Airborne Debris Test

CLEMSON
UNIVERSITY

Dear Mr. Record:

Windborne missile impact tests were performed on your LEEP STRUCTURAL CORE (LEEP CORE) PANEL SYSTEMS on the 10th of January of this year at the Wind Load Test Facility located at Clemson University, Clemson, South Carolina. The windborne missile impact tests were performed with the use of the facility's air cannon and a Decatur Electronics, Inc. Genesis-I radar gun. The purpose of the testing was to determine whether the LEEP CORE panel systems meet the Large Missile Impact tests as specified in the South Florida Building Code, ASTM E 1996, and the SBCCI standard, SS TD 12.

Background:

The large missile specified in all these standards is a 9 pound 2x4 piece of lumber. The missile is projected at the test object using an air canon and strikes the test object end on, perpendicular to the surface. For all buildings, other than essential facilities (hospitals and hurricane shelters), the missile impact speed specified for regions with the highest design wind speeds in the US is 50 feet per second (34 mph) in all three standards. ASTM E 1996 specifies a missile impact speed of 80 feet per second (55 mph) for essential facilities located in regions with the highest design wind speeds in the US. The test protocol requires that specimen resist impacts in the middle of the panel and in a corner of the panel. In order for a product to pass the test, the South Florida Building Code's impact standard allows no penetration of the protective system while the SBCCI and ASTM standards do allow penetration provided the hole is small enough to prevent a 3 inch sphere from passing through the hole.

The test standards also include testing of the panel system for 9000 cycles of pressure fluctuations, of various magnitudes up to the design pressure, after the panel has been subjected to the missile impacts. The tests performed at Clemson University only covered the missile impact portion of the test procedure and were intended to provide preliminary performance information.

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The panels consist of a polyurethane foam core that is chemically bonded during production to two light gage (0.019-inch thick) steel face sheets. The panels were 4 inches thick, 24 inches wide and 10 feet long. Three panels were shipped to Clemson University for testing. The three panels were connected together along their long edges using a built in tongue and groove system. The connection was made at the factory using polyurethane adhesive bonding between the edges of the tongue and groove system. The complete assembly allowed testing of impacts in the middle of the panels, near free edges and along the tongue and groove joint. The center of each panel contains a vertical channel shaped indentation (4 inches wide and 2.5 inches deep) that can accommodate building services. This indentation runs the entire length of the panel, creating the thinnest portion of the panel. Consequently, impacts near the center of the panel targeted both the middle of this channel, the edges of the channel, and regions where the panel had the full 4-inch thickness.

Before testing began, several Southern Yellow Pine (SYP) 2x4 boards were weighed and cut to produce missiles with weights of 9 lbs. (+/- 0.1 lbs.). The Genesis-I radar gun was calibrated with two tuning forks provided by Decatur Electronics, Inc. The panel system was mounted in front of a 12 foot wide by 12 foot tall steel chamber so that any missile penetrating the specimen would not pose a threat to people or equipment in the area. In order to provide a rigid support the panels, they were braced at the bottom and at a height of about 8 feet. Rigid supports insure that the impact loading of the missile is properly transferred to the panel system.

Panel Tests:

Initial tests were conducted with multiple impacts of the 9-pound 2x4 at a target speed of 34 mph. Two impacts were at 33 mph, several were at 35 mph, but most were at 34 mph. These impacts produced permanent indentations in or perforations of the exterior metal sheeting in all cases. The 34 to 35 mph impact speed for the 9-pound 2x4 wood missile turned out to be close to the threshold velocity for perforation of the exterior metal sheeting. Perforations occurred in three cases out of about 10 impacts. Figure 1 shows a typical exterior surface perforation with a missile speed of 35 mph. However, there was little or no deformation that could be observed on the interior surface of the panels for impacts in this speed range. The largest observable deformations of the interior surface occurred when the missiles struck on or near the vertical channel indentation. Figure 2 illustrates the type of interior surface deformation observed from an impact on or near the vertical channel. This deformation was limited to a slight local buckling of the thin metal interior sheet in the vicinity of the impact.

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During the course of the impact testing using the 9-pound 2x4 missile with impact speeds of 34 mph, each of the three panels was impacted with corner and center shots. In no instance did the missile come close to perforating the interior surface of any of the panels. Figure 3 shows the multiple impacts on the middle portion of the three panels. After the 34 mph missile impact tests had been completed, the missile speeds were increased in an effort to determine the threshold velocity for missile penetration of the entire panel. Total perforation occurred for missile speeds around 85 mph. A missile impact at 81 mph in the middle of one of the panels and near the bottom edge of a panel failed to totally perforate the panel. However, at those missile speeds, there was considerable deformation of the inner surface of the panel and what appeared to be delamination of the foam inside the panel.

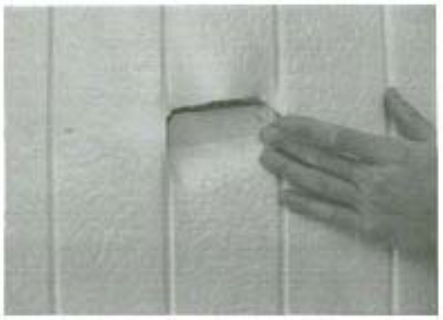
It should be noted that the impact speeds required to completely perforate the panels were more than twice the large missile impact velocity standard for conventional construction and even substantially exceeded, by about 50 percent, the threshold value (9-pound 2x4 at 55 mph) for essential facilities located in the highest wind regions of the US as specified in ASTM E 1996.

If you should have any questions about the tests or results, please do not hesitate to call.

Sincerely yours,

Timothy A. Reinhold

Timothy A. Reinhold, Ph.D., P.E. (Colorado)
Associate Professor
Director Wind Load Test Facility



Typical perforation of exterior metal sheeting (9-pound 2x4 at 35 mph)

Typical local indentation of interior surface from strike on exterior surface (9-pound 2x4 at 35 mph)

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LeepCore wall section resisted penetration of 9 pound wood 2 x 4s, shot on end, at speeds up to and including 81 mph.

Localized wall penetration occurred at 234% of Dade County test specification.

Inside surface bent but not penetrated

At speeds in excess of 90 mph, only local damage occurs and is easily repaired. Flying debris penetrating the LeepCore wall at such excessive speeds, is retained within the wall so humans inside such a building would not have been harmed .