

TORNADO OUTBREAK
of **2011**IN ALABAMA, GEORGIA, MISSISSIPPI,
TENNESSEE, AND MISSOURI **EF Scale Summary**

Currently, tornado intensity is classified using the “Enhanced Fujita” (EF) scale, which improves upon the original Fujita scale. The Fujita scale, originally developed by Dr. Tetsuya T. Fujita in 1971 (Fujita 1971), provided a method to rate tornado intensity by examining the affected area. Since there was no reliable method to accurately determine the wind speed of a tornado, the method allowed people to distinguish between weak and strong tornadoes using the damage caused by the tornado. The Fujita scale was updated and superseded by the EF scale, published in 2004 in *A Recommendation for an Enhanced Fujita Scale* (TTU 2004) and clarified in 2006 (TTU 2006).¹ The 2006 revision to this document clarified the steps in assigning an EF scale rating to a tornado event. More detailed information can be found at the TTU Wind Science and Engineering Research Center Web site.²

The EF scale is an important factor considered by architects and engineers in their evaluation of damage following a tornado. Its use has made it easier to distinguish those areas that are outside of the center of the tornado circulation and which experience lesser wind speeds; these are areas where wind-resistant design practices may reduce damage. It was important for the Mitigation Assessment Team (MAT) to document the EF scale rating at each damaged building it visited, as the increased clarity provided by the EF scale allows the MAT to better evaluate and recommend wind-resistant design practices that may be applicable for certain wind speeds.

The EF scale is presented similarly to the original Fujita scale. The EF scale includes six categories, from 0 to 5, that represent increasing degrees of wind damage (see Figure E-1). The wind speed correlation estimates for each category were improved upon from the estimates used in the original Fujita scale. Table E-1 shows the relationship between the 3-second gust speeds of the original Fujita scale and the EF scale.

¹ Available online from TTU at <http://www.depts.ttu.edu/weweb/Pubs/fscale/EFScale.pdf>.

² TTU Wind Science and Engineering Research Center Web site, www.wind.ttu.edu.

