PROCEEDINGS

Ice Ball Impact Testing of Siding

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Addressing the Building Envelope

ABSTRACT

Hailstorms cause considerable damage annually in the United States, with siding one of the more affected portions of a typical building. Disagreements sometimes arise among parties about whether observed damage has resulted from hailstone impact, normal weathering, material or manufacturing deficiencies, or other mechanical contact. A laboratory study was conducted to determine the diameter (size) of hailstones necessary to fracture vinyl or dent metal siding of common thickness and design. Freezer ice balls of various sizes were propelled at free-fall velocities to simulate hailstone impacts, and the threshold ice ball size to fracture or dent the various materials was determined.

SPEAKER

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RICHARD HERZOG is a principal engineer, meteorologist, Registered Roof Consultant, and branch manager for the Haag Engineering Minneapolis office. He is licensed as a professional engineer in 16 states. In his 20 years with Haag Engineering, he has authored or coauthored several articles related to roofing and storm damage issues. He is an instructor for several CE courses, including the Haag Certified Roof Inspector program, and has spoken for organizations, including the Roofing Industry Committee on Weather Issues (RICOWI), the Property Loss Research Board (PLRB), the Tile Roofing Institute (TRI), trade associations, contractor groups, and insurance companies. He has been the chairman of the RICOWI Hail Committee since 2001 and was lead author on the RICOWI Hail Investigation Project. He has testified in numerous court cases, arbitrations, and appraisal hearings, primarily on roofing and building envelope issues.

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SCOTT MORRISON joined Haag Engineering in 1989 and has worked in the Dallas corporate headquarters. His primary job responsibilities involve being in charge of projects to determine cause and extent of damage to roofing materials, building envelopes, or building structures, and to coordinate all testing and research activities. He has been involved in research projects regarding testing of roofing products, development of Haag's impact testing program, and hail climatology. Scott has presented seminars to thousands of attendees at conferences, trade organizations, and continuing education courses offered by Haag Engineering. He was part of the development team for the Haag Certified Roof Inspector (HCRI) Program. Scott has served on technical committees for ASTM and ARMA.

Ice Ball Impact Testing of Siding

ABSTRACT

Hailstorms cause considerable damage annually to buildings in the United States, with siding as one of the more affected elements of a typical building (Dewey and Grant, 2006). Assessment of hail-caused damage to siding is performed by consultants, contractors, and insurance professionals, but there is little technical literature available regarding the impact energy necessary to fracture or dent the siding. Disagreements sometimes arise among parties over whether observed conditions have resulted from hailstone impacts, normal weathering, material or manufacturing deficiencies, or other mechanical contact.

A laboratory study was conducted to determine the diameter (size) of freezer ice balls required to fracture vinyl or dent aluminum and steel siding of common thicknesses and profiles. Ice balls of various sizes were propelled at free-fall speeds of natural hail to simulate hailstone impacts. The study identified the areas on the siding profiles most susceptible to impact-caused fracturing or denting. The threshold ice ball size and impact energy to fracture or dent the various sidings also were determined. Different inspection techniques were employed, and their relative effectiveness was compared in detecting the smallest dents in aluminum and steel siding. Overall, the extent of fracturing or denting of the siding varied, depending on the ice ball size and impact energy, the impact site on the siding profile, and the thickness of the siding.

PURPOSE

Severe hailstorms are common in the United States, and some major storms have caused more than $1 billion in insured property damage (Changnon, 2009). This research project focused on the effects of simulated hail (freezer ice balls) on vinyl, aluminum, and steel siding. The sidings were impacted with ice balls propelled by the IBL-7—the seventh generation of ice-ball launcher developed by Haag Engineering Co.—to determine the extent of damage caused, if any. Various sizes of ice balls ranging from ½ in. to 2 in. in diameter were impacted against the sidings to determine the type and severity of condition incurred. The ice ball size at the threshold for each of the sidings was determined (Marshall 2010). All tested materials were new and unweathered.

SIDINGS TESTED

Common thicknesses and profiles of vinyl, aluminum, and steel siding were selected for impacting. See *Table 1*. The siding was fastened with screws to a plywood panel covered with a common weather-resistant barrier (house wrap), in accordance with manufacturer recommendations to simulate typical siding installations.

