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Engineering News

NSF-Supported Researcher Builds "The Most Historic Wall Since the Great Wall of China"

A robot developed with NSF support has built the first wall ever constructed entirely by machine, with no use of human hands. Measuring about 5 feet long, 3 feet high, and 6 inches thick, the wall was constructed in January 2004 in the University of Southern California lab of Behrokh Khoshnevis, Professor of Industrial & Systems Engineering. Khoshnevis, who calls his creation "the most historic wall since the Great Wall of China," believes that by the end of 2005, his robots will be able to construct a one-story, 2,000-square foot home on site in a single day.

A robot builds one of the first walls ever constructed entirely by automated processes in the University of Southern California lab of Professor Behrokh Khoshnevis, February 2004.

Professor Khoshnevis and graduate student Dooil Hwang with the robot they developed for automated construction of walls and buildings.

Khoshnevis' pioneering efforts to automate the building process are based on a technology known as Contour Crafting, a layered fabrication process controlled by computer. The idea came to him while repairing cracks in his Los Angeles home following a 1994 earthquake. After 7 years of research and development, Khoshnevis has created a robot that can build large structures by extruding semi-liquid material from a pump in inch-thick layers to form the outside edges of an object, such as the wall of a building. The robot moves back and forth along a gantry installed at the construction site to deposit each layer of the wall. After the exterior layers have been laid down, the robot returns to pour concrete or other filler material into the hollow wall. In effect, this technology will enable homes and other structures to be "printed out" from computer design software, much as ink jet printers produce documents from word processing software.

One key advantage of using Contour Crafting for automated building is its ability to make structures of virtually any geometry without the costly, time-consuming steps involved in making molds for manual construction of curved surfaces. "After a

20,000-year history, the process of constructing buildings is about to be revolutionized," says Khoshnevis. "This technology will allow architects, for the first time, to design buildings of any shape and configuration that can be constructed at no more expense than a structure with conventional, right-angled walls."

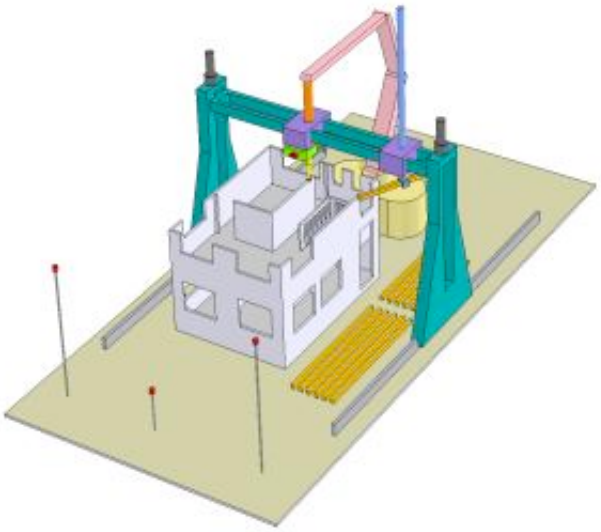

Diagram of construction of conventional building using Contour Crafting.

Khoshnevis also points to important environmental advantages associated with automated construction. Since Contour Crafting technology can build in 1 day what now takes 6 to 9 months of manual construction, it will dramatically reduce the need for workers to commute to building sites, thus easing pressure on congested transport systems and cutting transport-related air pollution. The technology produces little or no material waste, potentially reducing construction-related waste by 3 to 7 tons for each single-family house built using automated techniques. Moreover, construction materials can be chosen for their environmental characteristics, such as materials that reduce waste and promote recycling, and Khoshnevis is partnering with Degussa AG, the world's largest manufacturer and supplier of building materials, to develop the best material for use in automated construction. Contour Crafting technology can also produce very sophisticated walls with highly-insulating designs and materials.

"This research promises to usher in a new era in construction. Its strong point is the use of new materials and new information technologies to create the next generation of buildings," notes Perumalsamy Balaguru, Program Director for Structural Systems and Engineering, Division of Civil and Mechanical Systems, in NSF's Engineering Directorate. The first commercial-scale applications of automated construction technologies are likely to be for building emergency shelters and low-income housing, followed by general residential construction, especially homes with exotic architecture featuring complex curves and other geometries that are expensive to build using manual methods.

Khoshnevis also plans to explore the applicability of Contour Crafting technology for building extraterrestrial habitats. One of the very few feasible approaches for building structures on the Moon or Mars, Contour Crafting technology would have to be adapted to use lava paste created from dust on the lunar or Mars surface as a building material and researchers will have to develop greater understanding of how the technology would perform under partial-gravity conditions.

For more information, contact Behrokh Khoshnevis at khoshnev@usc.edu, (213) 740-4889. Animations of the Contour Crafting process may be viewed at www-rcf.usc.edu/~khoshnev.

See also related NSF ENG News articles on layered fabrication processes, including the research of MIT Professor Emanuel Sachs on 3D printing and the research of University of California-Irvine Professor Melissa Orme on high-speed, droplet-based manufacturing.