Appendix K

Guidance for Selection of Impact Resistant Constructed Wall and Roof Assemblies

K.0 Structural Missile Impact Criteria

The public shelter design criteria, which are also known as the EHPA criteria, require that exterior walls and roofs prevent perforation or penetration by windborne debris. Laboratory testing is the primary means of determining if a specific assembly (i.e., exterior and interior surface cladding, structural components and configurations, material properties, connections, etc.) is capable of satisfying the applicable performance criteria. Certain types of commonly used non-proprietary materials and constructed assemblies have been demonstrated through laboratory testing to satisfy the required debris impact performance criteria. Constructed assemblies that are approved for use without further testing by the authority having jurisdiction are commonly referred to as "deemed to comply." The deemed to comply method is recognized in section 1626.4, *Florida Building Code—Building*. Appendix K provides information for constructed wall and roof assemblies that have been tested and satisfy applicable large missile impact criteria.

K.1 Methodology

To begin the assembly selection process, determine the design wind speed of the EHPA. Higher design wind speeds impart higher velocities to entrained debris. Higher wind velocities can also lift and accelerate larger and heavier debris objects, as well as extend the distance downwind that an object can travel. As a planning guide, unanchored, inadequately anchored or poorly constructed large debris can be generated from sources within a distance of about 300 feet of proposed or constructed EHPA(s). Smaller debris down to the size of gravel can be generated from sources out to a range of possibly 1,500 feet. Research considered by the ICC storm shelter standard committee indicates that objects lifted by wind forces undergo rapid acceleration and achieve velocities of between 40 and 80 percent of the entraining wind field's velocity. For vertical surfaces ICC 500 uses 50 percent of the design wind speed. The percentage of wind speed is reduced to only 10 percent for horizontal surfaces.

The industry-recognized straight wind (which include hurricane) large missile that is used for impact testing is a nine pound sawn lumber 2x4 (9 lb 2x4). The 9 lb 2x4 large missile is also the missile required to satisfy ICC 500.

Debris impact testing of wall and roof assemblies has generally been conducted using a limited number of specified conditions (e.g., 9 and 15 lb 2x4s propelled at 34, 50 or 55, 75 and 100 miles per hour). Many of the more robust materials and assemblies, such as reinforced concrete and solid-grouted masonry, have satisfied test requirements that are significantly more demanding than typical ASTM E-1996 or SSTD 12 tested assemblies. To make use of existing impact test results a conversion method is helpful.

Current research indicates that an object's impact momentum, and not energy, provides the best correlation of test performance of a specified assembly when comparing missiles of different weights and velocities. Calculating the momentum associated with a published sample's impact test conditions permits the data to be converted to the industry standard straight wind 9 lb 2x4 missile. Impact momentum is calculated as follows: missile mass [weight (lb) / acceleration of gravity (32.2 ft/sec^2)] x missile velocity (ft/sec) = momentum (lb-sec); or:

$$\text{Momentum} = (W/g) \times v$$

In addition to momentum values, Tables K-1 and K-2 provide corresponding impact energy values to assist with conversion when momentum is not calculated but impact energy of a test is shown.

The following reference data sources are useful in selection of exterior envelope assemblies:

1. Florida Department of Education's list of approved roof decks can be found at the following web address (Memorandum, July 2016, *Roof Decks on Public Hurricane Shelters*): http://www.fldoe.org/core/fileparse.php/7735/urlt/0075365-roofdecksmemo.pdf
2. *Large Wind Missile Impact Performance of Public and Commercial Building Assemblies*, Florida Agricultural and Mechanical University-Florida State University (FAMU-FSU) in cooperation with the University of Florida (UF), 2004
3. *Summary Report on Debris Impact Testing at Texas Tech University*, Texas Tech University (TTU), 2003
4. *A Summary Report on Debris Impact Resistance of Building Assemblies*, NIST/TTU Cooperative Agreement, Windstorm Mitigation Initiative, 2006
5. *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (FEMA P-361), Federal Emergency Management Agency, 2015

Tables K-1 and K-2 provide large missile impact test property information for exterior envelope vertical and horizontal surfaces. Exterior envelope surfaces that are inclined less than 30 degrees from horizontal are considered horizontal surfaces. The level of protection columns refer to type of performance expectation: ASTM Levels D (9 lb 2x4 @ 34 mph) and E (9 lb 2x4 @ 55 mph) are both of lower performance than ICC 500, and ICC 500 protection which begins with ICC 500 design wind speed of 160 mph and increases accordingly.

Table K-1. Windborne Debris Impact Criteria Comparisons for Vertical Surfaces

Level of Protection, Vertical Surface	Hurricane Design Wind Speed, mph (3-sec gust)	Missile Weight, lbs	Missile Velocity, mph	Missile Velocity, ft/sec	Energy, ft-lb	Momentum, lb-sec
Enhanced-D[2]	68[1]	9	34	50	349	14
Enhanced-E[2]	110	9	55	80	910	22
ICC 500	160	9	80	117	1,925	32.8
ICC 500	165	9	83	121	2,047	33.8
ICC 500	170	9	85	125	2,173	34.9
ICC 500	175	9	88	128	2,303	35.9
ICC 500	180	9	90	132	2,436	36.9
ICC 500	185	9	93	136	2,573	37.9
ICC 500	190	9	95	139	2,714	39.0
ICC 500	195	9	98	143	2,859	40.0
ICC 500	200	9	100	147	3,008	41.0
ICC 500	205	9	103	150	3,160	42.0
ICC 500	210	9	105	154	3,316	43.1
ICC 500	215	9	108	158	3,476	44.1
ICC 500	220	9	110	161	3,639	45.1
ICC 500	225	9	113	165	3,806	46.1

[1] – Denotes tropical storm intensity wind speed.

[2] – ASTM E1996 Enhanced Impact.

Table K-2. Windborne Debris Impact Criteria Comparisons for Horizontal Surfaces

Level of Protection, Horizontal Surface	Hurricane Design Wind Speed, mph (3-sec gust)	Missile Weight, lbs	Missile Velocity, mph	Missile Velocity, ft/sec	Energy, ft-lb	Momentum, lb-sec
Enhanced-D[2]	68[1]	9	34	50	349	14
Enhanced-E[2]	110	9	55	80	910	22
ICC 500	160	9	16	23.5	77	6.6
ICC 500	165	9	17	24.2	82	6.8
ICC 500	170	9	17	24.9	87	7.0
ICC 500	175	9	18	25.7	92	7.2
ICC 500	180	9	18	26.4	97	7.4
ICC 500	185	9	19	27.1	103	7.6
ICC 500	190	9	19	27.9	109	7.8
ICC 500	195	9	20	28.6	114	8.0
ICC 500	200	9	20	29.3	120	8.2
ICC 500	205	9	21	30.1	126	8.4
ICC 500	210	9	21	30.8	133	8.6
ICC 500	215	9	22	31.5	139	8.8
ICC 500	220	9	22	32.3	146	9.0
ICC 500	225	9	23	33.0	152	9.2

[1] – Denotes tropical storm intensity wind speed.

[2] – ASTM E1996 Enhanced Impact.