iron – 10%
  - Cooking equipment – 9%
- being demolished
  - Intentionally set - 42%
  - Torch, burner, or soldering iron – 12%

R. Campbell, Fires in Structures Under Construction, Undergoing Major Renovation, or Being Demolished NFPA, April 2017

Fires in Buildings Under Construction

- Series of fires

—Da Vinci Apartments - 2014
  - Los Angeles, CA

—Metropolitan Apartments - 2017 (PRDC 3.0/1.0)
  - Raleigh, NC

—City Place Apartments - 2017
  - Overland Park, KS

—Fuse 47 Apartments – 2017 (PRDC 3.75/2.0)
  - College Park, MD

Fuse 47 Apartment Fire, College Park

National Construction Safety Team Act
Table 1. Preliminary Reconnaissance Decision Criteria

The Fuse 47 Apartment Complex Fire, College Park, Maryland, U.S. – 04/24/2017			
Preliminary Reconnaissance Criteria[1]	Low (1)	Med (3)	High (5)
1. Substantial Loss of Life or Disabling Injury			
A. Facility context	0	1 to 2	>2
B. Community context[2]	0 to 3	4 to 9	>10
C. Regional context[3]	0 to 5	6 to 19	>20
2. Significant Potential for Substantial Loss of Life: Exposed Population			
A. Facility context	<100	100 to 499	≥500
B. Community context	<1 000	1 000 to 9 999	≥10 000
C. Regional context	<100 000	100 000 to 999 999	≥1 000 000
3. Hazard and/or Failure Event(s)			
A. Earthquake	≤ MMI IV	MMI V to VII	≥MMI VIII
B. Hurricane at Landfall	≤Cat 3	Cat 4	Cat 5
C. Tornado	≤EF3	EF4	EF5
D. Coastal Inundation	< 3 ft	3 to 9 ft	≥ 10 ft
E. Fire Spread in Structures	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
F. Wildland Urban Interface Fire (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
G. Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	> 1000 lbs. TNT-equivalent
H. Impact	< 1×10^6 ft lb/sec	1×10^6 to 1×10^7 ft lb/sec	> 1×10^7 ft lb/sec
4. Consequences to resilience[4]			
A. Failure during Construction or in Service[5]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
B. Engineered Building Systems[6]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function

Fuse 47 Apartment Fire, College Park

C. Transportation & Utility Systems[7]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
D. Non-Engineered Building Systems	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Score: 15/4 = 3.75 Sum	2 x 1	1 x 3	2 x 5

5. Evacuation and Emergency Response[8]			
A. Evacuation	Normal evacuation	Moderate evacuation challenges	Severe evacuation challenges
B. Emergency Response	Normal operations	Moderate operational challenges	Severe operational challenges
Score: 4/2 = 2.0 Sum	1 x 1	1 x 3	0 x 5

6. International Events			
A. Codes, standards and enforcement	No building codes, standards, or enforcement	Building codes and standards, but no enforcement	Building codes and standards, with enforcement
B. Construction practices similar to the US	Minimally similar	Moderately similar	Significantly similar
Total Score: (From 1-4) 0.0 x n = 0.0 Sum	$(0.8)^n$	$(0.9)^n$	$(1.0)^n$

- **n is 0,1, or 2, depending on the number of selected items under each ranking category (i.e., Low, Med, or High) for Criteria 6. The factor applied to the Total Score is the product of all three factors.**

Metropolitan Apartment Complex, Raleigh, NC

National Construction Safety Team Act
Table 1. Preliminary Reconnaissance Decision Criteria

Metropolitan Apartment Complex Fire, Raleigh, North Carolina, U.S. – 03/16/2017			
Preliminary Reconnaissance Criteria[1]	Low (1)	Med (3)	High (5)
1. Substantial Loss of Life or Disabling Injury			
A. Facility context	0	1 to 2	>2
B. Community context[2]	0 to 3	4 to 9	>10
C. Regional context[3]	0 to 5	6 to 19	>20
2. Significant Potential for Substantial Loss of Life: Exposed Population			
A. Facility context	<100	100 to 499	≥500
B. Community context	<1 000	1 000 to 9 999	≥10 000
C. Regional context	<100 000	100 000 to 999 999	≥1 000 000
3. Hazard and/or Failure Event(s)			
A. Earthquake	≤ MMI IV	MMI V to VII	≥MMI VIII
B. Hurricane at Landfall	≤Cat 3	Cat 4	Cat 5
C. Tornado	≤EF3	EF4	EF5
D. Coastal Inundation	< 3 ft	3 to 9 ft	≥ 10 ft
E. Fire Spread in Structures	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
F. Wildland Urban Interface Fire (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
G. Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	> 1000 lbs. TNT-equivalent
H. Impact	< 1 x 10^6 ft lb/sec	1 x 10^6 to 1 x 10^7 ft lb/sec	> 1 x 10^7 ft lb/sec
4. Consequences to resilience[4]			
A. Failure during Construction or in Service[5]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
B. Engineered Building Systems[6]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function

Metropolitan Apartment Complex, Raleigh, NC

C. Transportation & Utility Systems[7]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
D. Non-Engineered Building Systems	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Score: 12/4 = 3.0 Sum	2 x 1	0 x 3	2 x 5

