

Test II Report on

**INVESTIGATION OF WIND PROJECTILE
RESISTANCE OF ROYAL BUILDING SYSTEMS
SHELTER WALL PANELS**

Submitted to

**Mr. John Todd
Royal Building Systems (Cdn) Limited
1 Royal Gate Blvd.
Woodbridge, Ontario L4L8Z7**

Testing Performed by

**The Wind Science and Engineering Research Center
Texas Tech University
Box 41023
Lubbock, TX 79409-1023**

Investigators

**Ernst W. Kiesling, Ph.D., P.E.
Larry J. Tanner, P.E.**

Date Submitted

June 14, 2001

Investigation of Wind Projectile Resistance of American Plywood Association Wood Laminated Panel

Overview of Project

Mr. John Todd of Royal Building Systems (Cdn) Limited contacted the Wind Science and Engineering (WISE) Research Center at Texas Tech University to assess the ability of their wall system to resist tornado forces and debris impacts. Tests were conducted on June 12, 2001. The specifics about each test, results and conclusions follow.

Royal Building Systems has developed a wall system utilizing extruded PVC. The PVC extrusions are approximately 5 ½-in. wide and 8 1/8-in. wide. The extrusions are joined by tongues and grooves with the different widths alternating position. Voids in the system's cells allow the concrete to flow from cell to cell and also permit the placement of reinforcing bars to placed vertically and horizontally. The concrete placed in the test samples had an allowable compressive strength of 3000 psi with pea gravel aggregate and was reinforced with Grade 60 reinforcing steel. Un-reinforced, vertically reinforced, and vertical + horizontal reinforced 4' x 4' wall samples for testing included the following:

RBS4 4" thickness

RBS6 6" thickness

RBS8i 8" thickness (6" concrete + 2" polyurethane insulation)

RBS8 8" thickness

The missile criterion used for the tests was a 15-lb. 2x4-in. wood board traveling along the board's longitudinal axis, striking the panel perpendicular to the panel face. The tornado test criterion uses this missile traveling at 100-mph which corresponds to a 250-mph ground wind speed storm and is the criterion used in designing for occupant protection. Additional factors of safety are inherent in the criterion since there is a very small probability that a missile will be traveling along its axis and will strike a wall perpendicular to its surface.

Testing From June 12, 2001

The RBS4 test panel was placed in front of the reaction frame for testing.



Target Placed in Front of Reaction Frame



RBS4 Test Panel Clamped to Reaction Frame

Missile Shot I – 102 mph

The un-reinforced RBS4, 4-in. thick, was impacted in the center of the panel near a tongue and grooved joint. The impact caused no structural damage to the panel, however, a small piece of the vinyl was broken at the point of impact.