PROCEDURE

The siding was inspected for damage and, if no damage was detected, mounted to test panels. The test panels comprised 2x4 (nominal) lumber to which ½-in.-thick plywood was nailed and covered with a weather-resistant barrier to simulate typical siding installation. The test assemblies were conditioned for more than 24 hours at 73°F (22.8°C), plus or minus 3°F (1.7°C) prior to testing. Freezer ice balls, propelled to develop the free-fall energies of same-size hailstones, were launched against the siding. The diameters of the ice balls measured approximately ½ in. (12.7 mm), ¾ in. (19.1 mm), 1 in. (25.4 mm), 1¼ in. (31.8 mm), 1½ in. (38.1 mm), 1¾ in. (44.5 mm), and 2 in. (50.8 mm). Table 2 lists ice ball parameters.

Distilled water was placed in molds and frozen and maintained at 0°F (-17.8°C) plus or minus 7°F (3.9°C). The ice balls were removed from the freezer, inspected by the naked eye for fractures, weighed, and launched at siding targets for a duration of 30 seconds. All areas on the siding were initially targeted to determine the most susceptible location. Upon determination of the most susceptible location, the siding was then targeted in that area. Ice ball impacts were made at 60° angles of incidence (reference a vertical line as a zero-degree angle of incidence) against the test assemblies after preliminary impacting determined the targeting that caused the greatest responses in the siding. Locations of impacts were separated approximately 6 in. so that the effects of one impact did not influence the effects of another. See *Figure 1*.

Thickness and Material	Style	Profile	Panel Projection[1]	Average Thickness[2]
0.042 vinyl	Clapboard	Double 4-in.	0.50	0.051
0.042 vinyl	Dutch	Double 4-in.	0.50	0.050
0.046 vinyl	Clapboard	Double 4-in.	0.625	0.059
0.046 vinyl	Dutch	Double 4-in.	0.75	0.060
0.044 foam-backed vinyl	Clapboard	Double 4-in.	1.375	0.051
19-gauge aluminum	Clapboard	Double 4-in.	0.50	0.031
24-gauge aluminum	Clapboard	Double 4-in.	0.50	0.039
29-gauge steel	Clapboard	Single 8-in.	0.625	0.038

Notes:
1. The measured thickness of the profile in inches.
2. The measured thickness of sheet material in inches.

Table 1 – Siding materials tested.

Diameter		Weight		Speed		Kinetic Energy	
(in.)	(mm)	(lbm)	(g)	(mph)	(kph)	(ft-lbf)	(J)
½	12.7	0.0022	0.998	38.3	61.6	0.11	0.15
¾	19.1	0.0073	3.311	45.1	72.6	0.50	0.68
1	25.4	0.0173	7.847	51.4	82.7	1.53	2.07
1¼	31.8	0.0338	15.331	57.3	92.2	3.72	5.04
1½	38.1	0.0584	26.490	63.1	101.5	7.77	10.53
1¾	44.5	0.0928	42.093	69.4	111.7	14.94	20.26
2	50.8	0.1385	62.823	76.1	122.5	26.80	36.34

Table 2 – Ice ball parameters.

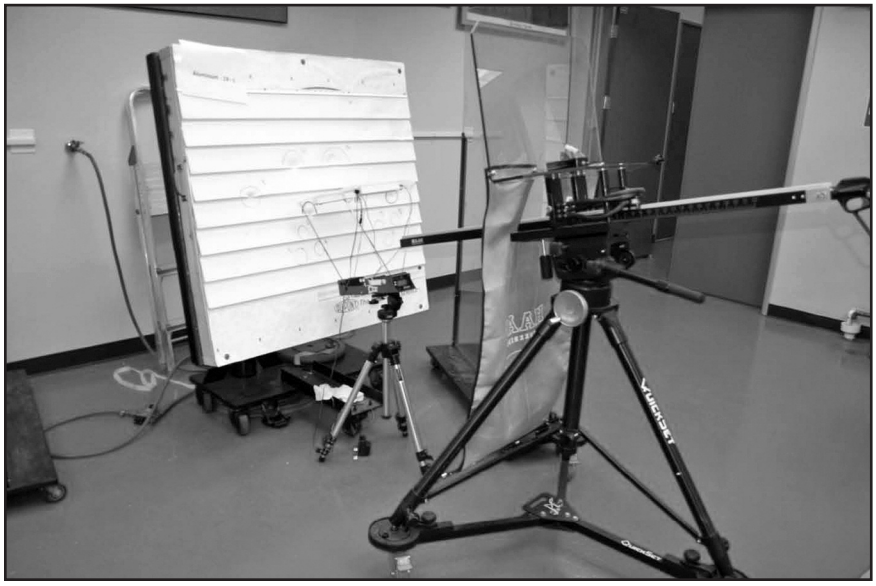


Figure 1 – Test setup.



