

Learning Target 6.6:

I can analyze the mutual interaction between Earth's systems and human activity.

Door that can take some punishment

If a windstorm product can survive a 15-pound, 12-foot-long 2 x 4 flying horizontally like a 100-mph missile, and also the pressure from 250-mph winds, then the product gets the Federal Emergency Management Agency (FEMA) seal of approval. Kiesling's Wind Science and Engineering Research Center (WISE) at Texas Tech has tested a variety of doors to these standards using a huge air bladder that simulates EF5 tornado conditions, creating [a list of doors](#) that survived the impact and the wind-pressure challenge. These doors are specifically intended for shelters or safe rooms, but they could certainly be used as entrances in a home, Kiesling says.

The Tech: The StormPro Window Shutter System from Curries Doors is a four-sided frame system and a hollow 16-gauge door with a polyurethane-wrapped 10-gauge steel liner at its core.

DIY-Friendly? Branden Shank, the technical support specialist for Curries Doors, says that if you can drill a hole into concrete and affix anchors, the installation process is simple.

Effectiveness: StormPro was tested at Texas Tech's WISE Center in accordance with FEMA 361, an objective baseline for building tornado and hurricane shelters.

Approximate Cost: \$5,520 for materials only--door, frame for a 3-foot-wide by 6-foot 8-inch-high opening, hinges, and concealed multipoint lock--as quoted by Murray Womble, a Curries Doors distributor out of Tulsa, Okla.

Fortify Your Garage Door

Kiesling, who is also executive director of the National Storm Shelter Association, calls garage doors the weakest link in a home. Once the garage door is lost, you can consider the house lost as well: High-speed winds pressurize the house and blow the roof off like a shaken soda can. Consumer Reports suggests purchasing windowless garage doors less than 9 feet wide that are rated to withstand 50 or more pounds of pressure per square foot, and Kiesling adds that a single door has a better chance of surviving than a double door. But you can also reinforce the door you already have.

The Tech: Secure Door offers a vertical bracing system made of aircraft-grade aluminum that serves as a rigid backbone for the garage door. It anchors into the wall above the door, into the floor and into each hinge, preventing the door from blowing in or suctioning out.

DIY-Friendly? With some basic tools on hand--an electric drill, masonry bit, socket driver, socket wrench, hammer, scissors and screwdriver--the first brace can be set up in 45 minutes; the others in less time. Once you've installed the system, the top bracket and floor anchor bolts are permanent, but the braces themselves can be disassembled and stored in the garage. When a tornado warning goes in effect, you can rig up the braces in less than three minutes.

Effectiveness: The system is Florida Building Code-approved and exceeds the Southern Building Code Congress International (SBCCI) retrofit wind-speed standards. According to wind-speed-pressure tests, if a standard windowless 7 x 16-foot rolled sheet-steel garage door is reinforced with three braces, it can withstand a maximum of 180-mph wind speeds. In other words, the door should resist wind pressure from an EF3 tornado and could potentially withstand an EF4.

Approximate Cost: \$159.99 per brace; \$480 for 3.



