Some EF-scale issues

by Tim Marshall, P.E.
Meteorologist

EF-scale discussion – AMS Annual Meeting – February 3, 2014

Some problems rating tornadoes

- **What to do about current errors in the EF-scale (i.e. cross-correlation issues)?**
- **What to do about variable wind flow in tornadoes. (Strong near-the-ground vertical component)?**
- **What to do about tornadoes that don't have the same duration?**
- **What to do about rating damage to vehicles, grain bins, irrigation systems, pavement scouring, crop damage, oil tanks, parking curbs, etc? (NON-DIs)**
- **What to do about tornadoes that don't hit anything?**

Cross Correlation – Comparisons

2. ONE-AND TWO-FAMILY RESIDENCES (FR12)
(1000 – 5000 sq. ft.)

Typical Construction

- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

5. APARTMENTS, CONDOMINIUMS AND TOWNHOUSES (ACT)
(Three stories or less)

Typical Construction

- Flat, gable, hip or mansard roof
- Asphalt shingles, tile, metal or BUR roof covering
- Plywood/OSB roof decking
- Light-framed wood or metal roof trusses
- Wood, metal or vinyl panels, stucco brick veneer or EIFS wall covering; combinations of wall coverings
- Wood or metal stud walls
- Wood floor diaphragms
- Sliding patio doors; balconies

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	76	63	95
2	Loss of roof covering (<20%)	99	82	121
3	Uplift of roof decking; significant loss of roof covering (>20%)	124	107	146
4	Uplift or collapse of roof structure leaving most walls standing	138	120	158
5	Most top story walls collapsed	158	138	184
6	Almost total destruction of top two stories	180	155	205

* DOD is degree of damage

Cross Correlation - Comparisons

12. LARGE ISOLATED RETAIL BUILDING (LIRB)

Typical Construction

- Flat roof with BUR and gravel or single-ply membrane roof; generally has a 2-3 ft parapet
- Open web joists and steel girders or joist girders supported by tall pipe columns
- Metal deck with rigid insulation or lightweight concrete fill slab
- Large windows on front side of building
- CMU walls, tilt-up concrete panels, metal stud walls covered with EIFS or combinations of these

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	68	57	83
2	Loss of roof covering (<20%)	81	68	103
3	Uplift of some roof decking; significant loss of roofing material (>20%); loss of rooftop HVAC	103	87	123
4	Long roof spans collapsed downward	122	103	144
5	Uplift and removal of roof structure	134	114	157
6	Inward or outward collapse of exterior walls	137	118	158
7	Complete destruction of all or a large section of the building	173	147	201

* DOD is degree of damage

23. WAREHOUSE BUILDING (WHB)

General Description

- This category includes all building systems except Metal Building Systems
- Examples include warehouse, storage and industrial buildings
- Buildings are generally rectangular in plan with flat, gable or hip roofs
- Built-up roofs with gravel, single-ply membrane ballasted, mechanically attached or fully adhered
- Light-frame steel construction with masonry bearing walls
- Large overhead doors
- Pre-cast concrete columns, beams and double tees with tilt-up wall panels
- Heavy timber construction with stud walls and wood panels

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	68	55	83
2	Loss of roofing material (<20%)	83	69	105
3	Inward or outward collapse of overhead doors	88	75	107
4	Uplift of roof deck; significant loss of roofing material (>20%); loss of rooftop HVAC equipment	103	88	122
5	Collapse of other non-bearing exterior walls	114	93	126
6	Collapse of pre-cast concrete tilt-up panels	124	102	144
7	Total destruction of a large section of building or entire building	158	131	186

* DOD is degree of damage

Not much difference. Can we combine them ?

