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TAMEST NATURAL HAZARDS SUMMIT

Responding to and Mitigating the Impacts

LUBBOCK, TEXAS
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#NATURALHAZARDSSUMMIT

Panel:
Improving Resiliency of Infrastructure to Prevent Fatalities and Mitigate Damages

MODERATOR

CHANDRA FRANKLIN WOMACK

Owner and Chief Executive Officer, Aran & Franklin;
Board Chair, Texas Windstorm Insurance Association

SPEAKERS

IAN GIAMMANCO, PH.D.

Lead Research Meteorologist & Sr. Director for Standards and Data Analytics,
Insurance Institute for Business & Home Safety

MARC LEVITAN, PH.D.

Lead Research Engineer, National Windstorm Impact Reduction Program,
National Institute of Standards and Technology

CHRIS LETCHFORD, D.PHIL.

Professor and Chair
Rensselaer Polytechnic Institute

Advancing Windstorm Resilience through Design for Tornadoes

Marc L. Levitan, Ph.D.
Lead Research Engineer
National Windstorm Impact Reduction Program (NWIRP)
marc.levitan@nist.gov

TTU Class of 1985, 1988, and 1993

Why Haven't We Considered Tornadoes in Conventional Engineering Design?

Common Misperceptions

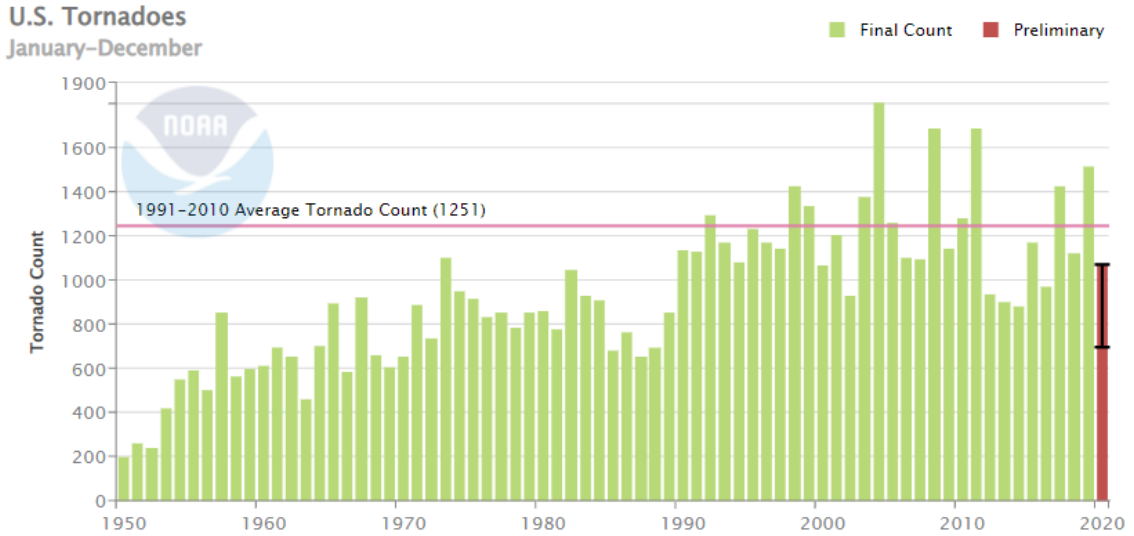
- Too rare
- Losses are small compared to other hazards
- Nothing we can do about them
- Inadequate knowledge
- Buildings would all be concrete bunkers
- Too expensive

