CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Various commonly used wall and roof assemblies in the State of Florida for light commercial buildings, educational facilities, public facilities, EOCs and other similar construction, were examined in this study for the large missile impact testing. Three different missile test criteria were used: (a) the basic FBC specified 2 by 4 in. 9 lb missile at 34 mph; (b) the enhanced-A DOE specified 2 by 4 in. 15 lb missile at 50 mph; and (c) the Enhanced-B test with 2 by 4 in. 15 lb missile at 60 mph. The following conclusions can be made based on the large missile impact test results from this study:

Wood Stud Wall Assemblies

1. A total of nine wood stud wall assemblies were tested in this study. Most of the commonly used Florida wood framed wall assemblies were not strong enough to withstand the FBC recommended basic impact. Wood stud exterior wall assemblies with stucco on 1/2 in. plywood, stucco on 7/16 in. OSB, stucco on 5/8 in. gypsum board, stucco on 1/2 in. dinsglass, 5/16 in. Hardiboard on 1/2 in. plywood, 5/16 in. Hardiboard on 7/16 in. OSB, and 3/4 in. Advantech failed the basic test with complete penetration of the missile. These assemblies are, therefore, not compliant with basic FBC missile impact criteria.

2. Wood stud wall assemblies with brick veneer on 1/2 in. plywood and brick veneer on 7/16 in. OSB passed the enhanced-A missile impact test, but failed the enhanced-B test. These

assemblies comply with the FBC recommended basic and enhanced-A DOE missile impact criteria.

3. Similar missile impact behaviors were demonstrated by 1/2 in. plywood and 7/16 in. OSB wall assemblies.

Metal Stud Wall Assemblies

4. Of the three metal stud wall assemblies tested in this study, two assemblies with 5/16 in. Hardiboard on 1/2 in. plywood, and 5/16 in. Hardiboard on 7/16 in. OSB failed the basic test and, therefore, do not satisfy the FBC basic missile impact criteria.

5. Wall assemblies with 26 ga. 5V Galvalume on 1/2 in. plywood conform only to the FBC basic missile impact criteria, and do not satisfy any higher standards.

6. Wood stud and metal stud wall framing systems with identical claddings showed similar missile impact behavior. So, it may be concluded that the framing system has little effect on wall missile impact capacity.

Concrete Wall Panels

7. Concrete wall panels, in general, performed better than wood or metal stud wall assemblies in resisting large missile impact.

8. The CMU wall with 8 in. thickness only conformed to the FBC basic large missile impact criteria.

9. AAC wall with 8x8x24 in. blocks passed the basic large missile impact, but failed both the enhanced-A and enhanced-B impacts.

10. The 6 in. ICF and 5 in. tilt-up walls passed both the enhanced-A and enhanced-B impact tests, and are, therefore, conforming to all three test criteria.

Roof Metal Framing Systems

10. Five roof metal framing systems were tested herein. The framing systems with 26 ga. Galvalume on 1/2 in. plywood and 26 ga. Standing Seam on 1/2 in. plywood were found to comply with the FBC basic test criteria only.

11. Metal deck with 5V Galvalume on 1-1/2 in. structural deck passed the basic and enhanced-A test criteria, but failed the enhanced-B test. This assembly is suitable only for the basic and enhanced-A missile impacts.

12. Asphalt shingle roofing on 7/16 in. OSB failed in the basic test, and does not conform to any missile impact criteria.

13. The 3 in. metal deck system passed the basic and enhanced-A test without the penetration of the missile, but failed the enhanced-A 2 test. This system is, therefore appropriate for the basic and enhanced-A test criteria.

Concrete Roof Panels

14. The 6 in. and 8 in. hollow core slabs were tested in this research. The 6 in. slab passed the enhanced-A test, but was not tested for the enhanced-B test, as it was damaged by the enhanced-A impact and was not fit for further enhanced-B impact. The 8 in. slab passed both the enhanced-A and enhanced-B impact without any damage. The 6 in. hollow core slab, therefore, conforms to only the basic and enhanced-A test criteria, and the 8 in. hollow core slab is acceptable according to the basic, enhanced-A and enhanced-B test criteria.

5.2. Recommendations

The following recommendations may be made based on the findings of this study:

1. Tables D.1 through D.5 present the recommended wall and roof assemblies that may or may not be used in hurricane protected structures. These tables also provide the construction details for these assemblies.

2. This study also recommends the large wind missile performance improvement of assemblies listed in Tables 5.1 and 5.2. Several possible improvements are suggested in these tables; case specific improvements may be chosen by design professionals.

3. It is recommended that wall assemblies with stucco on 1/2 in. plywood, stucco on 7/16 in. OSB, stucco on 5/8 in. gypsum board stucco on 1/2 in. dinsglass, 5/16 in. Hardiboard on 1/2 in. plywood, 5/16 in. Hardiboard on 7/16 in. OSB, and 3/4 in. Advantech not be used for basic FBC protection or enhanced-A protection. Roof assemblies with asphalt shingles on 7/16 in. OSB should also be excluded from consideration. All these assemblies failed the basic FBC specified large wind missile impact test.