Cross Correlation - Comparisons

27. TREES: HARDWOOD

Typical Construction

- Hardwood: Oak, Maple, Birch, Ash

DOD*	Damage description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1"-3" diameter)	74	61	88
3	Trees uprooted	94	76	118
4	Trunks snapped	107	93	134
5	Trees debarked with only stubs of largest branches remaining	143	123	167

- DOD is degree of damage

28. TREES (SOFTWOOD)

Typical Construction

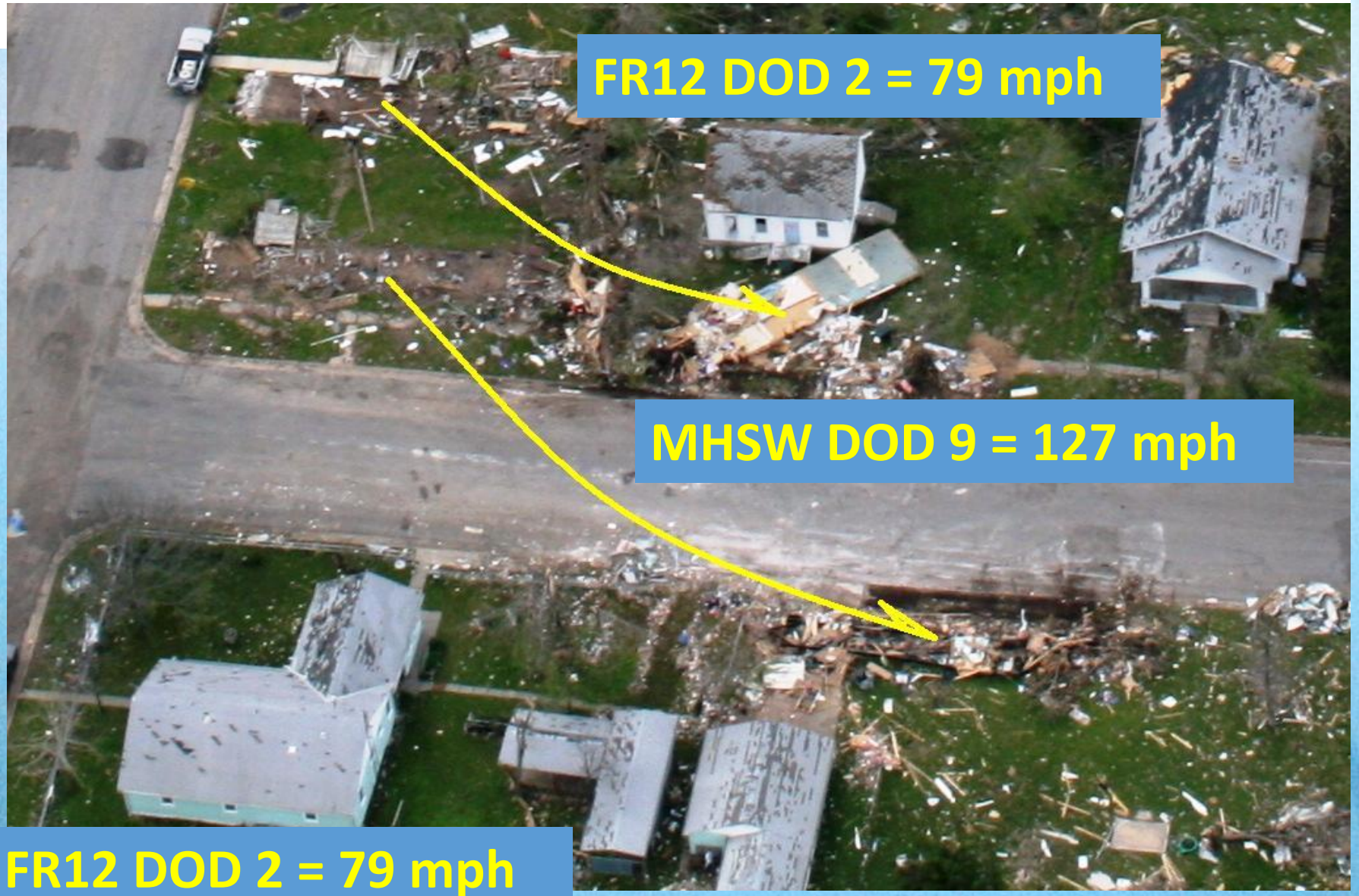
- Softwood: Pine, Spruce, Fir, Hemlock, Cedar, Redwood, Cypress