Credit: NOAA/ITAE

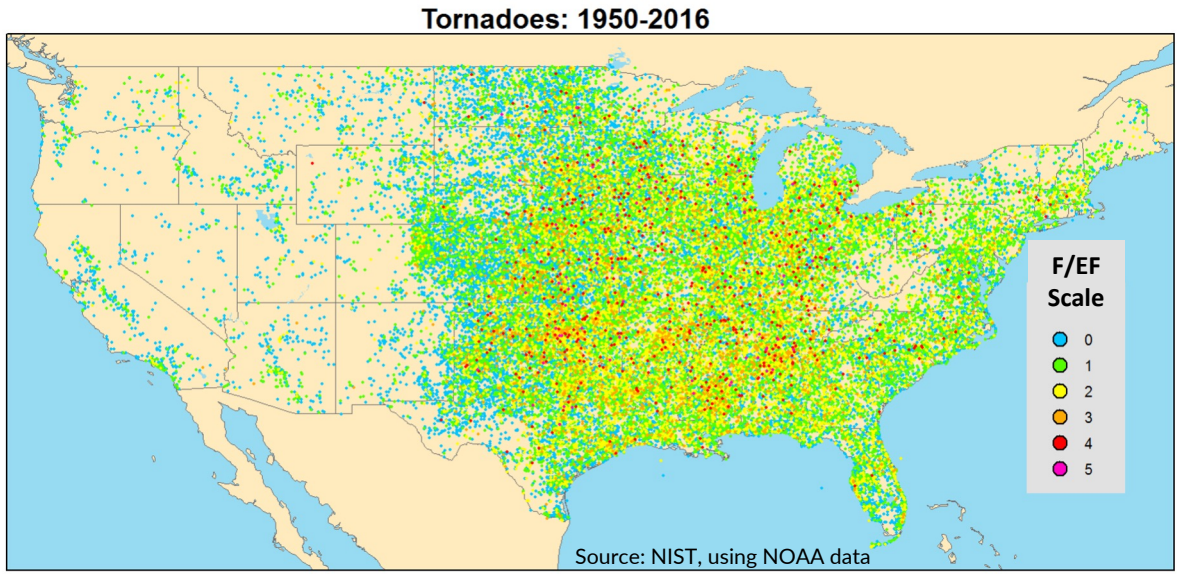
Perceptions may be shaped by the few violent tornadoes per year that make the headlines

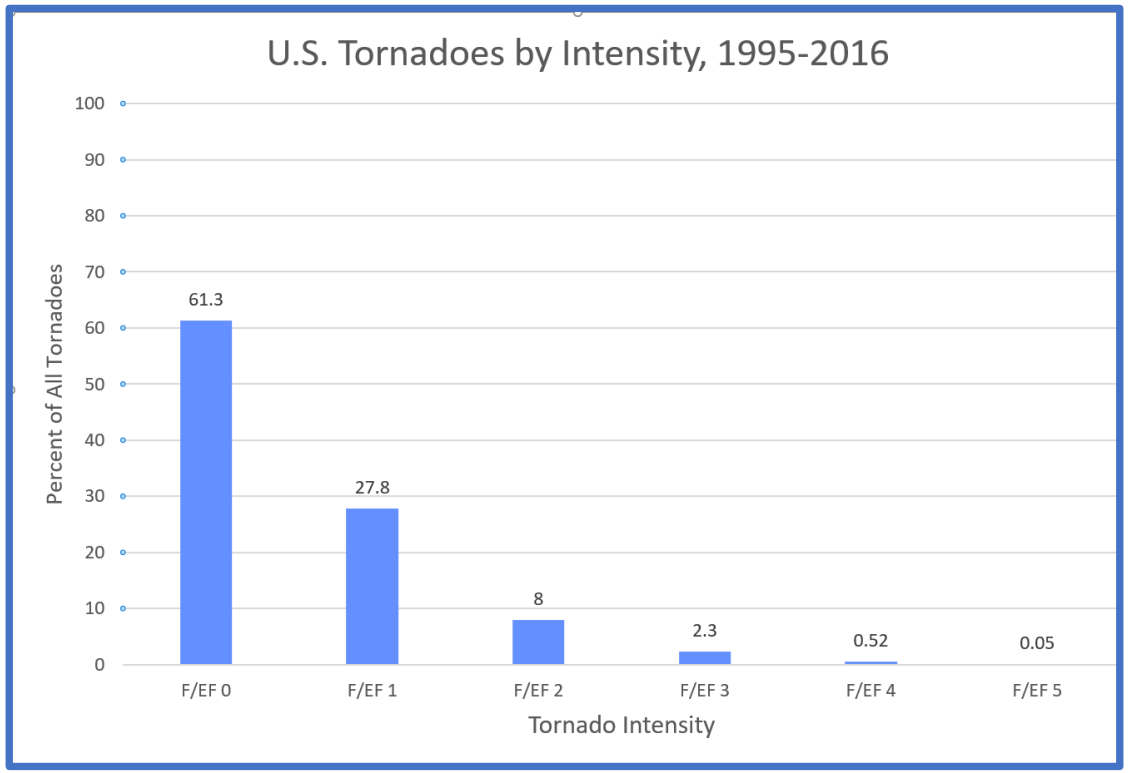
Tornado Frequency

Source: NIST, from NOAA data



Number of *reported* tornadoes. Many go unreported.





