



Earthquake Prevention and Retrofitting

On August 23, 2011, at 1:51 p.m., a magnitude 5.8 earthquake occurred in central Virginia. The epicenter was 5 miles south/southwest of the town of Mineral, Virginia, and 38 miles northwest of Richmond, Virginia. This was the largest earthquake east of the Rocky Mountains since a magnitude 5.8 event in 1944 on the New York/Ontario border and the largest earthquake in Virginia since a magnitude 5.9 event in 1897 in Giles County in western Virginia.

Although Steve Smith's home is near the epicenter, it escaped most of the damage his neighbors received: chimney damage or collapse, plaster/drywall cracking, foundation wall cracks and blowouts, brick veneer falling away, and structures shifting and separating.

Relying on his background in the construction business, Smith used construction techniques and materials that were above and beyond code requirements and normal construction techniques for this area. He also will use a new technique to retrofit the damage that did occur.

Smith used manufactured open-web steel floor joists, placed at 16 inches on center. With less mass and weight, there was less movement and therefore less damage from the earthquake. The lighter structure with stronger connections lowers the seismic force. Steel's high strength and ductility make it a good material for earthquake-resistant design.

As an alternative to typical milled timber, Smith used laminated veneer lumber (LVL) as a header over door and window openings and on bearing walls. This greatly improved the structural integrity for seismic considerations. LVL is stronger than milled lumber, more uniform, and less likely to twist or bow. Smith used another successful building technique to construct his 9 foot by 20 foot porch pad: 16-gauge corrugated-steel decking covered with 6 inches of concrete reinforced with #6 ($\frac{3}{4}$ inch) re-bar. Unlike other cracked and displaced concrete patios and porch pads in the area, Smith's pad only moved slightly, and moved as a single unit, without cracking, breaking, or collapsing.

The house did suffer some cracking in the cast-in-place concrete foundation walls. After consulting with his contractor employer, Smith decided to retrofit the foundation using carbon fiber reinforcement.

Disclaimer

The FEMA Best Practices Portfolio consists of mitigation stories submitted by individuals and communities that describe measures they have taken to reduce the loss of life and property from disasters. These Best Practices are meant to provide ideas and concepts about reducing losses and to encourage others to evaluate their own risk and consider mitigation as a long-term solution to reducing that risk. Although some stories may suggest specific applications or building techniques, they are not meant to provide

technical advice about construction techniques or types of materials to use. Building codes will vary by locality; if you are making structural changes or improvements always check with your local government regarding codes that apply to your home or community. If using a contractor, be sure to use one who is licensed and bonded. For additional information on building codes and building science, visit the FEMA Library, at <http://www.fema.gov/library>.