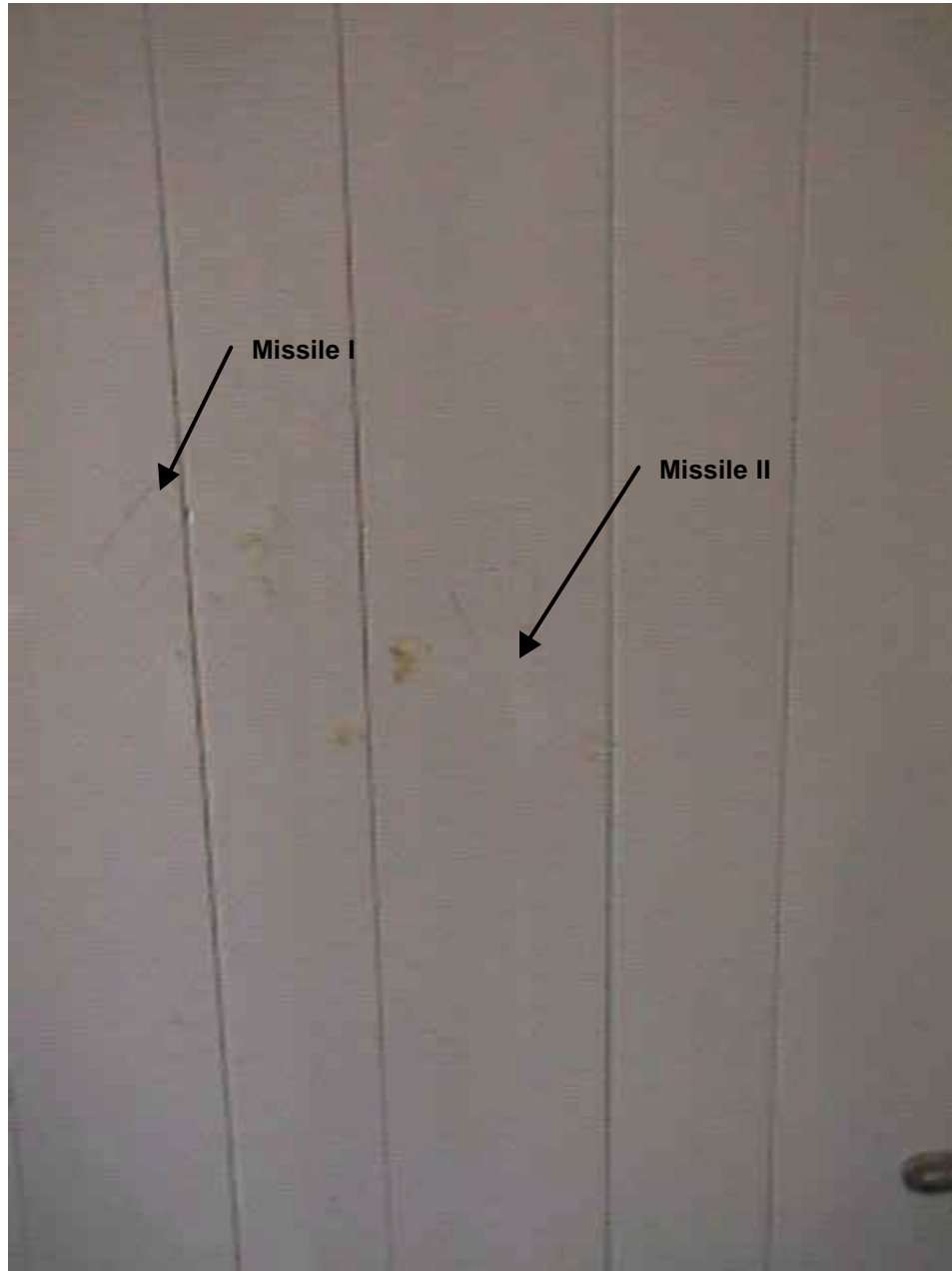
Front of impacted Test Panel



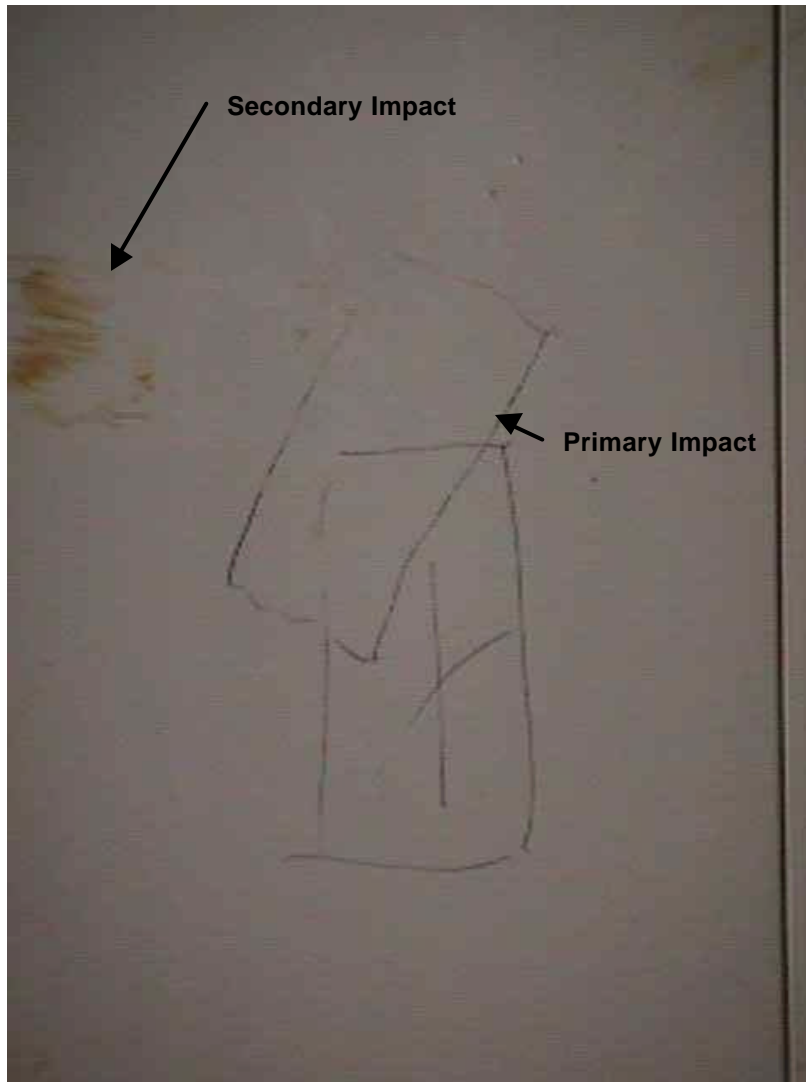
Point of Impact

Missile Shot II –102 mph

The test panel was impacted a second time striking the center of the 8-in. extrusion. The impact caused the missile to shear, thereby allowing a secondary impact on the panel by the trailing portion of the missile. No visible damage resulted from either the primary or secondary missile impact.



Target Impacted by Missile II



Target Impacted by Test Missile II

Conclusions

Within the bounds of reasonable engineering and technical certainty, and subject to change if additional information becomes available, the following is my professional opinion:

The 4' x4' un-reinforced RBS4 test panel resisted the 100 mph, 15-lb. 2x4 missile. The missile speed correlates to a 250 mph ground wind speed tornado. The tested panel thereby meets the criteria as established by FEMA #320, "Taking Shelter From The Storm" for debris impact resistance. The other test samples, un-reinforced and reinforced (RBS4-reinforced, RBS6, RBS8i, and RBS8), though not tested, are also considered FEMA 320 compliant, since they represent stronger systems by virtue of their reinforcing and increased concrete thickness. However, it is recommended that an engineering analysis be conducted on the un-reinforced wall system for resistance to the storm wind pressures. Bending in walls is produced by these pressures and is normally best resisted by reinforcing steel.

Larry J. Tanner, P.E.

Use of Testing Report and TTU and WISE Logos