Source: NIST, using NOAA data

- **Violent tornadoes are uncommon**
- **Vast majority of all tornadoes are ≤ EF2**
  - **EF0-EF1 Tornadoes – 89.1%**
  - **EF0-EF2 Tornadoes – 97.1%**

Tornado Impacts

Source: NIST, from NOAA data

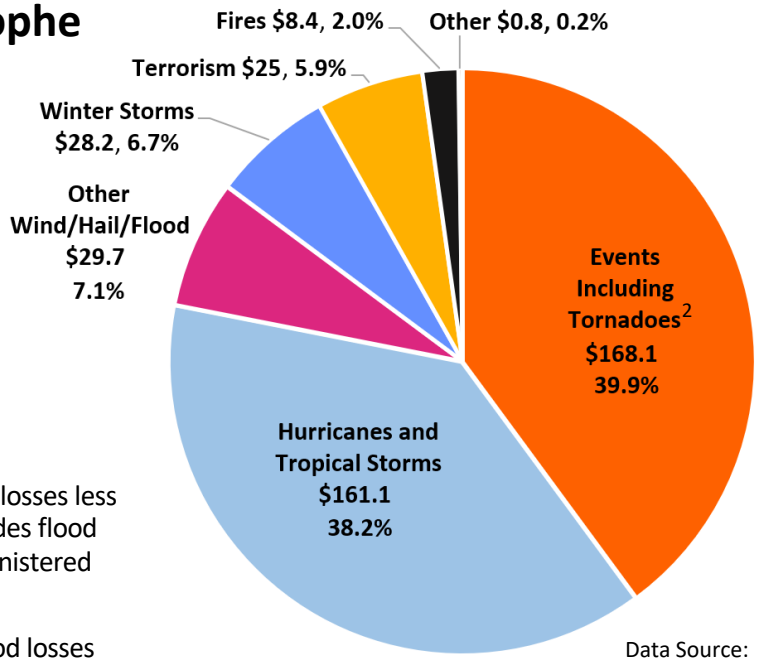
- **U.S. Tornado Fatalities ≈ 5,600 (1950-2011)**
- **Tornado Fatalities > Hurricane + Earthquake Fatalities**
- **Tornado Fatalities Overwhelmingly Occur Inside Buildings**

Tornado Fatalities are a *Buildings* Problem

Source: NIST (2014)

U.S. Insured Catastrophe Losses By Cause,[1] 1997-2016

(in 2016 $ billions)

