Building Better Houses

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Basic Wind Speed Design
3-sec gust at 10m

ASCE-7 Standard DOES NOT include design for tornadoes

Types of homes that can be made more wind resistant

- Wood frame
- Reinforced concrete masonry units
- Poured concrete
- Precast concrete
- Insulated concrete form (ICF)
- Steel Frame
- Others (modulars, manufactured, log, etc.)

The problem with wood-framed homes in high winds:

- Failure of foundation/sill plate attachment
- Failure of wall/foundation attachment
- Failure of sill plate/floor attachment
- Failure of windows, doors, unbraced walls
- Failure of roof/wall attachment
- Failure of roof decking attachment
- Failure of roof covering attachment

Moore, OK 2013

Vilonia, AR 2014
Destroyed home 2013

Cut nails on exterior walls

Typical connection of wall to slab

F indicates likely failure areas

Stud
Bottom plate
Concrete slab

Types of connections to slab

Bolt
Strap
Shot
Pin
Cut
Nail

Straight-nailed studs pulled away from plate.

Studs pulled out from strapped plate

Failure of bottom plate/foundation attachment (shot pins)
Scrape in slab where cut nail moved

Bottom plate in back yard contains cut nail.

All that was left of this house was the cut nails left in foundation.

The “SLIDER”

J-bolts in cells - not fully grouted

SLIDER on CMU foundation
Failure of floor/sill plate attachment

Loss of wind led to loss of roof

Loss of window led to loss of wall

The effects of internal wind pressure

Garage doors blew in, wall blew out

Garage door blew in, wall blew out
Garage door frame failure
Bending of the metal door bracket and deformation of track where door roller had been.

Failure of jamb-door attachment
Insufficient Nail Penetration

Stiffening bracket and glider track by FEMA

Bracing of garage door for hurricanes by FEMA

Typical rafter-top plate connection that performs poorly when it is uplifted

Poorly attached roof slid off house due to internal pressure
Toenailed connection was pulled apart when the roof was uplifted.

Improperly braced gable end fell outward.

Roof decking was not installed correctly.

Whole sheets of roof decking with shingles.

Stapled roof deck on new home after hurricane.

Undamaged structure but no roof shingles.
Asphalt shingles were stapled incorrectly to the roof. However, the nail holes in the tiles were larger than the fastener heads. Mortar bonded to roofing underlayment but not to the tiles. Such tiles became airborne. Tiles didn't bond to the mortar patty. Can we build a better house? Wind-resistant wood-framed homes

http://www.awc.org/standards/wfcm.php
Wind-resistant wood-framed homes

https://www.fema.gov/media-library/assets/documents/3293

"Above code" diagram of wall-to-slab foundation connection by FEMA

Stud/Bottom plate strapping

Solid sheathing on homes

Properly bolted plates and fully sheathed walls

Stronger connection “above code”

Metal strap from stud to plate. Pull-out strength is increased about 10x.
“Above code” anchorage for concrete foundations by FEMA.

Metal truss clip can also help prevent rotation

The “hurricane clip” connects rafters to the top plates

Various roof clips

Lateral bracing of roof trusses per FEMA
- **Gable end and soffit retrofit**
- **Bond roof deck to trusses with foam**
- **Replace high profile metal vents with low profile vents**
- **Install fiber-cement siding instead of vinyl.**
- **Install laminated shingles instead of 3-tab shingles**
  - 6 nails per shingle
- **Install impact resistant windows and doors**
CONCRETE MASONRY HOMES

CMU Home Construction

Steel reinforcement in cells

Typical detail at bottom of CMU wall

CMU wall / foundation attachment

Locations of steel reinforcement in wall

Source: HUD
Wood framed roof/CMU wall attachment

Source: FEMA

Rafter Ties to CMU bond beam

Stucco applied to exterior surface

Stucco surface on CMU wall

CMU house

CMU house
Collapse of unreinforced CMU wall

POURED CONCRETE HOMES

Steel reinforcement

Concrete Dome Home Wall Cross Section

Concrete dome home w/ attached room

Concrete Dome Home Blanchard, OK
EF-4 tornado – Blanchard, OK

Concrete Dome Home Before and After Hurricane Ivan

Concrete Home construction

Wood framed roof added

Concrete Home survived Hurricane Katrina
Precast concrete homes

ICF (Insulated Concrete Form) HOMES

ICF homes

Poured slab - ICF modules
Braced gable end

ICF roof/wall detail

Proper strapping of roof trusses. However, roof deck and covering failed making house an economic total loss.

Finished ICF duplex

ICF Roof - Before Concrete

ICF roof - with Concrete
ICF house hit with weak tornado

STEEL-FRAMED HOMES

One and two story homes

Steel wall framing

Standing up steel frame walls

Steel studs - frame wall
Metal framing screws

Steel-frame wall attachments

Steel frame around windows and doors

Steel wall/roof attachment

Before/After Cladding

Installation of brick masonry
REFERENCES


Related talks at this conference

- Tuesday 10:45-11:30a - New Building Code for Moore - Chris Ramseyer
- Tuesday, 1:15 - 2pm - Tornado Resistant Construction - Tim Reinhold
- Wednesday 9:45-10am - What Building Performance? - David Prevatt

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