All shook up: UH engineer pioneer in earthquake research

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Standing more than 15 feet tall at two stories, weighing nearly 40 tons and containing more than a mile of pipes to transport oil pressure to its 40 jacks, the "Universal Element Tester" measures the strength of reinforced concrete under earthquake-like conditions. Civil Engineering Professor Thomas Hsu (pictured) and his colleagues designed and built this one-of-a-kind machine housed at UH. Credit: Todd Spoth

An expert at testing the strength of reinforced concrete under earthquake-like conditions, one University of Houston professor was recently honored for two decades of shaking things up.

Thomas Hsu, the John and Rebecca Moores Professor of Civil Engineering in the Cullen College of Engineering at UH, was presented with the Arthur J. Boase Award from the American Concrete Institute (ACI) for his achievement in the field of reinforced concrete research.

The main tool in Hsu's earthshaking pursuits has been a piece of equipment dubbed the "Universal Element Tester" (UET). Developed and housed at UH, the UET stands more than 15-feet tall at two stories, weighs nearly 40 tons and contains more than a mile of pipes to transport oil pressure to its 40 jacks. Each jack is capable of applying 100 tons of force to test the strength of element panels of steel-reinforced concrete.

This instrument is distinguished by its unique capability to test large panel elements under varied controlled forces and is the only device in the world capable of performing comprehensive testing of reinforced concrete panel elements. The data from these tests can be integrated by computer techniques to predict the behavior of whole structures constructed from such elements when threatened by real-life destructive forces, such as earthquakes.

All structures can be exposed to four basic actions: axial force, bending, shear and torsion. By controlling individual pairs of jacks, the UET can subject elements made of various concrete materials to all four. The machine is able to perform three-dimensional (3-D) tests, but so far it has only been used in the one-dimensional (1-D) axial force – compression/tension, or pushing in and pulling out – and the two-dimensional (2-D) actions of bending and of shear – a force similar to the action of a scissor. The fourth type of action is torsion, or twisting, which is a 3-D problem.

"Looking into the future, I chuckle when I tell my students that I've figured out pretty well the material laws for 1-D and 2-D actions, and that it's up to them to figure out the material laws in 3-D," Hsu said.

Additionally, the UET is the only device in the world able to perform cyclic loading tests on reinforced concrete elements, in which the pressure applied by the jacks changes direction back and forth.

“Cyclic loading is important because it allows us to simulate what structures endure during an earthquake,” Hsu said. “That’s one of the most important research topics in reinforced concrete today.”

Research performed on the UET has resulted in approximately 60 published articles, and Hsu is currently writing his third book, “Unified Theory of Concrete Structures,” that sums up the past 20 years of research performed with the machine. It includes conclusions from 1-D and 2-D stress testing, including cyclic loading tests, as well as theories derived from these tests that predict how reinforced concrete responds to 1-D, 2-D and 3-D stresses.

“We’re pushing a new frontier in structural engineering with this book,” Hsu said. “We’re building a theory that integrates and unifies all four types of actions.”

Hsu’s unified theory will allow engineers to accurately predict the seismic behavior of concrete buildings and bridges and to design concrete structures that are more cost effective and reliable in resisting earthquake hazards. The theory also will pave the way for engineers to predict the behavior of more sophisticated concrete structures, such as buildings with shear walls, nuclear reactor containment vessels and concrete offshore platforms.

Source: University of Houston