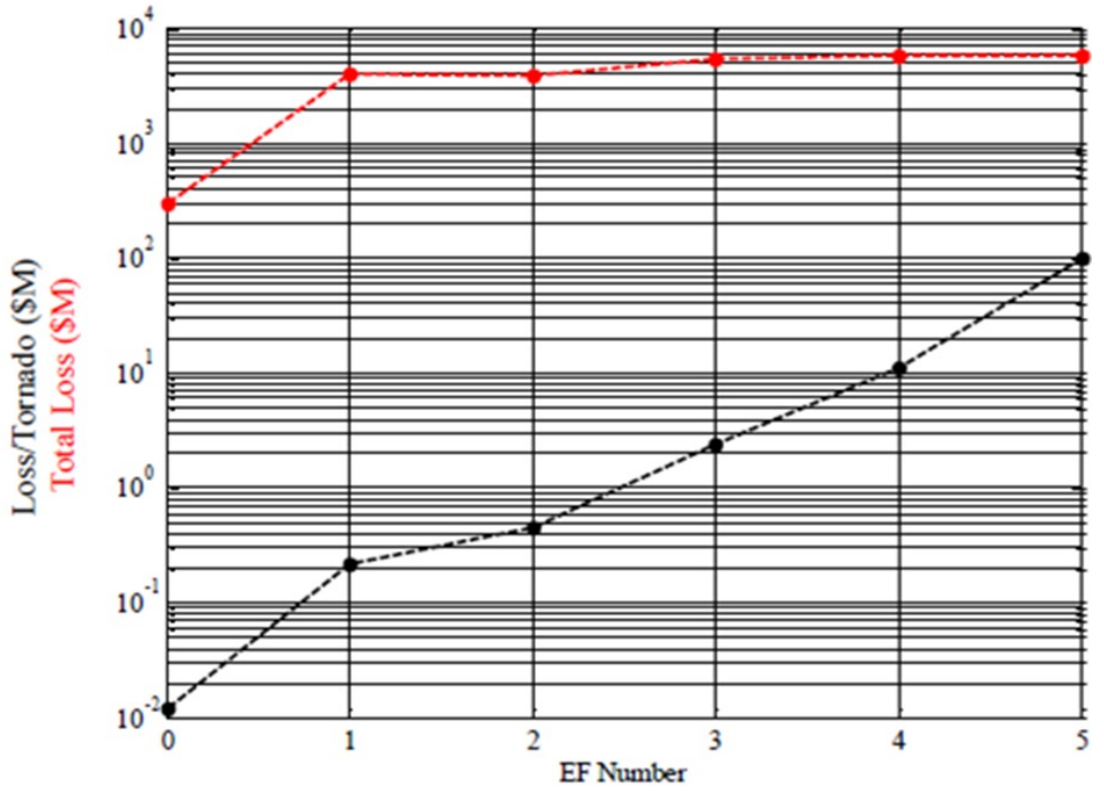


[1] Excludes catastrophes causing direct losses less than $25 million in 1997 dollars. Excludes flood damage covered by the federally administered National Flood Insurance Program.

[2] Includes other wind, hail, and/or flood losses associated with catastrophes involving tornadoes.

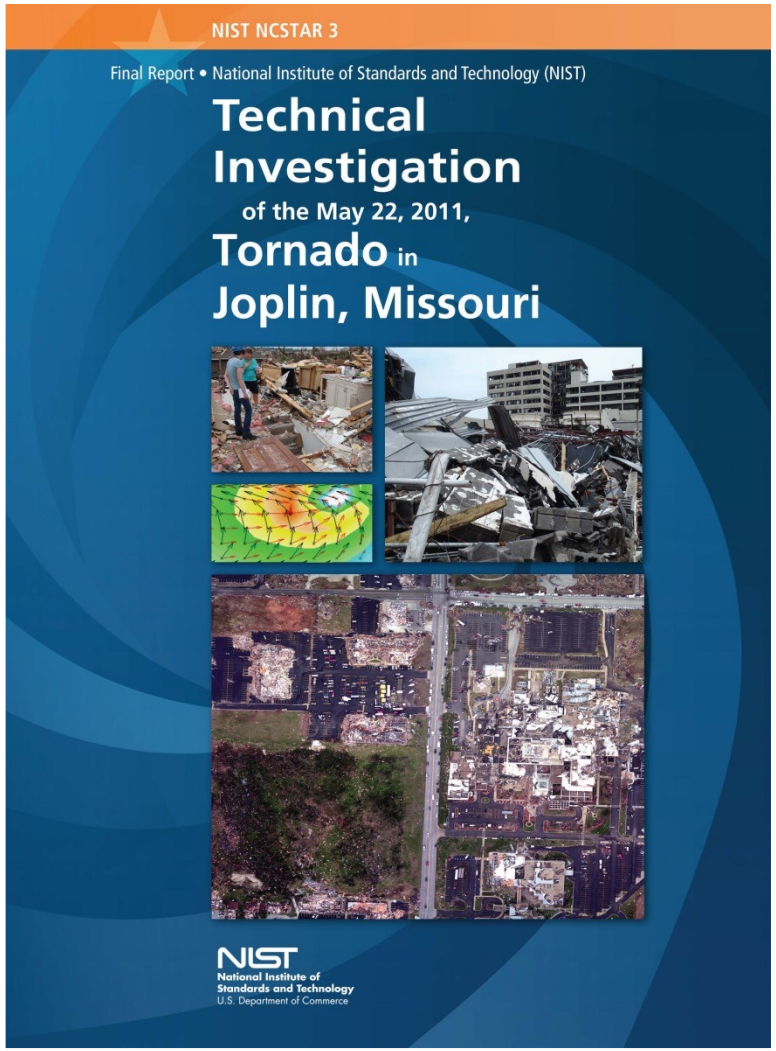
Data Source:
Insurance Information Institute

