Structural Testing

issues and advances related to structural testing

An overall view of the IBHS Research Facility. Courtesy of IBHS.

Putting Mother Nature in a Box

By John Lyons, P.E., S.E., and Jason Meadows, P.E.

In August of 1992, Hurricane Andrew made landfall in southern Florida. Andrew came on shore with torrential rain accompanied by 145 mph sustained winds with 170 mph gusts, which was measured before the equipment was rendered inoperable by the ever increasing winds. Andrew was the third costliest tropical system to impact the United States, with damages estimated near $26 billion and 23 storm-related deaths.

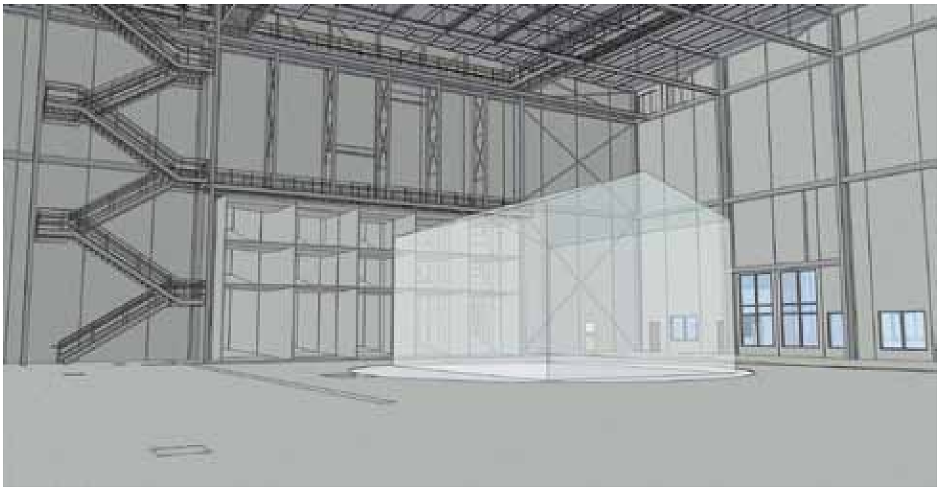
What if we had a way to reduce the cost or prevent loss of life from catastrophic events? What if we could put Mother Nature in a box to more accurately study the effects of wind and wind-driven rain? That is exactly what the Institute for Business and Home Safety (IBHS) has done in Richburg, South Carolina.

The IBHS Research Facility – the only one of its kind – will significantly advance building science by enabling researchers to more fully and accurately evaluate various residential and commercial construction materials and systems. It is designed to attack full-scale test structures with the winds and rains of hurricanes, the pounding hail of severe thunderstorms, or wind-driven fire embers.

Privately funded by a consortium of insurance companies, this $40 million facility will produce new building standards for construction practices, and test current and future materials against the worst Mother Nature has to offer. Real-world application of IBHS research findings will lead to more sustainable, durable communities and will provide a foundation for development of solid public policy, such as improved building codes.

The Research Facility as a Whole

The IBHS Research Facility is a complex of 6 buildings. At nearly 42,000 square feet, the main structure includes an observation area, a test chamber, and a fan array that pumps air through a flow contraction area before it enters the test chamber. There is an 11,000-square-foot office and conference building which has offices for the staff and classrooms for presentations. The remainder of the campus consists of four pre-engineered metal buildings used to facilitate mechanical and electrical equipment, test-specimen



Sketch-up view of a test specimen in the test chamber. Courtesy of Odell Associates, by Tommy Dew, Jr.

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construction, and weathering of the test specimens where the shingles may be heated to approximate the condition of weathered roofing. The specimen (i.e., a two-story house) is moved throughout the facility on a custom designed motorized house moving system.

There are four key engineered components of the IBHS Research Facility that are used to facilitate these studies: the fan array and flow contraction area, test chamber, turntable, and fire protection systems.

An overall view of the IBHS Test chamber and office building. Courtesy WALTER P MOORE.

Fan Array and Flow Contraction Area

The fan array and flow contraction area provides support for the 105 electric fans on one end and funnels the air through 15 tubes towards a smaller area on the other end, which increases the velocity of the moving air and promotes uniformity of the flow exiting each tube. The structures supporting the fan array and the contraction area are structurally independent from the main building and are constructed of precast concrete. Precast offered a durable substrate on which the fans could be mounted. Its mass also mitigates vibration introduced into the structure from the operation of the fans. Typical slabs and walls are made of 8-inch-thick precast panels. Stability along the axis of the chamber is provided by load-bearing walls, and stability transverse to the axis is provided by external 1-foot-thick precast buttress walls. The walls and slabs of the reduction chamber were given a smooth finish to reduce the turbulence in the air flow.