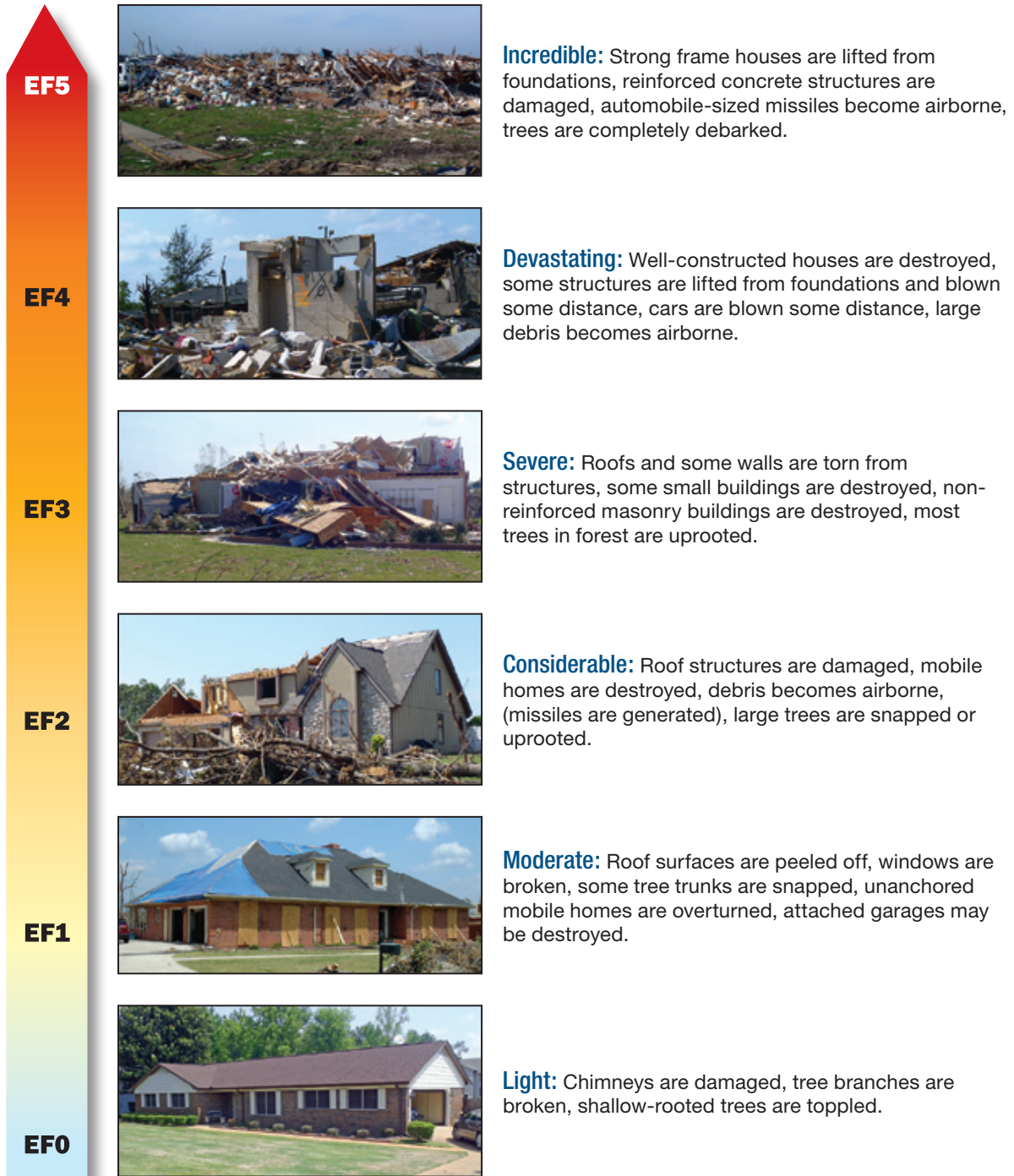


Figure E-1: The EF scale is based on level of typical observed damage

Table E-1: Wind Speeds Used in Fujita Scale Compared to EF Scale

Fujita Scale	Fujita Scale: 3-Second Gust (mph)	EF Scale	EF Scale: 3-Second Gust (mph)
F0	45–78	EF0	65–85
F1	79–117	EF1	86–110
F2	118–161	EF2	111–135
F3	162–209	EF3	136–165
F4	210–261	EF4	166–200
F5	262–317	EF5	Over 200

mph = miles per hour; EF = Enhanced Fujita

The EF scale uses 28 damage indicators (DIs) to categorize building use and type of construction (Table E-2). Each DI includes damage description categories; each is assigned a number termed the degree of damage (DOD), and each has a damage description associated with an expected estimated wind speed. Table E-3 shows an example of the DOD and damage descriptions for a single-family residence. The DOD includes the expected wind speed that would most likely produce the observed damage. Photographs are included in the supporting documentation for the EF scale in *A Recommendation for an Enhanced Fujita Scale* (TTU 2006) to assist investigators.

Table E-2: EF Scale Damage Indicators

DI No.	Damage Indicator (DI)	Use
1	Small Barns or Farm Outbuildings (SBO)	Residential
2	One- to Two-Family Residences (FR12)	
3	Manufactured Home – Single Wide (MHSW)	
4	Manufactured Home – Double Wide (MHDW)	
5	Apartments, Condos, Townhouses [three stories or less] (ACT)	
6	Motel (M)	Commercial and Retail Structures
7	Masonry Apartment or Motel Building (MAM)	
8	Small Retail Building [fast food restaurant] (SRB)	
9	Small Professional Building [e.g., doctor’s office, branch bank] (SPB)	
10	Strip Mall (SM)	
11	Large Shopping Mall (LSM)	
12	Large, Isolated Retail Building [e.g., K-Mart, Wal-Mart] (LIRB)	
13	Automobile Showroom (ASR)	
14	Automobile Service Building (ASB)	Schools
15	Elementary School [single story; interior or exterior hallways] (ES)	
16	Junior or Senior High School (JHSH)	Professional Buildings
17	Low-Rise Building [1–4 stories] (LRB)	
18	Mid-Rise Building [5–20 stories] (MRB)	
19	High-Rise Building [more than 20 stories] (HRB)	
20	Institutional Building [e.g., hospital, government, or university] (IB)	

Table E-2: EF Scale Damage Indicators (concluded)

DI No.	Damage Indicator (DI)	Use
21	Metal Building Systems (MBS)	Metal Buildings and Canopies
22	Service Station Canopy (SSC)	
23	Warehouse Building [tilt-up walls or heavy timber construction] (WHB)	
24	Transmission Line Towers (TLT)	Towers/Poles
25	Free-Standing Towers (FST)	
26	Free-Standing Light Poles, Luminary Poles, Flag Poles (FSP)	
27	Trees: Hardwood (TH)	Vegetation
28	Trees: Softwood (TS)	

EF = Enhanced Fujita, DI = damage indicator

SOURCE: RECOMMENDATION FOR AN ENHANCED FUJITA SCALE (TTU 2006)

Table E-3: Example – EF Scale DOD for DI No. 2 (Single-Family Residence)