Keeping Your Lid On

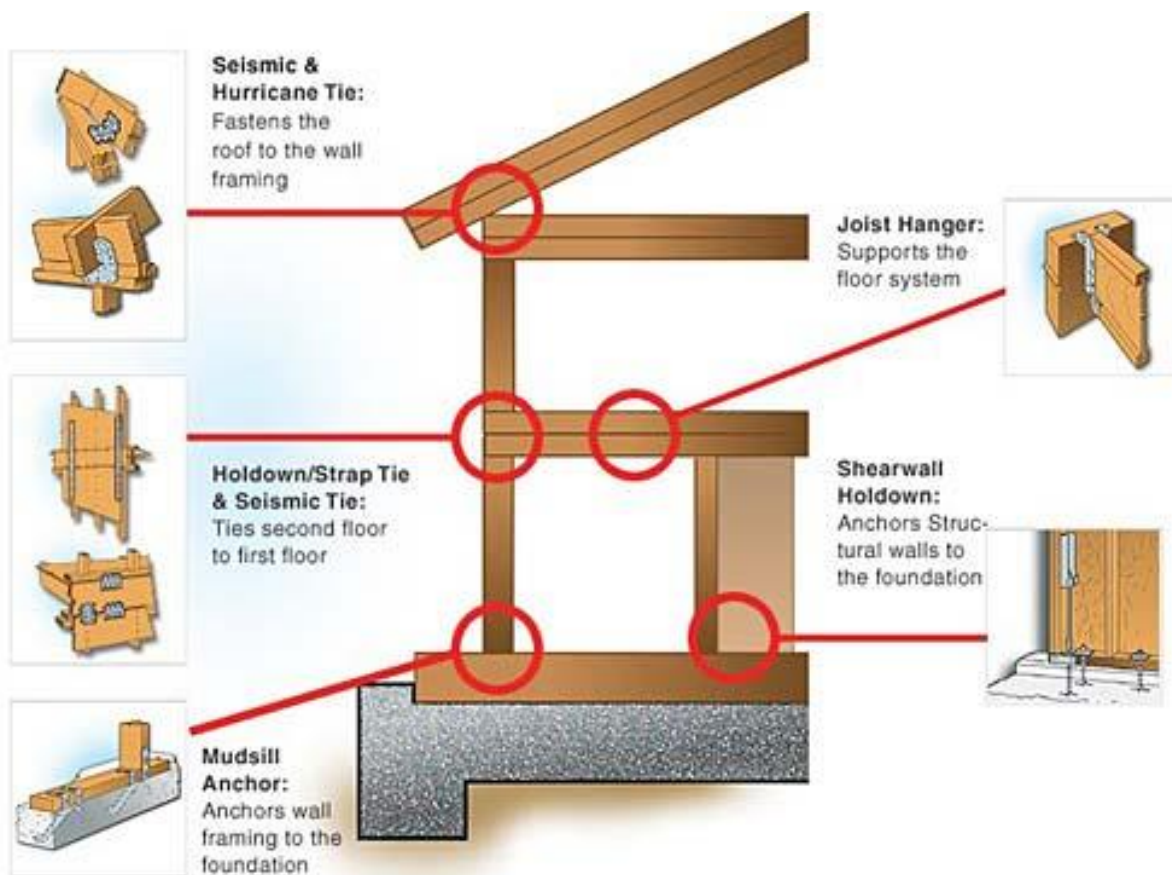
During a tornado, the winds blowing over a home exert an inward pressure against the windward wall, outward pressure against the sidewalls and leeward wall, and upward pressure against the roof, Kiesling says. The combination of those pressures will rip through weak connections. "The roof lifts off and the walls are left without any lateral stability or bracing. They tend to collapse outwards, and the house looks as if it's exploding," he says. "So if you can keep that roof on, you have more resistance against the wind."

The Tech: Simpson Strong-Tie galvanized-steel hurricane clips come in a range of uplift protections, from 300 to 1500 pounds. Hurricane clips connect the top plate to trusses or rafters, greatly increasing the strength of connection between the two. "The typical connection in the house is a toenail, where the nail is driven in at an angle. If you pull on it, it pulls right out," Randy Shackelford, building code engineer for Simpson Strong-Tie, says.

DIY-Friendly? If you can follow instructions and drill a hole with a steady hand, you can put up hurricane clips. There are a few connectors designed specifically for retrofitting a roof via the tight quarters of an attic. The HGA10, which connects the top plate to the truss, is the most common, Shackelford says.

Effectiveness: Uplift protection ranges from 400 to 1500 pounds or more, depending on the clip. Allowable loads, or the maximum load a connection is designed to provide, were determined by static load testing and building code calculations in accordance with the International Code Council and ASTM D1761. But which you use, and how many, depends upon your house design and where you live. In a low-danger area, you might have a clip approved for 500 pounds of uplift protection on every other member of the roof. Living near the coast in hurricane country, you might pick the most substantial connector and put one on every truss.

Approximate Cost: \$500 for a 2000-square-foot, one-story home designed to resist 110-mph winds; \$550 for a 2500-square-foot, two-story home designed to resist 110-mph winds. Both include cost of labor. Using pneumatic tools would reduce the above costs by \$300, respectively.



Shutter those Windows:

A common tornado misconception is that opening the windows and creating a wind tunnel helps to equalize the pressure inside and outside the home. But an open window is just a direct gateway for high-speed debris, and can actually cause the house to become pressurized, like blowing air into a balloon. Instead of opening the windows, put a layer on top of them.