Average Loss/Tornado and Total Loss, by F/EF number (in 2011 $)



Source: NIST (2014)

Genesis of New Tornado Load Design Methods



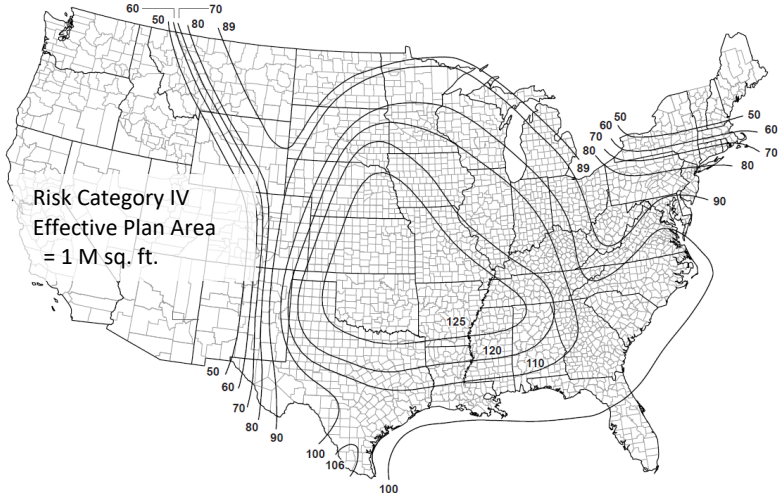
http://dx.doi.org/10.6028/NIST.NCSTAR.3

16 recommendations for improving

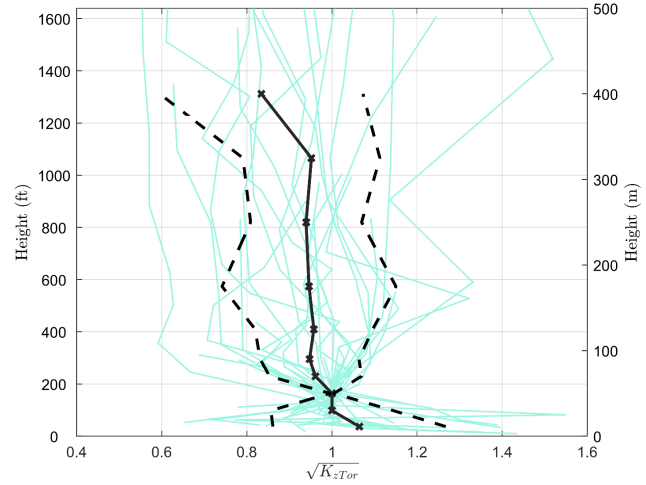
- Tornado hazard characterization
- Design and construction of buildings and shelters
- Emergency communications and warnings

Followed by 6 years R&D to create

- First-ever probabilistic hazard maps, incl. size effects
- Science-based tornado load methodology



Example Design Tornado Speed Map (mph)
(Note: 1 mph = 0.447 m/s)



Normalized Tornado Speed Profile

Tornado Loads - New in ASCE 7-22 Standard

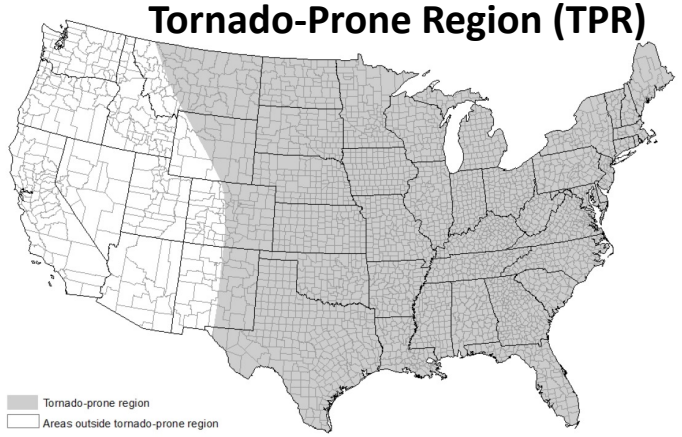
Credit: NOAA Photo Library, NOAA Central Library; OAR/ERL/National Severe Storms Laboratory (NSSL).