Careful attention was given to the accommodation of the 16-blade, 5½-foot diameter fans. These fans, in conjunction with the reduction chamber, are capable of producing winds equivalent to Category 3 hurricane strength over land. The superstructure of the fan array is designed to support large 8,000-pound thrust from each fan, as well as the overall maximum thrust of 400 kips from the entire fan array. The fans also weigh upwards of 9,000 pounds each, which require the fan array to be supported on a large mat foundation.

In front of the fans is a 400-foot diameter 'clear zone' that is kept free from debris and obstructions. Air entering the fans comes from this zone. Wire mesh screens across the fan intake prevents foreign objects from being drawn into the fan. A 20-foot-high earthen berm planted with pine trees is just outside this clear zone and serves to absorb sound waves from the fan array which might otherwise be objectionable to surrounding residents.

Test Chamber

The 21,000-square-foot chamber houses the test specimen and must withstand an internal wind pressure of 30 psf due to the force of wind moving through the chamber. A 60-foot clear height is maintained throughout the chamber. The walls and steel framing members are designed to withstand impact loads which could be caused by airborne debris separating from the test specimen. The outlet wall consists of 6-inch-thick reinforced concrete precast panels that are capable of resisting the impact of a 15-pound 2x4 traveling at 100 mph. The roof structure consists of 10-foot-deep structural steel wide flange roof trusses supporting wide flange purlins and metal deck. The roof framing and trusses are designed and braced to perform in uplift conditions when the chamber is pressurized during a test. The roof deck is fastened with self tapping screws, which provide superior resistance to uplift. All steel members within the test chamber are galvanized to guard against corrosion, as the chamber will often be subjected to rain-tests. Due to the galvanization process, all members have field-bolted connections. The side walls of the test chamber are also precast concrete due to the required impact resistance.

The aluminum deluge truss rig being assembled on the test chamber floor just above the turntable. Courtesy WALTER P MOORE.

Turntable

A 55-foot-diameter custom-built turntable is used to allow the building specimen to be rotated at different angles relative to the air stream. The turntable has a 6-inch-thick concrete slab surface which is used to secure the specimen during testing, and is designed for gravity loads, as well as for shear and overturning loads due to the force of the wind acting on the specimen. Three building designs were assumed in the analysis so that the loads could be enveloped for the turntable design: a two-story framed house, a small brick veneer commercial building, and a typical prefabricated metal building.

Fire Protection

In addition to a dry pipe sprinkler system at the roof of the test chamber, a deluge sprinkler system guards against a possible fire in one of the test specimens installed on the turntable. The system needed to be positioned within 15 feet of the test specimen roof, but must be raised during a test so it does not interfere with the air flow. Lighting Production Equipment and Walter P Moore designed a 20-inch by 20-inch, 55-foot by 63-foot aluminum rigging grid which supports the sprinkler system piping, and a system of 4,000 pound hoist motors is used to raise and lower the rigging grid. A system of elbow joints and swivel bearings allows the rigid 8-inch-diameter supply piping to remain attached in any position. In addition, four remotely controlled water cannons are strategically placed around the chamber. The fire protection system is fed by a 750,000-gallon water tank which was constructed on the facility (650,000 gallons is allocated for fire suppression through the deluge and sprinkler systems, while the remaining 100,000 gallons is used for rain production, the water cannons and a water curtain at the outlet that is used to quench embers blowing out of the test chamber).

Moving Forward

Although the design and construction of this $40 million research facility presented many engineering challenges, the engineers and architects were more excited about the larger purpose of the facility. In the same manner in which automobile crash tests improved the safety of vehicles, this research facility promises to give building designers an unparalleled opportunity to learn and to improve the safety and performance of our built environment.

The IBHS Research Facility will, without a doubt, lead to more sustainable and durable structures for future generations. It will provide the research needed to improve future building codes. The researchers at the IBHS Research Facility will begin their experiments in early 2011.▪

Project Team

Owner:	Institute for Business and Home Safety, Tampa, FL
Structural Engineer:	Walter P Moore, Atlanta, GA
Design Architect:	Odell Associates Inc., Charlotte, NC
MEP Engineer:	United Engineering Group, Charlotte, NC
Civil Engineer:	BP Barber, Charlotte, NC
Precast Supplier:	Metromont, Greenville, SC
Contractor:	Holder Construction Company, Atlanta, GA
Macton:	Oxford, CT
Lighting Production Equipment:	Atlanta, GA