The Tech: PlyLox Window Clips are a screw- and nailless alternative to other window-shutter systems. Snap them onto the plywood you're going to use to cover your windows--you can use sheets as thin as 7/16 inch or as thick as 3/4 inch. Then firmly lodge the clip into the window space. The serrated overhang of the clip bites down into the window casing upon insertion. As suction forces pull on the panel, the teeth become embedded deeper into the recessed opening material and resist expulsion.

DIY-Friendly? Rob Fee, president of PlyLox, says that if you measure and cut the plywood covers in advance, you can board up a standard home in 20 minutes. Make sure there is 1/8-inch clearance on all four sides of the plywood so the clips will fit.

Effectiveness: The clips were tested for impact and pressure resistance up to 150 mph at the National Association of Home Builders test lab. Fee says PlyLox clips are ideal for hurricanes, though they probably won't be enough against the incredible force of an EF4 or EF5 tornado.

Approximate Cost: \$29.95 for a 20-pack of 1/2-inch residential clips; \$32.95 for a 20-pack of stainless steel clips.



Cable Tite: Pine Down your Home

After you've boarded up the windows, bolstered the garage door and secured the weak connections in the roof, you still have to worry about keeping the structure on the ground. The gyrating winds of a twister can pluck a home from its foundation.

The Tech: Cable-Tite is one way to keep structures more grounded than ever. With tensile strength of 6700 pounds, Cable-Tite ties the house down by connecting the J-bolt of the foundation to the top plate. With the twist of a wrench, a cam-locking device at the base tightens the cables to a uniform degree, and exerts constant downward pressure on the home. "It's like a Chinese finger lock," Cable-Tite founder Ted Bransford says of the cam lock. "It only pulls in one direction"--down.

DIY-Friendly? Not unless you are starting home construction from scratch or planning a major renovation, which will expose existing J-bolts, top plates, and studs. If you are, the Cable-Tite website offers thorough instructions on DIY assembly.

Effectiveness: The Smith-Emery Laboratories of Los Angeles approved Cable-Tite for uplift protection to 6900 pounds.

Approximate Cost: \$1500 for a 1500-square-foot home.

Walls of Concrete

"We can't change where tornadoes strike, but we can change the way we build and prepare for the inevitable," ARXX CEO Gael Maurant says. That could mean building your home not with traditional timber construction, but a new kind of material: ICFs.

The Tech: Insulating concrete forms, or ICFs, are solid interlocking blocks made of rigid, resilient foam called expanded polystyrene. ARXX's forms are made of two panels of the foam held in place by plastic or steel connectors. Once the building blocks are set, a rebar framework is inserted into the space between the foam panels and concrete is poured. The result: an airtight, insulated, fire-resistant structure. The blocks can be stacked to create 24-inch-thick walls and solid foundations.

DIY-Friendly? ICF is an alternative to timber-frame construction, so you use it when you're putting up walls--either when beginning a building from scratch or building an addition onto a pre-existing home. ARXX does not recommend that homeowners tinker with ICF blocks without thorough training. Even then, a skilled installer should oversee the process.

Effectiveness: ARXX forms passed FEMA's standard impact and wind-pressure tests. The embedded video shows ICFs' resistance to a flying 2 x 4, as well as an ICF home surviving an EF2 tornado.

Approximate Cost: "When you look at what it costs to build with ICF, it is reasonably comparable to timber-frame construction," Maurant says. ICF homes are energy-efficient, requiring 44 percent less energy to heat and 32 percent less energy to cool. "We did a Habitat for Humanity project in Philadelphia. People there were paying \$300 a month in heating and cooling costs. Now they're paying \$60 a month with ICF," she says.