Figure 2 – Single fracture at a lap in vinyl siding from a 1-in.-diameter ice ball.



Figure 3 – Multiple curved fractures at a lap in vinyl siding from a 1½-in.-diameter ice ball.

Weights and speeds of the ice balls were measured, the latter by a ballistics chronograph, and kinetic energies were calculated. Kinetic energies fell within a range of zero to plus 10% of target kinetic energies, or the data were discarded.

FINDINGS

Results of impacts against siding with freezer ice balls ranged from no marks to fractures in vinyl siding. As determined during the preliminary impacting, the most sensitive targets on the vinyl sidings were the laps. The fractures in vinyl siding varied from single fractures to multiple curved fractures to punctures. The threshold-size ice balls generally generated single fractures, whereas larger-sized ice balls caused multiple curved fractures or punctures. See *Figures 2* and *3*. The lengths of the fractures in vinyl siding varied such that no correlation between ice ball sizes and lengths of fractures was established.

Results of impacts by freezer ice balls against aluminum and steel siding ranged from no marks to rounded dents and also larger distortions, referred to as buckles. The shapes of dents in the metal siding varied from circular to oval. Buckles in metal varied from circular to irregular in nature. In no instance was the aluminum or steel fractured or punctured by the ice ball impacts; however, the paint coating was spalled or fractured by some impacts with ice balls 1½ in. or larger. See *Figures 4*, *5*, and *6*.

Impacts were made by freezer ice balls of various diameters to determine the threshold size for fractures in vinyl siding or dents and buckles in metal siding. The threshold size (Marshall, 2000) is the size of ice ball that initiated fractures in vinyl siding or dents in aluminum and steel siding. See *Table 3* for the complete list of threshold sizes. Generally, impacts by ice balls larger than 1½ in. (38.1 mm) grossly fractured the vinyl siding and grossly buckled the aluminum and steel siding.

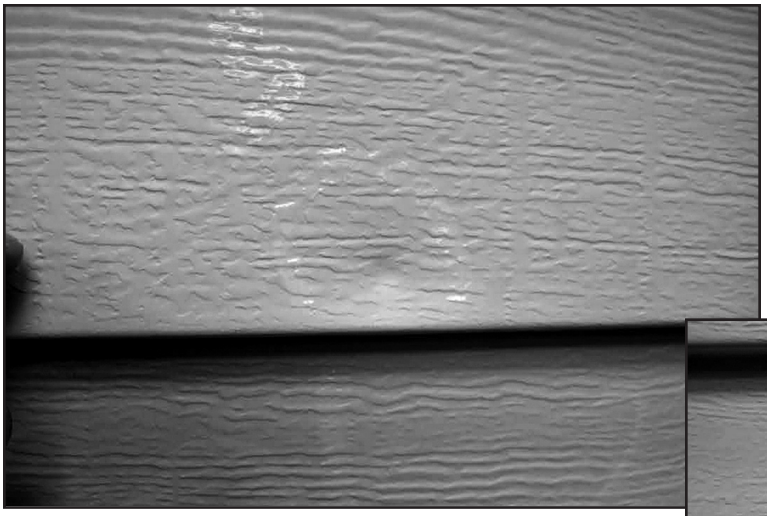
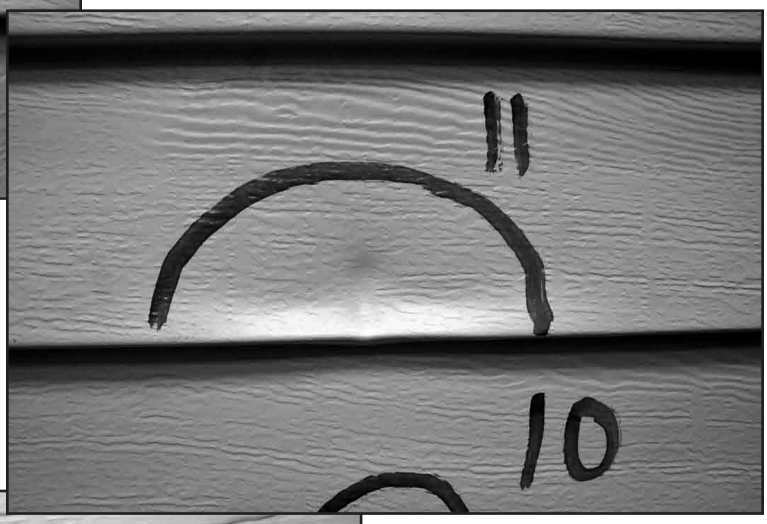


Figure 4 – Dent in the aluminum siding from a 1-in.-diameter ice ball.