5. Evacuation and Emergency Response[8]			
A. Evacuation	Normal evacuation	Moderate evacuation challenges	Severe evacuation challenges
B. Emergency Response	Normal operations	Moderate operational challenges	Severe operational challenges
Score: 2/2 = 1.0 Sum	2 x 1	0 x 3	0 x 5

6. International Events			
A. Codes, standards and enforcement	No building codes, standards, or enforcement	Building codes and standards, but no enforcement	Building codes and standards, with enforcement
B. Construction practices similar to the US	Minimally similar	Moderately similar	Significantly similar
Total Score: (From 1-4) 0.0 x n = 0.0 Sum	$(0.8)^n$	$(0.9)^2$	$(1.0)^n$

- **n is 0,1, or 2, depending on the number of selected items under each ranking category (i.e., Low, Med, or High) for Criteria 6. The factor applied to the Total Score is the product of all three factors.**

Grenfell Towers, London

Decision Criteria for NCST Preliminary Reconnaissance
Grenfell Tower Fire, London, U.K. – 06/14/2017

1.0 Event Consequence			
	Low	Medium	High
A. Mortality			
Facility context	0	1 to 2	>2
Community context[1]	0 to 3	4 to 9	>10
Regional context[2]	0 to 5	6 to 19	>20
B. Exposed Population			
Facility context	<100	100 to 499	≥500
Community context	<1 000	1 000 to 9 999	≥10 000
Regional context	<100 000	100 000 to 999 999	≥1 000 000
C. Hazard and/or Failure Intensity			
Earthquake	≤ MMI IV	MMI V to VII	≥MMI VIII
Hurricane at Landfall	≤Cat 3	Cat 4	Cat 5
Tornado	≤EF3	EF4	EF5
Coastal Inundation	< 3 ft	3 to 9 ft	≥ 10 ft
Fire Spread in Structures	Fire spread not beyond area of origin	Fire spread throughout a structure	Fire spread beyond structure of origin
Wildland Urban Interface Fire (WUI)	High Forest Service Fire Danger Rating	Very High Forest Service Fire Danger Rating	Extreme Forest Service Fire Danger Rating
Blast	< 99 lbs. TNT-equivalent	100 - 999 lbs. TNT-equivalent	> 1000 lbs. TNT-equivalent
Impact	< 1 x 10^6 ft lb/sec	1 x 10^6 to 1 x 10^7 ft lb/sec	> 1 x 10^7 ft lb/sec
D. Physical Damage[3]			
Failure during Construction or in Service[4]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Engineered Building Systems[5]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function

Grenfell Towers, London

Transportation & Utility Systems[6]	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Non-Engineered Building Systems	Minimal physical damage and/or loss of function	Moderate physical damage and/or loss of function	Severe physical damage and/or loss of function
Count x Weight:	0 x 1 = 0	1 x 3 = 3	3 x 5 = 15
Event Consequence Score:	**18/4 = 4.5**		

2.0 Evacuation and Response[7]			
A. Evacuation	Normal evacuation	Moderate evacuation challenges	Severe evacuation challenges
B. Emergency Response	Normal operations	Moderate operational challenges	Severe operational challenges
Count x Weight:	0 x 1 = 0	1 x 3 = 3	1 x 5 = 5
Evacuation and Response Score:	**8/2 = 4.0**		

3.0 International Events Factor[8]			
A. Codes, standards and enforcement	No building codes, standards, or enforcement	Building codes and standards, but no enforcement	Building codes and standards, with enforcement
B. Construction practices similar to the US	Minimally similar	Moderately similar	Significantly similar
Criertia Factor:	$(0.8)^0 = 1$	$(0.9)^1 = 0.9$	$(1.0)^1 = 1.0$
Total Factor:	**1 x 0.9 x 1.0 = 0.9**		

Fires in Buildings Under Construction

2015 International Building Code (ICC)-

Use and Occupancy Classification

- Group A- Assembly
- Group B- Business
- Group E- Educational
- Group F- Factory/Industrial
- Group I- Institutional
- Group M- Mercantile
- Group R- Residential
- Group S- Storage

Fires in Buildings Under Construction

- 2015 International Building Code (ICC)
  - Type I and II - non combustible building elements
    - Steel and concrete
  - Type III – fire resistant combustible
    - exterior walls non combustible or 2 hr fire rating
    - Other elements 1 hr (IIIA) or 0 hr (IIIB) fire rating
  - Type IV – Heavy Timber
    - building elements non combustible, fire-retardant-treated wood, or cross-laminated timber
    - 8 x 8 inch support'
    - Partitions – 1 hr fire rating
  - Type V – combustible
    - wood for structural frame, bearing walls, floor, roof
    - 1 hr (VA) or 0 hr (VB) fire rating

Fires in Buildings Under Construction

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 504.3: Allowable Building Height (Ft above Grade)	A, B, E, F, M, S, U	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 1, I-3	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 2, I-2	NS	65	55	65	50	40
		S					
	I-4	NS	65	55	65	50	40
		S	85	75	85	70	60
	R	NS	65	55	65	50	40
		S13R	60	60	60	60	60
		S	85	75	85	70	60