Concrete Cloth

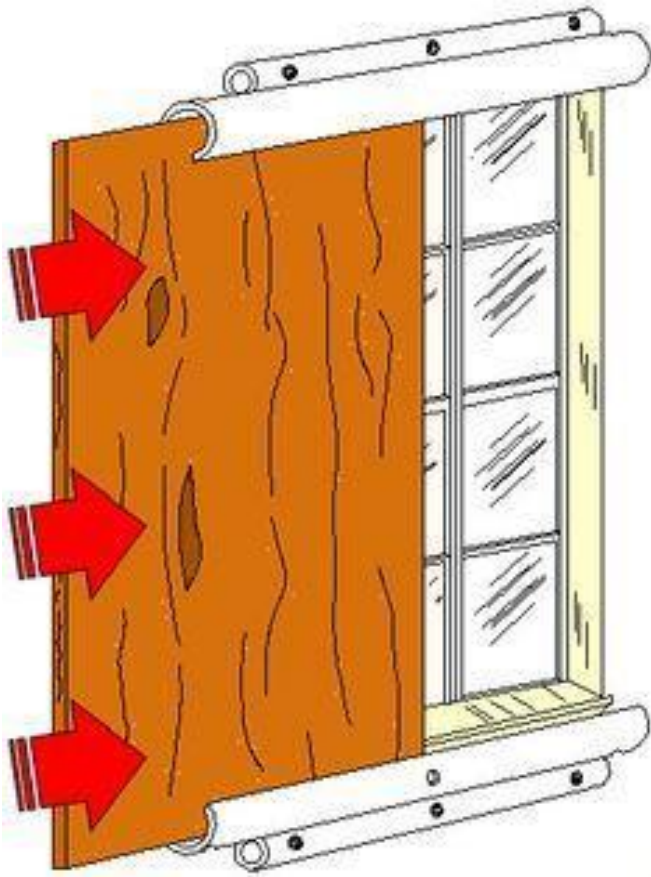
This material has been used to line ditches, create subterranean walls in mines, protect slopes, shield buildings and make rapidly deployable military shelters. If it can stop bullets, will it repel one of Mother Nature's deadliest stunts?

The Tech: Just add water to this cement-impregnated fabric and it inflates and hardens like a cast, thickening in a matter of 24 hours to a durable layer that is both water- and fireproof. "The cloth cannot be over hydrated, so this is a simple process," says Peter Brewin, one of the founders of the British company Concrete Canvas, which invented it. Once wet, the material stays malleable for up to 2 hours.

DIY-Friendly?: When using the cloth to clad a safe room, Brewin recommends stretching it between wooden joists and nailing it into position, or using standard masonry hardware when affixing the cloth to stonework. Then, just add water. Concrete Canvas does most of its business with large-scale construction, but Brewin is working to make Concrete Cloth more readily available to consumers at retail stores.

Effectiveness: Bath University tested Concrete Canvas Shelters, another product from Concrete Canvas, to resist wind speeds of 134 mph. A layer of the thickest model, CC13, which "inflates" to half an inch after hydration, stopped 50 percent of .22-caliber steel projectiles traveling at 675 mph during impact tests. Still, Kiesling says you can't be completely certain the material will withstand all tornado threats. In the past, he says, a number of products on the market that resisted bullet penetration then failed debris-impact testing with a 2 x 4. "It's an interesting concept they are looking at, but I can't express optimism about it until it is tested further."

Approximate Cost: Brewin estimates that the CC13 model would cost \$6 per square foot. Thus, armoring a 10 x 10-foot space would cost about \$600.



Taking Shelter from the Storm

Designing a home from scratch to be virtually indestructible would mean building it with more than six times the strength of an ordinary house, Kiesling says, which is "economically unattractive to say the least." The best way to ensure your family's safety without bankrupting yourself is rigging a safe space. "The biggest advantage of having one is the peace of mind of knowing that there is a safe place available," he says. That often means an underground shelter, but it's possible to create an above ground safe room.

The Tech: DuPont StormShelter is an in-home safe room made out of Kevlar, the material that makes police vests bulletproof and is five times stronger than steel. The shelters come in a variety of dimensions, from 4 x 6-foot to 12 x 12-foot, and can be wired for electricity and outfitted with plumbing.

DIY-Friendly?: Installing a DuPont StormShelter is possible with the combined efforts of an architect and contractor. Such top-shelf shelters are usually designed right into the house so that they can be inconspicuous, Kiesling says. They can also be mounted on a slab in a pre-existing home.

As an alternative, you can stiffen the walls of a small space in the house--a closet, pantry or bathroom--by using ICFs or steel wall sheathing. [FEMA provides a set of guidelines for building a safe room](#) in the house, basement or underground. Kiesling adds: "You can fairly inexpensively buy a manufactured shelter, a concrete box or a steel box that would mount on a concrete slab in the garage."

Effectiveness: DuPont's StormShelter is FEMA-certified to withstand 250-mph winds and impact from a 2 x 4 traveling at 100 mph.

Approximate Cost: \$6,500 to \$16,000, depending on dimensions and upgrades.



THIS SHELTER SURVIVED AN F5 TORNADO!