DOD	Damage Description	Lower- and Upper-Bound Wind Speed Range (3-second gust in mph)	Expected Wind Speed (3-second gust in mph)
1	Threshold of visible damage	53–80	65
2	Loss of roof covering material (<20%), gutters, and/or awning; loss of vinyl or metal siding	63–97	79
3	Broken glass in doors and windows	79–114	96
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	81–116	97
5	Entire house shifts off foundation	103–141	121
6	Large sections of roof structure removed; most walls remain standing	104–142	122
7	Exterior walls collapsed	113–153	132
8	Most walls collapsed except small interior rooms	127–178	152
9	All walls collapsed	142–198	170
10	Destruction of engineered and/or well-constructed residence; slab swept clean	165–220	200

EF = Enhanced Fujita, DOD = degree of damage, DI = damage indicator

(a) The differences between “expected,” “upper bound,” and “lower bound” wind speeds are relatively complex. When assessing typical DIs, professionals familiar with wind effects on buildings and familiar with building sciences should be consulted.

SOURCE: RECOMMENDATION FOR AN ENHANCED FUJITA SCALE (TTU 2006)

After a tornado event, assessment teams rate the intensity of the tornado based on observed damage to individual buildings, structures, or other DIs (as shown in Table E-2) using damage descriptions for each DI (such as the example shown in Table E-3) to determine the appropriate DOD. Structures along the path of a tornado may be assigned several different EF ratings ranging from EF0 to EF5, based on their location within the center of the tornado circulation. Several DIs must be considered when assigning an EF scale rating for a tornado event; therefore, although the EF rating assigned

to individual structures may vary along the path of a tornado, the overall tornado intensity is assigned a single rating. For archival purposes, a tornado is officially labeled by the NWS according to its highest intensity along its path.

To assign an accurate EF scale ranking to a tornado event, several DIs must be rated.

The EF scale is still evolving and may be revised based on field observations made by post-tornado assessment teams. For instance, the MAT noted in its report that the EF scale currently does not include listings for all possible DIs, nor does it include photographic documentation of all DODs (refer to Section 10.7 and Section 11.7 of the MAT report). A focus of the MATs and other storm researchers is to provide additional data that can be incorporated in future updates and refinements to the EF scale and the EF methodology.

Using the EF methodology, the MAT evaluated buildings it visited. The EF ratings given by the MAT for sites visited in Alabama, Georgia, Mississippi, and Tennessee are shown in Table E-4 and for Joplin, MO, in Table E-5. Characteristics such as building age, code built to, siting, construction methods, etc. can affect the amount of damage caused by a tornado; these characteristics can therefore cause a deviation (either lower or higher) between the observed damage and resulting DOD rating and the expected wind speed assigned in the EF scale.

Table E-4: MAT EF Ratings for Sites Visited in Alabama, Georgia, Mississippi, and Tennessee

MAT EF Scale Ratings by Location: AL, GA, MS, TN						
Municipality	Location	Latitude	Longitude	Analysis		
				DI	DOD	EF Rating
Alabama						
Athens	McCulley Mill Road residence near shelter	34.76957	-86.8635	2	6	2
Birmingham	Apartment building	33.53808	-86.8907	5	4	2
Cullman	3rd Street NE historic residence	34.17959	-86.8325	2	7	2
	Three-story church/school	34.17846	-86.8339	20	7	2
Hackleburg	Ray Road residence adjacent to Hackleburg Community Shelters	34.28556	-87.8208	2	8	3
	Hackleburg Police Station	34.27583	-87.8272	9	8	2
	Hackleburg School Complex: Elementary, Junior High, and High School	34.28111	-87.8331	15	7	2
	Hackleburg Fire Department	34.27556	-87.8275	21	3	1
Harvest	Doris Avenue single-family home adjacent to manufactured home	34.82223	-86.7746	2	2	0
	Placid Drive residence #1	34.83972	-86.7347	2	4	1
	Placid Drive residence #2	34.84028	-86.7350	2	6	2
	Doris Avenue single-wide manufactured home	34.82216	-86.7741	3	7	1
	Lockhart Road double-wide manufactured home	34.81996	-86.7711	4	1	0

Table E-4: MAT EF Ratings for Sites Visited in Alabama, Georgia, Mississippi, and Tennessee (continued)