Figure 5 – Large dent in the aluminum siding from a 1½-in.-diameter ice ball.



Especially small dents in aluminum and steel were difficult to detect. The most useful techniques were tactile: rubbing one's finger along the siding, rubbing chalk across the impacted area, shining a high-intensity light at a low angle along the siding, and the removal of the panel for observation on its back side. Each technique proved helpful with certain profiles of siding. Dents were the most difficult to detect in siding with embossments to simulate wood grain.

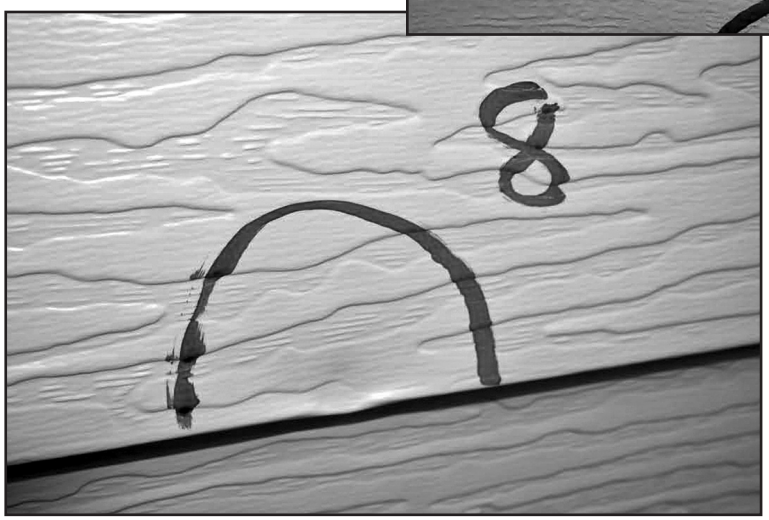


Figure 6 – Dent in the steel siding from a 1½-in.-diameter ice ball.

DISCUSSION

Threshold sizes for fractures in vinyl siding ranged from ¾ to 1¼ in. ice balls. Variation in threshold size could relate to a combination of factors, including thickness, profile, support conditions, and quality of material. Fractures in the vinyl siding at the threshold size were located at the lap in the siding—the most sensitive area of the siding profile to impacts. Impacts by ice balls 1½ in. in diameter and larger were sufficient to fracture profile areas other than the lap.

The 0.046 Dutch lap vinyl siding exhibited the greatest resistance to impacts of the tested profiles, with a threshold of 1¼-in. ice balls. The 0.044 foam-backed lap vinyl siding was the least impact-resistant, with threshold size of ¾-in.-diameter ice balls.

Dents in the metal siding varied from circular and oval dents to buckles. The smaller dents in the metal siding were virtually nondiscernible and detectable only with special observation techniques. The thresh-

Thickness and Material	Style	Threshold Ice Ball Size (in.)
0.042 vinyl	Clapboard	1
0.042 vinyl	Dutch	1
0.046 vinyl	Clapboard	1
0.046 vinyl	Dutch	1¼
0.044 foam-backed vinyl	Lap	¾
19-gauge aluminum	Clapboard	¾
24-gauge aluminum	Clapboard	¾
29-gauge steel	Clapboard	1

Table 3 – Threshold for vinyl siding (fractures) or metal siding (dents).

old for dents in aluminum siding was the ¾-in. ice ball and the 1-in. ice ball for steel siding. Ice balls 1½ in. in diameter or larger buckled the metal siding substantially.

CONCLUSIONS

Based on our testing and analysis of the eight profiles of siding, we have determined the threshold size of freezer ice ball necessary to fracture vinyl siding or dent aluminum or steel siding. We have reached the following conclusions:

1. Threshold sizes of ice balls that fractured vinyl siding ranged from ¾ to 1¼ in. in diameter. Sizes of fractures or punctures were not reasonable indicators of ice ball size.
2. The lap area of the vinyl siding was the most susceptible to impact-caused fractures.
3. Threshold size denting 19-gauge and 24-gauge aluminum siding was a ¾-in.-diameter ice ball.
4. The threshold-size ice ball that dented 29-gauge steel siding was 1 in. in diameter.
5. For metal siding, the siding profiles did not significantly affect the susceptibility to ice ball-caused dents.
6. Dents in metal siding caused by threshold-size ice balls were not visually discernible and were detected only when utilizing special techniques.

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