CONSTRUCTION TECHNOLOGY

Houses out of the printer

A US-engineer wants to revolutionize the house building: he develops robots that extrude concrete through a nozzle. He promises that within one day time entire buildings can be printed. The German Degussa Corp. shows interest.

Human beings are meant to use their brains, Behrokh Khoshnevis says. They should benefit from their creative potential – instead of letting it get rusty over mundane work that can be performed just as well by machines. Fortunately an army of millions of typists, for example, were freed by the advent of the word processor. "That job was beneath human potential", he says, "it had to disappear."

If everything goes as expected, Khoshnevis, 53, is on the way to free humanity from a series of other professions, such as concrete builder, mason, carpenter, roofer, plumber, pavement and tile worker, painter, building supervisor and many more. The engineer, descendent of Iran and faculty member of the University of Southern California in Los Angeles, is working on a robot that will automatically construct houses and entire settlements at impressive and unprecedented speeds.

The device that Khoshnevis has in mind, may be called "A-house-in-a-day-machine". His target: some day a robot will build a 200 square meter (2000 sqft) family home from ground up within hours - with roof, tiles and all piping; only trifles like windows and kitchens would be missing in his instant-housing. Khoshnevis wants to construct cheaper than ever before and totally different: "I do not want to see anymore human exploitation in this field."

Many experts take Khoshnevis' plans seriously. The National Science Foundation granted several hundred thousand dollars for his research. His concepts won an award (" best paper") at a robotized construction conference. His own university which would share in revenues encourages him to found a company. Venture capital investors show interest. The first simple small house should be erected already within a year. And in distant Germany the curiosity of a powerful company, "Degussa", is stimulated.

Gerhard Albrecht is head of R&D for construction chemicals at Degussa in the Bavarian town of Trostberg. Some weeks ago he met Khoshnevis in a Düsseldorf airport-restaurant. The researcher showed him his plans on a laptop. Albrecht was impressed. The Degussa-man anticipates anyway that after automobile construction or ship building automation would eventually advance into house building as well. What Khoshnevis intends means "a quantum leap for the modern construction industry".

The researcher will get support from Degussa, Albrecht announces. The Degussa group is the world market leader in the business of admixtures for construction, and in case Khoshnevis is successful the demand for these costly admixtures would rise – e.g. Degussa additives allow for a special concrete which flows easily but hardens within moments. "Without construction chemicals", says Albrecht, "things will not work."

Khoshnevis has come far. A prototype already stands in a narrow lab at his university. In January he set the device in operation for the first time. Independently, without a persons hand, the machine constructed a fine piece of wall: perfect in form, almost 30 centimeters high and just as deep, about 1.5 meters long. "This", Khoshnevis announces boldly, "is the greatest achievement since the Great Wall of China." Because "if a wall can be made so can a house."

The term "building" does not really convey the new concept. Khoshnevis' machine has nothing to do with what happens on construction sites today. It does not build houses, it prints them. 550 years after the invention of printing, now house-printing proclaims its arrival.

Similar to an ink jet printer placing text on paper, Khoshnevis' apparatus is building up material in 3D : there is no print head with ink that is moved over the paper. Instead the robot mixes special concrete to a rapidly hardening mixture, a sausage construction material which the machine lays down exactly where the computer wants it. Layer by layer the construction extends in height. First it forms the outer boundaries of a wall, then it fills it with concrete; and holes are positioned where piping and other utilities are needed (see graphics p.125).

The machine receives its instructions from the architect's computer, creating precisely what he has previously drawn using a standard CAD-program (" Computer Aided Design"). Khoshnevis has named his technology "Contour Crafting" (CC). For architects and prospective home owners it promises the beginning of an era of unlimited playful experimentations.

With the exception of the limits of statics there would hardly be any more limitations imposed on the builders in the CC era. The new technology permits to realize almost any forms: arched or cylindrical walls which would not be more expensive than straight ones. Therefore, houses could be built at the site in series, much like in an assembly line – however, individually planned and unique building designs would be possible in this construction approach.

The concept of 3-D-printing was not invented by Khoshnevis; his approach scales it up, adapts it to new materials, and implements it at the construction site. In other areas of industry such procedures have been known for more than 15 years as "Rapid Prototyping" (RP). RP machines build all kinds of products in layers out of plastic resins or metal powder. For example RP is used in the car industry in order to produce models, parts for small series or

moulds for casting. Surgeons sometimes make preliminary studies for complicated operations on RP-models of body parts of their patients. Researchers have even perfectly reconstructed by RP the 5300 years old skull of the (mummy) Ötzi.

"Without doubt", Khoshnevis says, "this will revolutionize the building industry." The introduction of new technologies into this conservative industry is "long overdue". He thinks it is incredible that robots have totally changed the method of car manufacturing but not house building, even though a car is much more complicated than a house. He often asks himself, "why somebody has not called this to mind so far".

At least in Japan gigantic building companies have experimented for years with robots. There on many construction sites automated machines are bringing out concrete, laying cement floors, fusing and assembling prefabricated parts together and managing fully automatic warehouses. However, in spite of numerous particular successes, the great robot revolution in construction industry has not yet happened – perhaps this is because generally robots perform isolated and single tasks.

Khoshnevis is certain about his success. With his machine, he says, dramatic savings could be achieved. The biggest part of total labor cost can be omitted, just as can the enormous capital costs for building projects which require several months to complete. Furthermore, the environment would be relieved: house printing would hardly produce debris from building and there would be no dust and noise.

In addition to constructing walls the machine could use pre-produced parts (e.g., wall modules for power and telephone lines, beams and tiles for the roofs on site) much like robots in car manufacturing. Before depositing concrete it could independently anchor the reinforcing steel modules. This would not be complicated, says Khoshnevis, if one regards the entire house building as an industrial fabrication process. The machine could even plaster, paint and even imprint surfaces according to one's wishes with an integrated color ink jet printer.

Because the machine is driven by a digital blueprint, fascinating new possibilities could follow: historic towns like Bam in Iran destroyed by an earthquake could be reconstructed very fast. Within days a row of CC-machines could erect entire quarters, emergency lodgings for catastrophe victims, barracks for soldiers - and some time or other, Khoshnevis dreams, "habitats on Moon and Mars".

At last Khoshnevis too may finally get his dream house: the housing-revolutionist still lives in a rented home.

MARCO EVERS, DER SPIEGEL 8/2004