4. Further full-scale large missile impact testing is needed to validate the performance of retrofitted assemblies, as presented in Tables 5.1 and 5.2.

5. The FBC large missile failure criterion is based only on missile penetration. This study shows that an assembly can be heavily damaged without complete missile penetration. A concrete panel may crack heavily or a metal siding may be partially separated from its frame. From the occupant safety point of view, modifications to the FBC failure criteria should be suggested.

Table 5.1: Recommended Improvements of Performance for Wall Assemblies

Item No. (Tables D.1-D.3)	Assembly	Assembly Description	Recommended Actions for Performance Improvement
1, 10	Plywood	Stucco on 1 layer of 1/2 in. plywood	• Provide thicker plywood siding, such as 19/32 or 3/4 in. • Provide more layers of plywood siding • Add steel sheathing, although not a common practice in Florida.
2, 11	OSB	Stucco on 7/16 in. OSB	• Provide thicker OSB siding, such as 19/32 or 3/4 in. • Provide more layers of OSB siding. • Add steel sheathing, although not a common practice in Florida.
3, 12	Gypsum Board	Stucco on 5/8 in. Gypsum Board	• Provide thicker Gypsum Board, such as 1 in. • Provide more layers of Gypsum Board siding. • Add steel sheathing, although not a common practice in Florida.
4, 13	Dinsglass	Stucco on 1/2 in. Dinsglass	• Provide thicker Dinsglass siding, such as 5/8 in. • Provide more layers of OSB siding. • Add steel sheathing, although not a common practice in Florida.
5, 14	Hardiboard on plywood	5/16 in. Hardiboard horizontal siding on 1/2 in. plywood	• Provide thicker plywood siding, such as 19/32, 5/8 or 3/4 in. A 5/8 in. plywood performs better, as shown in Table D.1 (Item 5) and D.2 (Item 14). • Provide more layers of Hardiboard and/or plywood sidings. • Add steel sheathing, although not a common practice in Florida.
6, 15	Hardiboard on OSB	5/16 in. Hardiboard horizontal siding on 7/16 in. OSB	• Provide thicker OSB siding, such as 1/2, 19/32, 5/8 or 3/4 in. • Provide more layers of Hardiboard and/or plywood siding. • Add steel sheathing, although not a common practice in Florida.
7, 16	Advantech	3/4 or 5/8 in. Advantech	• Provide thicker Advantech siding, such as 1 in. • Provide more layers of Advantech siding. • Add steel sheathing, although not a common practice in Florida.
8, 17	Brick veneer on plywood	Brick veneer on 1/2 in. plywood	• Provide thicker plywood siding, such as 19/32 or 3/4 in. • Provide more layers of plywood siding.
9, 18	Brick veneer on OSB	Brick veneer on 7/16 in. OSB	• Provide thicker OSB siding, such as 1/2, 19/32 or 3/4 in. • Provide more layers of OSB siding.
19	Galvalume on plywood	26 ga. 5V Galvalume on 1/2 in. plywood	• Provide thicker (such as 24 or 22 ga.) or more layers of 5V Galvalume. • Provide thicker (such as 19/32 or 3/4 in.) or more layers of plywood
21	CMU	8 in. CMU wall	• Provide grouted cells • Provide vertical reinforcement, such as #5 bar @ 16 in. o.c.

Table 5.1: Recommended Improvements of Performance for Wall Assemblies (contd.)

Item No. (Tables D.1-D.3)	Assembly	Assembly Description	Recommended Actions for Performance Improvement
22	AAC Blocks	Wall with 8x8x24 in. AAC blocks	• Add reinforcement • Use larger blocks
23	ICF	6 in. ICF wall	• No improvement required
24	Tilt-up Wall	5 in. tilt-up wall	• No improvement required

Table 5.1: Recommended Improvements of Performance for Wall Assemblies (contd.)

Table 5.2: Recommended Improvements of Performance for Roof Assemblies

Item No. (Tables D.4-D.5)	Assembly	Assembly Description	Recommended Actions for Performance Improvement
25	5V Galvalume on plywood	24 or 26 ga. 5V Galvalume on 1/2 in. plywood	• Provide thicker (such as 22 ga.) or more layers of 5V Galvalume. • Provide thicker (such as 19/32 or 3/4 in.) or more layers of plywood
26	Standing Seam on plywood	24 or 26 ga. Standing Seam on 1/2 in. plywood	• Provide thicker (such as 22 ga.) or more layers of Standing Seam. • Provide thicker (such as 19/32 or 3/4 in.) or more layers of plywood • Provide larger screws at closer spacing.
27	Structural deck with roofing	1-1/2 in. structural deck (20 to 22 ga.) with 26 ga. 5V Galvalume roofing	• No improvement required
28	Metal Deck	3 in. metal deck (22 ga.)	• Provide larger lap screws at closer spacing.
29	OSB	Wood, tiles or asphalt shingles on 7/16 in. OSB	• Provide thicker OSB siding (such as 1/2, 19/32 or 3/4 in.) • Provide more layers of OSB siding. • Add steel sheathing, although not a common practice in Florida.
30	Hollow Core Slab	6 in. hollow core slab	• Provide 8 in. slab
		8 in. hollow core slab	• No improvement required

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