DOD	Damage description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1" – 3" diameter)	75	62	88
3	Trees uprooted	87	73	113
4	Trunks snapped	104	88	128
5	Trees debarked with only stubs of largest branches remaining	131	112	153

* DOD is degree of damage

Not much difference. Can we combine them ?

Manufactured housing performance



House vs. Manufactured Home

2. ONE-AND TWO-FAMILY RESIDENCES (FR12)
(1000 – 5000 sq. ft.)

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- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

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10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

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3. MANUFACTURED HOMES – SINGLE WIDE (MHSW)

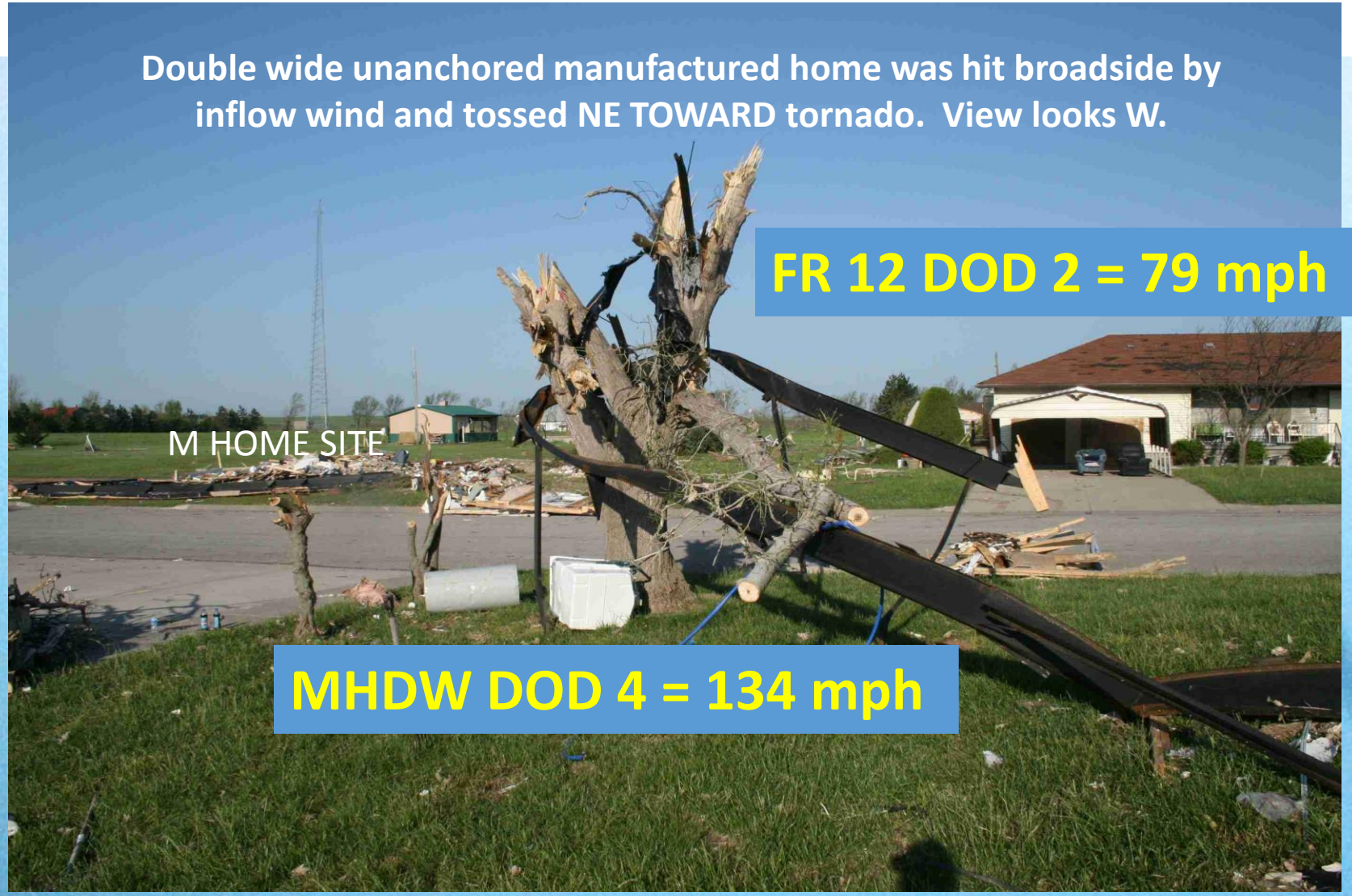
Typical Construction

- Steel undercarriage supported on concrete block piers
- Metal straps and ground anchors (Frame and/or over-the-top strap anchors)
- Asphalt shingles or one-piece metal roof covering
- Wood roof joists
- Metal, vinyl or wood siding
- Wood stud walls and partitions
- Better construction in post 1974 models in coastal areas

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	61	51	76
2	Loss of shingles or partial uplift of one-piece metal roof covering	74	61	92
3	Unit slides off block piers but remains upright	87	72	103
4	Complete uplift of roof; most walls remain standing	89	73	112
5	Unit rolls on its side or upside down; remains essentially intact	98	84	114
6	Destruction of roof and walls leaving floor and undercarriage in place	105	87	123
7	Unit rolls or vaults; roof and walls separate from floor and undercarriage	109	96	128
8	Undercarriage separates from unit; rolls, tumbles and is badly bent	118	101	136
9	Complete destruction of unit; debris blown away	127	110	148

DOD is degree of damage

DW Manufactured home performance



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- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