Credit: ASCE

ASCE 7-22 Tornado Load Requirements Summary

- Risk Category III/IV buildings in TPR
  - Assembly occupancies, schools, nursing homes, hospitals, fire, police, etc.
- Tornado design speeds ≈ EF0-EF2
  - Depends on Risk Category, location, plan size
- **Designing for most common tornadoes, not most intense**
- Loads can increase significantly, sometimes >100%
- Construction costs don't increase much, generally <0.15%

Tornado-Prone Region (TPR)

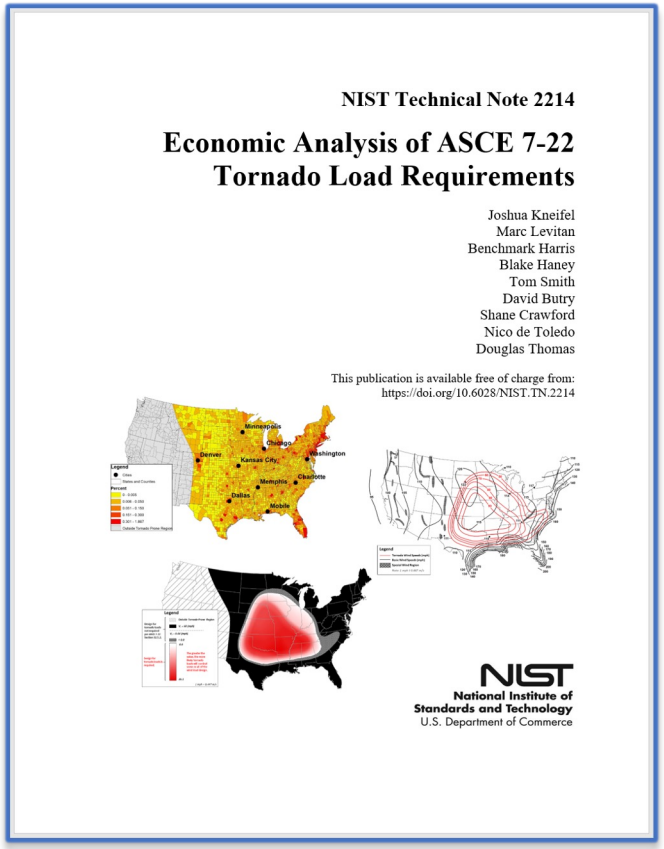


Enhanced Fujita (EF) Tornado Intensity Scale

EF #	Gust Speed (mph)	% U.S. Tornadoes[1]
0	65-85	61.3
1	86-110	27.8
2	111-135	8.0
3	136-165	2.3
4	166-200	0.52
5	Over 200	0.05

97.1%

[1] 1995-2016. Source: NIST, using NOAA data.


NIST Technical Note 2214

Economic Analysis of ASCE 7-22 Tornado Load Requirements

Joshua Kneifel
Marc Levitan
Benchmark Harris
Blake Haney
Tom Smith
David Butry
Shane Crawford
Nico de Toledo
Douglas Thomas

This publication is available free of charge from: https://doi.org/10.6028/NIST.TN.2214

