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A NEW ANGLE ON PYRAMIDS

Scientists Explore Whether Egyptians Used Concrete

By Colin Nickerson / Globe Staff / April 22, 2008

CAMBRIDGE - It's a theory that gives indigestion to mainstream archeologists. Namely, that some of the immense blocks of Egypt's Great Pyramids might have been cast from synthetic material - the world's first concrete - not just carved whole from quarries and lugged into place by armies of toilers.

Such an innovation would have saved millions of man-hours of grunting and heaving in construction of the enigmatic edifices on the Giza Plateau.

"It could be they used less sweat and more smarts," said Linn W. Hobbs, professor of materials science at Massachusetts Institute of Technology. "Maybe the ancient Egyptians didn't just leave us mysterious monuments and mummies. Maybe they invented concrete 2,000 years before the Romans started using it in their structures."

That's a notion that would dramatically change engineering history. It's long been believed that the Romans were the first to employ structural concrete in a big way, although the technology may have come from the Greeks.

A handful of determined materials scientists are carrying out experiments with crushed limestone and natural binding chemicals - stuff that would have been readily available to ancient Egyptians - designed to show that blocks on the upper reaches of the pyramids may have been cast in place from a slurry poured into wooden molds.

These researchers at labs in Cambridge, Philadelphia, and St. Quentin, France, are trying to demonstrate that Egyptians of about 2,500 BC could have been the true inventors of the poured substance that is humanity's most common building material - used in everything from Rome's Pantheon to Boston's Big Dig.

At MIT, Hobbs and two colleagues teach a course called Materials in Human Experience. Over the years, undergraduates in the program have recreated from scratch such artifacts as Samurai swords, tinkling Meso-American bells, and even a swaying 60-foot plant-fiber suspension bridge like those built by the Incas.

Now a scale-model pyramid is rising in Hobbs's sixth-floor lab, a construction made of quarried limestone as well as concrete-like blocks cast from crushed limestone sludge fortified with dollops of kaolinite clay, silica, and natural desert salts - called natron - like those used by ancient Egyptians to mummify corpses.

The MIT pyramid will contain only about 280 blocks, compared with 2.3 million in the grandest of the Great Pyramids. And no whips cracked overhead last week as Myat-Noe-Zin Myint, Rachel Martin, and three other undergraduates stuffed quivering just-mixed "Egyptian" concrete into cobblestone-sized wooden molds marked "King Tut Plywood Co."

"It feels like Jell-O, but will turn rock-hard," Myint said of the sharp-smelling concoction.

The aim of the class is to teach engineering innovation, but the project may also prove that ancients, at least in theory, could cast pyramid blocks from similar materials, which would have been available from dried river beds, desert sands, and quarries.

Hobbs describes himself as "agnostic" on the issue, but believes mainstream archeologists have been too contemptuous of work by other scientists suggesting the possibility of concrete.

"The degree of hostility aimed at experimentation is disturbing," he said. "Too many big egos and too many published works may be riding on the idea that every pyramid block was carved, not cast."

Archeologists, however, say there is simply no evidence that the pyramids are built of anything other than huge limestone blocks. Any synthetic material showing up in tests - as it has occasionally, even in work not trying to prove a concrete connection - is probably just slop from "modern" repairs done over the centuries, they say.

"The blocks were quarried locally and dragged to the site on sleds," said Kathryn Bard, an Egyptologist at Boston University and author of a new book, "An Introduction to the Archaeology of Ancient Egypt."

"There is just no evidence for making concrete, and there is no evidence that ancient Egyptians used the stuff," she said.

The idea that some pyramid blocks were cast of concrete-like material was aggressively advanced in the 1980s by French chemical engineer Joseph Davidovits, who argued that the Giza builders pulverized soft limestone and mixed it with water, hardening the material with natural binders that the Egyptians are known to have used for their famous blue-glaze ornamental statues.

Such blocks, Davidovits said, would have been poured in place by workers hustling sacks of wet cement up the pyramids - a decidedly less spectacular image than the ones popularized by Hollywood epics like "The Ten Commandments," with thousands of near-naked toilers straining with ropes and rollers to move mammoth carved stones.

"That's the problem, the big archeologists - and Egypt's tourist industry - want to preserve romantic ideas," said Davidovits, who researches ancient building materials at the Geopolymer Institute in St. Quentin, France.

In 2006, research by Michel W. Barsoum at Philadelphia's Drexel University found that samples of stone from parts of the Khufu Pyramid were "microstructurally" different from limestone blocks.

Barsoum, a professor of materials engineering, said microscope, X-ray, and chemical analysis of scraps of stone from the pyramids "suggest a small but significant percentage of blocks on the higher portions of the pyramids were cast" from concrete.

He stressed that he believes that most of the blocks in the Khufu Pyramid were carved in the manner long suggested by archeologists. "But 10 or 20 percent [of the blocks] were probably cast in areas where it would have been highly difficult to position [whole stone] blocks," he said.

Barsoum, a native of Egypt, said he was unprepared for the onslaught of angry criticism that greeted peer-reviewed research published two years ago by himself and scientists Adrish Ganguly of Drexel and Gilles Hug of France's National Center for Scientific Research.

"You would have thought I claimed the pyramids were carved by lasers," Barsoum said.

Advocates of the concrete-block theory admit it's tough to prove, because any cement made by ancient Egyptians would have been concocted from pulverized natural limestone, with binding materials made of similarly natural materials. To eyes less eager to find concrete, the binders might look just like impurities in an ordinary stone block.

Nearly every prominent Egyptologist is adamant that the pyramids are made solely of giant blocks cut with crude copper or stone tools. They note that proponents of the concrete theory are chemists or materials specialists with little experience at ancient digs - lab researchers, not shovel-wielding field archeologists.

Ancient drawings and hieroglyphics are cryptic on the subject of pyramid construction. Theories as to how the Egyptians might have built the huge monuments to dead pharaohs depend heavily on conjecture based on remnants of rubble ramps, as well as evidence that nearby limestone quarries contained roughly as much stone as is present in the pyramids.

Zahi Hawass, head of Egypt's Supreme Council of Antiquities, minced no words in assailing the concrete idea. "It's highly stupid," he said via a spokesman. "The pyramids are made from solid blocks of quarried limestone. To suggest otherwise is idiotic and insulting."

Hobbs and his students are undismayed by the controversy.

"It's fascinating to think that ancient Egyptians may have been great materials scientists, not just great civil engineers," Hobbs said. "None of this lessens the accomplishments of the ancient Egyptians, although I suppose pouring concrete is less mysterious than moving giant blocks. But it really just suggests these people accomplished more than anyone ever imagined."

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