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4. MANUFACTURED HOME – DOUBLE WIDE (MHDW)

Typical Construction

- Steel undercarriage supported on concrete block piers
- Multi-unit connection at roof, floor and end walls
- Frame straps and ground anchors spaced at 10 – 12 ft apart
- Flat, gable or hip roof shape
- Asphalt shingles or metal roof panels
- Plywood/OSB roof decking
- Wood rafter or shallow joist construction
- Metal, vinyl or wood siding

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	61	51	76
2	Loss of shingles or other roof covering (<20%)	76	62	88
3	Damaged porches or carports	78	67	96
4	Broken windows	83	68	95
5	Uplift of roof deck and loss of significant roof covering material (>20%)	88	75	108
6	Complete uplift of roof; most walls remain standing	93	77	110
7	Unit slides off CMU block piers	94	78	109
8	Removal of entire roof structure leaving most walls standing	97	80	117
9	Complete destruction of roof and walls leaving undercarriage in place	113	93	131
10	Unit rolls, displaces or vaults	114	82	130
11	Undercarriage separates from floor, rolls and tumbles, badly bent	127	109	145
12	Complete destruction of unit; debris blows away	134	119	154

* DOD is degree of damage

Need to add churches

I have been using SRB for Churches

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	54	81
2	Loss of roof covering (<20%)	78	65	98
3	Broken windows, including clear story windows or skylights	89	74	107
4	Exterior doors fail	100	82	118
5	Uplift of roof decking; significant loss of roof covering (>20%); loss of rooftop HVAC equipment	100	84	117
6	Collapsed façade or parapet walls	103	85	123
7	Uplift or collapse of entire roof structure	124	105	145
8	Collapse of exterior walls; closely spaced interior walls remain standing	144	123	165
9	Total destruction of entire building	157	148	200

* DOD is degree of damage

But need collapse of large span sanctuary with exterior classrooms/offices remaining - Separate DI.

