

# A Concrete Slab for Y3K

by Martin Holladay

For the past ten years, a Hindu community in Kauai, Hawaii, has been planning the construction of a traditional stone temple. According to accounts in *Hinduism Today*, Satguru Sivaya Subramuniyaswami, the spiritual leader of the community, told the architect that he needed a concrete foundation designed to last at least 1,000 years.

Deva Rajan, owner of Canyon Construction in Moraga, Calif., was one of the builders consulted. "When we asked, 'How do you create concrete structures to last 1,000 years?' No one had a ready answer," said Rajan. "In the construction industry, we are never asked to perform work for this kind of longevity." It turns out that most steel-reinforced concrete structures eventually break apart when the rebar begins to rust.

"All concrete is porous to some degree," says Wilbert S. Langley, a civil engineer and concrete consultant from

Sackville, Nova Scotia. "As corrosive ions from the atmosphere — sulfates and chlorides which are part of acid rain — percolate through the concrete, eventually the steel corrodes. I would say, optimistically, that present-day concrete structures will last 75 years before the onset of corrosion."

Eventually Rajan contacted Kumar Mehta, an expert on fly-ash concrete from the Civil Engineering Department of the University of California at Berkeley. Mehta, an academic expert with little job-site experience, was thrilled to be invited to help with the project. "I am a materials scientist," said Mehta. "No one had asked me to design even a driveway before."

Mehta contacted Langley for help. They designed a 4-foot-thick slab of fly-ash concrete, placed over a 3-foot-deep base of compacted  $\frac{3}{4}$ -inch crushed stone.

Mehta's most surprising recommendation was to skip the steel reinforcement. "Granite doesn't come with rebar," says Mehta. According to Langley, "We are getting away from extremely rigid structures. We've found that the stronger the concrete is in the beginning, the weaker it ends up. The old Roman concrete structures were weak, but they moved under loads, and consequently they have stood for 2,000 years."

The massive foundation slab — 117.5x56x4 feet — was placed in two lifts, each 2 feet thick, during two days in August 1999. The concrete supplier, Hale Kauai, delivered exactly 1,000 cubic yards of concrete. The concrete contractor, SteelTech of Honolulu, used 50 workers to place the concrete, as saffron-robed monks looked on. For each truckload, the quantity of superplasticizer was adjusted as necessary in order to achieve the specified slump. Only one of the 108 truckloads was rejected for being too soupy.

The concrete placement went very well. Just as predicted by Mehta, the monolithic slab, which has no control joints, did not crack. "On a slab this size, with normal concrete, I'd expect a crack every 6 to 8 feet," said Dr. Craig Newton, assistant professor of civil engineering at the University of Hawaii. Mehta was exhilarated at the quality of the concrete. "This hasn't happened for 2,000 years," said Mehta. "Not since the Greeks and Romans has such a massive placement of concrete been completed without a single crack." The \$600,000 foundation is expected to achieve a strength of 7,000 psi within a year.

The foundation is now lying under 10 feet of soil. This surcharge of dirt, which weighs about 3.6 million pounds, is about the same weight as the granite



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The concrete workers, unfamiliar with fly-ash concrete, were skeptical at first about how it would finish. They were pleasantly surprised that the concrete had ample cement paste. The power screeding, bull floating, and finishing went very quickly.

blocks that the foundation is designed to support. The purpose of the surcharging is to allow the slab to settle now, before the stone walls are laid, rather than after the building is built. "The settlement to date is less than an inch," says Langley.

For the past ten years, in Bangalore, India, workers using hammers and chisels have been painstakingly carving several thousand granite building stones for the temple walls and roof. Next summer, the dirt surcharge on the foundation will be removed, and workers will begin assembling the walls — without any mortar.



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The second 2-foot lift of concrete was placed one week after the first. About 57% of the cement in the concrete, by weight, was replaced with fly ash. The slow-curing concrete has not cracked. The Hindu community gathered to watch the concrete pour with great interest, and a vegetarian lunch was served to all the workers.