MAT EF Scale Ratings by Location: AL, GA, MS, TN						
Municipality	Location	Latitude	Longitude	Analysis		
				DI	DOD	EF Rating
Alabama (continued)						
Fultondale	Residential neighborhood	33.60716	-86.7947	2	6	1
	Fultondale Fire Station	33.60909	-86.7995	21	3	1
Phil Campbell	Stalcup Circle residences	34.34583	-87.7075	2	6	2
	Phil Campbell Middle and High School	34.34944	-87.7078	16	8	2
Pleasant Grove	Safe Room at 10th Street residence	33.48378	-86.9874	2	2	0
	6th Way residence	33.49162	-86.9818	2	8	4
	12th Street residence #1	33.48031	-86.9975	2	9	4
	12th Street residence #2	33.48035	-86.9988	2	9	4
	12th and 13th Streets residences	33.48030	-86.9975	2	10	4
Rainsville	Plainview Schools:					
	High school	34.48156	-85.8222	16	3	1
	Elementary school	34.48156	-85.8222	15	5	1
Tuscaloosa	5th Street residence	33.21083	-87.4831	2	2	0
	Two-family residences:					
	Building 40	33.18619	-87.5522	2	3	1
	Main structure on 10th Avenue	33.18482	-87.5523	2	8	3
	Crescent Lane residence on top of ridge	33.21556	-87.4886	2	9	4
	Hardened area "shelter" at 16th Street E residence	33.19662	-87.5317	2	9	4
	Manufactured housing park:					
	Unit B	33.20566	-87.4927	3	3	0
	Unit A	33.20566	-87.4927	3	7	1
	Apartment buildings at 5th Avenue E	33.19377	-87.5301	5	2	1
	LaRocca Nursing Home	33.21063	-87.4925	5	4	2
	Chastain Manor Apartments:					
	Townhouses (one-story)	33.21199	-87.4954	5	4	3
	Townhouses (two-story)	33.21193	-87.4945	5	6	4
	Apartment building behind Fire station 4	33.20632	-87.5097	5	5	3
	Tuscaloosa Police Station	33.20689	-87.5039	9	3	1
Retail stores "A" and "B"	33.19993	-87.5240	12	7	4	

Table E-4: MAT EF Ratings for Sites Visited in Alabama, Georgia, Mississippi, and Tennessee (concluded)

MAT EF Scale Ratings by Location: AL, GA, MS, TN						
Municipality	Location	Latitude	Longitude	Analysis		
				DI	DOD	EF Rating
Alabama (concluded)						
Tuscaloosa (concluded)	Armed Forces Reserve Center:					
	Building behind main building with service bays	33.18652	-87.5515	14	4	1
	Low-rise building	33.18676	-87.5514	17	4	1
	Alberta Elementary School	33.20796	-87.5025	15	10	4
	University Place Elementary School	33.19301	-87.5393	16	10	3
	Fitness center	33.20053	-87.5217	21	7	3
	Curry Building city complex EOC	33.17961	-87.5629	23	7	3
	Communications Tower at 35th Street	33.17793	-87.5637	25	3	2
Georgia						
Ringgold	Middle school	34.92238	-85.1127	16	6	1
	High school	34.92234	-85.1130	16	6	1
Mississippi						
Smithville	Brasfield Lane residence adjacent to below-ground shelter	34.06278	-88.4072	2	6	2
	Gum Street residence in front of old cellar/shelter	34.07111	-88.3917	2	6	2
	Below-ground shelter at Poplar Street residence	34.07083	-88.3958	2	9	4
	Community shelter at manufactured housing park at Commerce and Dunlap Streets	34.06972	-88.3997	3	9	3
	Police Station	34.06889	-88.3982	9	8	3
	Fire Station	34.06722	-88.3981	21	3	1
	Cell tower	34.06444	-88.4103	25	2	3
Tennessee						
Cleveland	Blue Springs Elementary School	35.08809	-84.9094	15	6	1

Table E-5: MAT EF Scale Ratings for Sites Visited in Joplin, MO

MAT EF Scale Ratings by Location: Joplin, MO					
Location	Latitude	Longitude	Composite		
			DI	DOD	EF Rating
Safe Room at Alabama Avenue residence	37.06656	-94.4861	2	4	1
Safe Room at Adele Avenue residence	37.0614	-94.5391	2	9	3
Mercy Village Apartments	37.06009	-94.5263	5	3	2
Greenbriar Nursing Home	37.06294	-94.5209	9	9	3
Walmart	37.0729	-94.4716	12	6	4
Home Depot	37.06958	-94.4744	12	7	4
East Joplin Middle School	37.06764	-94.4489	16	7	2
Joplin High School	37.06757	-94.5054	16	11	3
Ozark Center for Autism - Jackson Ave	37.06397	-94.5218	17	5	3
St. John's Medical Center	37.05933	-94.5322	20	10	3
St. Paul's United Methodist Church	37.06271	-94.5441	21	3	1