Add more DOD's for FST

25. FREE-STANDING TOWERS (FST)

Typical Construction

- Cell phone pole or tower
- Microwave tower

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	92	76	113
2	Collapsed cell-phone pole or tower	133	113	157
3	Collapsed micro-wave tower	136	116	160

* DOD is degree of damage

Need to account for detached, tossed and crumpled trussed towers (i.e. Bowdle SD)

What is a well-built house ?

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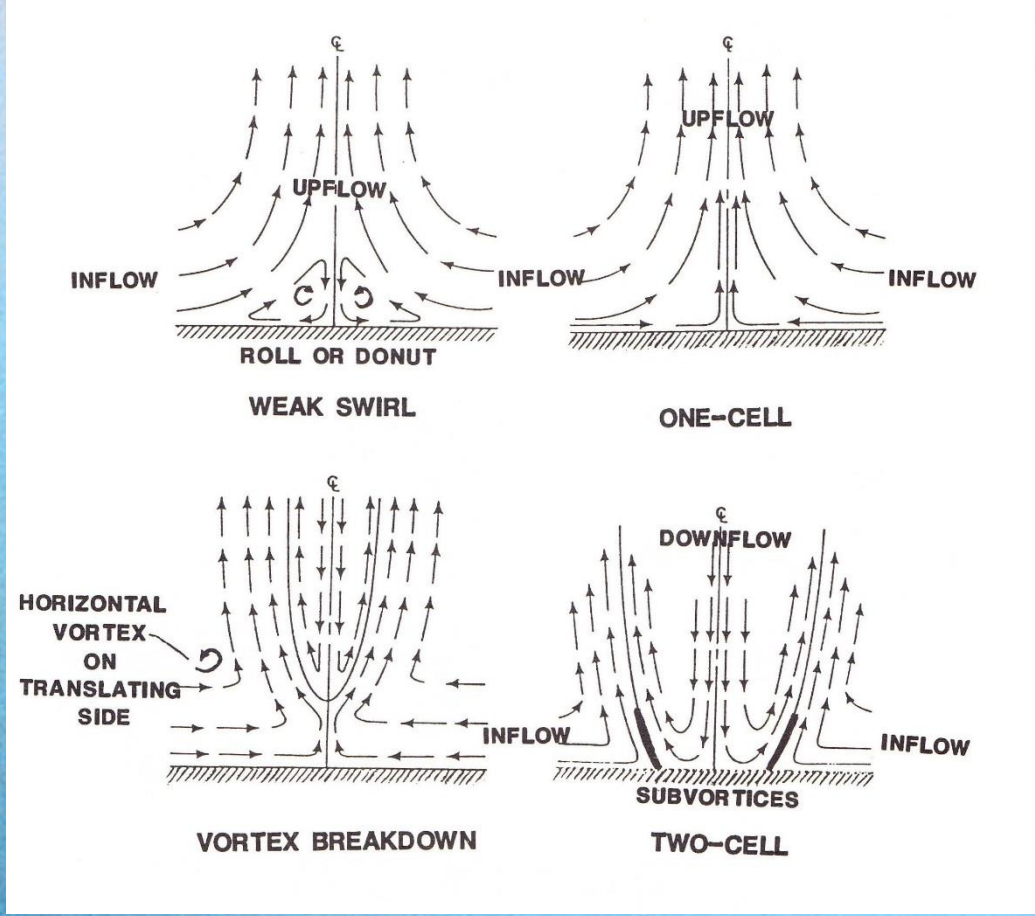
Should conventional stick-built be in the same category as ICF homes ? What about CBS ?
Is there really such thing as an EF-5 to a conventional stick built home?

Vertical velocities near the ground



EF-scale is defined as a HORIZONTAL wind

Strong tornadoes do other things besides destroy buildings like:

Scour vegetation and road pavement

Toss heavy objects large distances

More examples of non DI’s

Need to explain how to incorporate non-DIs in the damage survey.