The written report and supplemental photos and/or videos may be referenced or distributed by your company. But, Texas Tech University cannot endorse products nor can the name of the University or any of its units or personnel be used in advertising without first securing written permission from the University. Any misuse or misrepresentation of the report and/or pictures will result in action being taken by the University against the responsible parties.

Storm shelter manufacturers or producers who have had products tested at Texas Tech University can use the Texas Tech University Wind Engineering logo provided they conform to the following:

- I. The Texas Tech University Wind Engineering logo may not be so prominent as to mislead the public or unduly play upon the Texas Tech University Wind Engineering name.
- II. Whenever the logo is used one of the two alternative statements below is to be employed in the text:

Alternate 1 – whole shelter

The use of the Texas Tech University Wind Engineering logo signifies that the complete shelter structure was tested and successfully passed missile impact resistance tests at Texas Tech University.

Alternate 2 - shelter component

The use of the Texas Tech University Wind Engineering logo does not signify that the entire shelter structure was tested at Texas Tech, but rather only [shelter component – name explicitly] was tested and successfully passed missile impact resistance tests at Texas Tech University.

- III. All advertising and promotional texts containing the use of the Texas Tech University Wind Engineering logo are to be presented to the Texas Tech University Office of Technology Transfer and Intellectual Property for review and approval before distribution.

Texas Tech University will challenge any use of the Texas Tech University Wind Engineering logo that does not conform to the above standards.