

CHAPTER 1

INTRODUCTION

1.1. General

Tropical storms, hurricanes and tornadoes are natural disaster-causing phenomenon, which have a high probability rate of impact in the State of Florida. This is due to the tropical weather in most of Florida, and also due to the fact that the State has an extensive shoreline measuring over 8,426 miles. The State is affected by at least a few of these storms each year on a regular basis. Florida has experienced a massive influx in its population for the past few decades. This population increase has resulted in a proliferation of various types of construction, including single-family residential buildings, condominiums, hotels and motels. This has increased the potential of storm-induced damage on Florida construction and personal injury or death of the occupants.

Experience with hurricanes in the U.S. and with tropical storms around the world has established the importance of windborne debris to the performance of buildings in windstorms. Compromising of the building envelope by windborne debris during a hurricane leads to major economic loss through damage to building content, possible failure of structural systems, and present a hazard to building occupants. Hence, it is important that the building design process address these important hurricane effects, which affect building performance.

The importance of windborne debris protection to building performance in hurricanes became quite evident to experts involved in the building industry following the devastating

effects of Hurricane Andrew in 1992. This hurricane created an enormous amount of windborne debris, which caused substantial damage to building envelopes. The impact of Hurricane Andrew, the costliest hurricane in the U.S. (NHC 2002) prompted reviews by several local, state and federal agencies. Since then, engineers and building officials have had to address issues concerning building design to account for enhanced turbulent wind pressures and debris carried by these winds. New requirements for design have been developed to ensure the integrity of the building envelope during a hurricane. One such requirement is the missile impact test, where the impact of windborne debris in a hurricane is simulated by launching a wooden 2x4 at glazed openings, exterior walls and the roof of a building. To comply with the test, the building's exterior must withstand the impact of a wooden 2x4 striking head-on traveling at a designated velocity.

Extensive research work has been performed at the Texas Tech University (TTU) Wind Engineering Research Center (WERC) and other places on the effect of windborne debris impact on the building envelope and its components (McDonald 1985, 1988, 1990, 1999, Cook *et al* 1998, 1999, 2000). Based on this research, several national and regional building codes have adopted the TTU missile impact testing procedure (with modifications as deemed necessary) for establishing minimum debris resistance acceptance criteria of the external envelope for buildings (ASCE-7 2002, SBC 2000, FBC 2001).

The recently adopted Florida Building Code (FBC) specifies that all parts of systems of a building envelope must meet the impact test criteria or be protected with a device satisfying the test criteria. According to the FBC and the International Building Code (IBC 2003), the Large Missile Impact Test is valid for assemblies and materials used up to 30 ft. in height. ASCE 7-02 specifies a maximum applicable height of 60 ft. for this test. In this test, entire assembled units

are subjected to a 2 by 4 in. lumber weighing 9 lb impacting at a speed of 50 ft/sec (equivalent to 34 mph), representing hurricane conditions in Florida. The TTU missile impact test procedure is designed to represent tornado wind speeds up to 250 mph. The TTU large missile test involves shooting 2 by 4 in. lumber weighing 15 lb at 100 mph horizontally. Therefore, using such listed approved systems may result in over-designed exteriors for hurricane wind type missile impacts covered in the FBC.

The Division of Emergency Management (DEM) at the Florida Department of Community Affairs (DCA) is in the process of developing a comprehensive standard (NHC 2002) for NHC Category 5 hurricane resistant Emergency Operations Centers (EOC). Among various features, the survivable EOCs must be “...*Designed and built to survive the range of anticipated hazards and to function effectively...*” In the absence of such a standard, the Enhanced Hurricane Protection Areas (EHPA) guidelines from the FBC are being used for EOCs. The EOC buildings also must satisfy wind load provisions from the ASCE 7-98 specifications, and most importantly, windborne debris impact criteria from the Standard Building Code (SBC 2000), ASTM standard E-1996 (2004), ASTM standard E-1886 (2004), or TAS 201 (2001). The expected DCA EOC standard will be very useful in providing a comprehensive single source guideline. The EHPA guidelines state that wind and debris exposure can be supplied through the FBC criteria, provided an enhanced wind speed of 40 mph above the code specified basic design wind speed is used. A draft EOC Survivability Performance Category table from DCA lists Performance Category 3 (from 0 – 4 scale) as “Hurricane Enhanced Protection”, with missile impact resistance of a 2 by 4 in. 15 lb stud traveling at 50 mph. This enhanced criterion is more stringent than the FBC large missile impact test criteria. With the enhanced hurricane design wind speeds specified in the draft table, it may

be sufficient to achieve the Performance Category 3 missile impact resistance for survivable EOCs. There is at least one EOC in each Florida County. It is clear from the above discussion that the FBC large missile impact standards based on a 2 by 4 in. stud at 34 mph speed may not be sufficient for EOCs, schools and/or certain commercial buildings. Some other building standards for hazard design have incorporated more stringent missile impact criteria. For example, the U.S. Department of Energy (DOE) standard 1020 *Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities* lists Performance Categories 1 – 4 (DOE 2002). For Categories 3 - 4 for essential facilities, Table 3-1 in this standard provides missile impact criteria as a 2 by 4 in. 15 lb plank traveling at 50 mph. The international Code Council (ICC 2004) Storm Shelter Standard Committee proposed a draft large windborne debris impact criteria for hurricanes with design wind speeds between 160 and 200 mph (3-sec gust).

The University of Florida (UF) performed a number of large missile impact tests on various wall and roof assemblies (Braden 2004, Cook *et al* 1998, 1999, 2000, Ellifritt and Johnson 1998, Staley 1999, Anderson 1995), based on the FBC large missile impact standards. TTU and UF performed numerous missile impact tests on wall and roof assemblies, but TTU primarily focused on tornadic missile criteria, whereas UF focused on the FBC criteria. The enhanced missile impact criteria were not utilized by TTU. Although UF performed a few tests with the enhanced criteria, these tests did not include all the wall and roof assemblies commonly used in Florida. It was, therefore, necessary to investigate the performance of commonly used Florida wall and roof assemblies that were not tested previously.

1.2. Objectives

The objectives of the project were:

1. To prepare a comprehensive list of wall and roof assemblies that have passed previous large missile impact testing.
2. To select typical roof and exterior wall assemblies for Florida light commercial buildings, educational facilities, public facilities, EOCs and other similar construction.
3. To select assemblies that have not been tested for large missile impact.
4. To perform large missile impact testing on selected roof and exterior wall assemblies that have not been tested previously.