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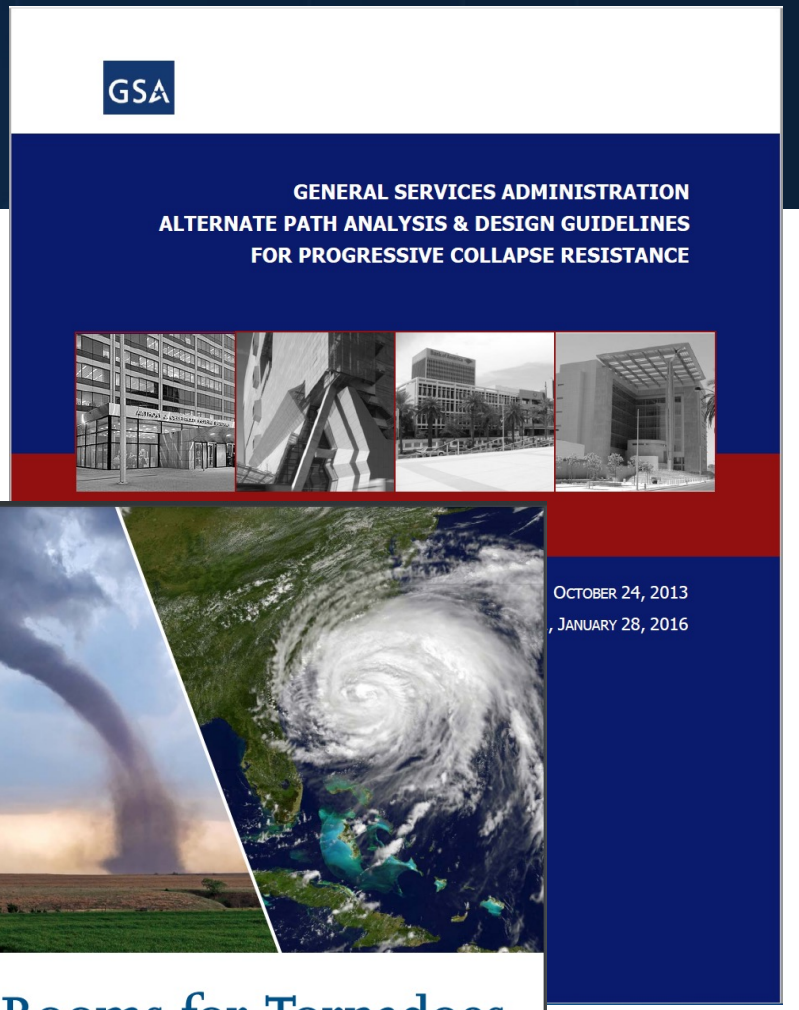
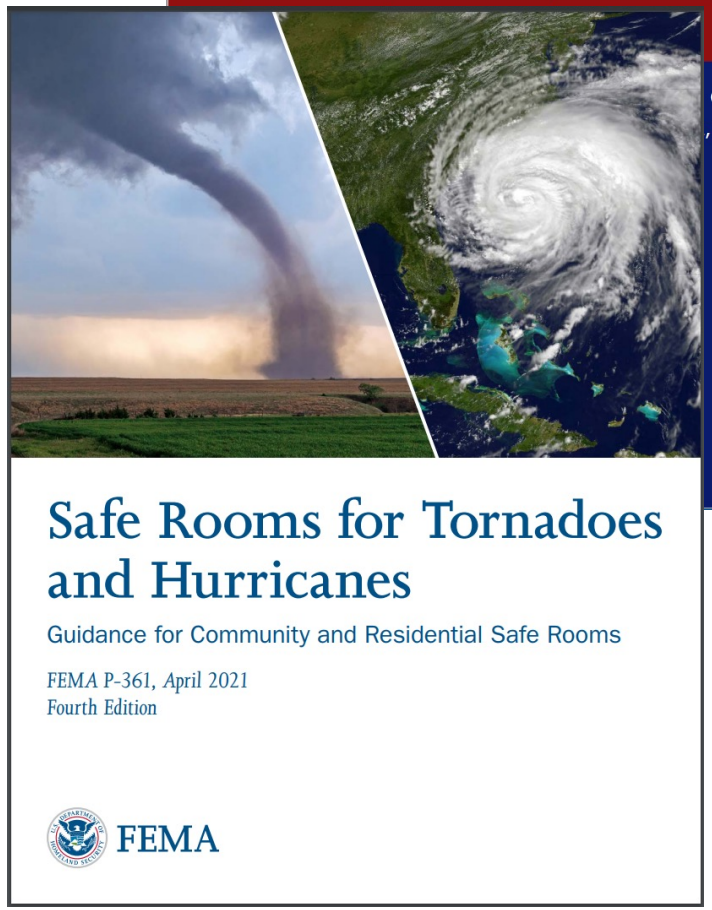
Implementation - Improving Tornado Resilience

- **Add tornado loads to 2024 IBC**
  - Proposal passed the IBC Structural Committee
- **Why wait until 2024? (*assuming* approval)**
- **Federal/State/Local governments can adopt now**
  - Many examples of ‘above code’ requirements
    - Federal
    - State - Alabama and Illinois adoption of requirements for ICC 500 Storm Shelters in Schools
    - Local – Joplin MO and Moore OK tornado resistant residential code requirements





engineering laboratory