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Concrete Homes Technology Brief No. 7: *Concrete Homes Built-In Safety*

Debris driven by high winds presents the greatest hazard to homeowners and their homes during tornadoes and hurricanes. Laboratory testing at the Wind Engineering Research Center, Texas Tech University, compared the impact resistance of residential concrete wall construction to conventionally framed walls. The frame walls failed to stop the penetration of airborne hazards. The concrete walls successfully demonstrated the strength and mass to resist the impact of wind driven debris.

What was tested?

Various wall specimens were subjected to the impact of a 2 x 4 wood stud traveling at up to 100 MPH. This is equivalent to the weight and speed of debris generated in 99 percent of the tornadoes occurring in the United States. Wind speeds are less than 150 MPH in 90% of tornadoes. Ten wall specimens were constructed, each representative of the type of construction now used to build frame homes and concrete homes in the U.S. Tables 1 and 2 describe each wall assembly tested.

The Wind Engineering Research Center's compressed air cannon was used to propel a 2 x 4 wood stud debris "missile" at the test walls. The stud was propelled along its axis with the leading end hitting the specimen. Electronic timing devices measured the speed of the debris as it traveled from the cannon to the test walls located 16 ft.-6 in. away.

How did the frame walls perform?

The frame walls lacked the weight and mass to resist the impact of the wind driven debris. In each case, the debris traveled completely through the wall assembly with little or no damage to the "missile."

Table 1: Frame Wall Test Results

Wall Type:	Test Wall Description:	Speed of Debris:	Results:
Wood Frame:	2 x 4 wood studs at 16" o.c., 3-1/2 in. batt insulation, 5/8 in. gypsum board interior finish, vinyl siding over 3/4 in. plywood sheathing exterior finish	109.0 mph	The debris "missile" perforated completely through the wall assembly. Little damage to the missile.
	2 x 4 wood studs at 16 in. o.c., 3-1/2 in. batt insulation, 5/8 in. gypsum board interior finish, 3 in. brick veneer with 1 in. air space, over 3/4 in. plywood sheathing exterior finish	69.4 mph	The debris "missile" perforated completely through the brick veneer, and interior finish. Minor damage to the missile.
Steel Frame:	Steel studs at 16 in. o.c., 3-1/2 in. batt insulation, 5/8 in. gypsum board interior finish, vinyl siding over 3/4 in. plywood sheathing exterior finish	103.5 mph	The debris "missile" perforated completely through the wall assembly. Little damage to the missile.
	Steel studs at 16 in. o.c., 3-1/2 in. batt insulation, 5/8 in. gypsum board interior finish, synthetic stucco over 1/2 in. gypsum board sheathing exterior finish	50.9 mph	The debris "missile" perforated completely through the wall assembly. No damage to the missile.

How did the concrete walls perform?

The concrete stopped the debris from traveling through the wall. Exterior finishes were damaged by the impact, but the concrete walls were unscathed. Even the narrowest, 2 in. thick section of "waffle grid" ICF wall was undamaged by the direct impact of debris at over 100 MPH.

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Table 2: Concrete Wall Test Results

Wall Type:	Test Wall Description:	Speed of Debris:	Results:
Concrete:	6 in. thick reinforced concrete wall, #4 vertical reinforcement bars, 12 in. o.c. No finishes.	102.4 mph	No cracking, front face scabbing or back face spalling of concrete observed.
	6 in. thick reinforced concrete wall, #4 vertical reinforcement bars, 24 in. o.c. No finishes.	102.4 mph	No cracking, front face scabbing or back face spalling of concrete observed.
ICF:	Block ICF foam forms, 6 in. thick flat concrete wall, #4 vertical reinforcement bars, 12 in. o.c. Vinyl siding. (Tested a second time with similar results.)	103.8 mph	Debris penetrated vinyl siding and foam form. No cracking, front face scabbing or back face spalling of concrete wall observed.
	Block ICF foam forms, 6 in. thick flat concrete wall, #4 vertical reinforcement bars, 24 in. o.c. 3 in. brick veneer with ties spaced 1 ft-0 in. o.c. ea. way.	99.0 mph	Debris penetrated and cracked brick veneer. Foam form dented. No cracking, front face scabbing or back face spalling of concrete wall observed.
	Panel ICF foam forms, 4 in. thick flat concrete wall, #4 vertical reinforcement bars, 24 in. o.c. Vinyl siding.	96.7 mph	Debris penetrated vinyl siding and foam form. No cracking, front face scabbing or back face spalling of concrete wall observed.
	Block ICF foam forms, variable thickness "waffle" concrete wall, 6 in. maximum thickness, and 2 in. minimum thickness. #4 vertical reinforcement bars in each 6 in. vertical core at 24 in. o.c. Synthetic stucco finish. (Tested a second time with similar results.)	100.2 mph	Debris penetrated synthetic stucco finish, and foam form. Impact of wall at 2" thick section. No cracking, front face scabbing or back face spalling of concrete wall observed.

Note: All concrete tested: 3000 psi comprehensive strength, maximum aggregate size 3/4 in, 6 in. slump.

What about damage from hurricanes?

Hurricane wind velocities will be less than the equivalent maximum speeds modeled in the tests. Missile testing designed to mitigate property damage losses from hurricanes use a criterion of a 9-pound missile traveling about 34 MPH.

What's the bottom line?

The strength and durability of concrete walls offer unmatched resistance to the devastation of major storms. Concrete homes are less likely to suffer major damage from debris than conventionally framed houses. This greater measure of built-in safety makes cement-based ICF construction systems the quality choice for your new home.

Additional Related Resources

Additional Resources can be found in the PCA Bookstore or in the PCA Reference Library. For More Information, contact the Library at library@cement.org or 847.972.9174.

DVD511 *"Concrete Homes-Built In Safety"* DVD documenting the results of the wind driven debris impact testing. All ten of the impact tests are featured and research report, RP122.
RP122 *"Investigation of Wind Projectile Resistance of ICF Homes"* Written report with photos detailing the results of the wind driven debris impact research. Background information on the criteria and assumptions used to generate the test design are included.

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