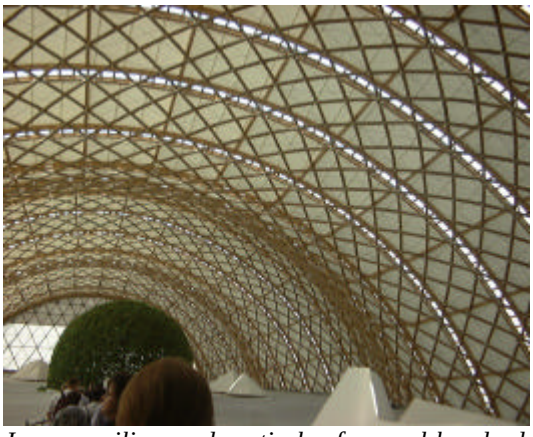
World's Fair Bamboo – 20,000 square feet

By Darrel DeBoer, photographs by the author unless noted. This article speaks to code, seismic and structural issues around one of the largest bamboo structures ever attempted.

The theme of **Expo2000 in Hannover**, Germany allowed each country to show off their ecological vision for the 21st century. The "Hannover Principles," drafted almost a decade ago after great deliberation among the best thinkers in the field of sustainability, were almost universally ignored. All the vision in the world could only generate the usual lifeless steel and glass 3D travel brochures instead of truly thoughtful design. The U.S. pavilion was conspicuously absent while virtually every other country in the world participated.

Several traditional earthen structures from Ethiopia, Yemen and Bhutan, focused well on the past. But, the only two buildings in the entire fair offering intriguing new solutions were Shigeru Ban's Japanese pavilion, made entirely of paper and the bamboo pavilion from the **Zero Emissions Research Institute** (www.ZERI.org) designed by Simon Velez from Colombia.



Japan pavilion made entirely of several-hundred-foot long cardboard tubes and resin-coated paper

ZERI's mission is to put together industries and processes where the leftover from one becomes the fuel for the next, with no waste at the end. Bamboo met their criteria well as they state that the giant grass sequesters 40 times more CO2 per square meter

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per year than pine trees, and the preservative method was to smolder bamboo sawdust to smoke-cure the culms. In effect, the bamboo treated itself against insects and fungus using the naturally occurring pyrolitic acids. The spectacular CD, available on the ZERI website explains the details through drawings, and many photos.

In a structure 14 meters (47 ft.) high, 40 meters (139 ft.) in diameter, using 4,000 Colombian *Guadua angustifolia* culms, some small diameter "Chusquea" culms (used as the ceiling under the mezzanine level) and Arboloco (Montanoa quadrangularis), or "crazy tree" wood columns; 39 Colombian carpenters built the whole building in 13½ weeks. The result is one of the few buildings that meets the modernist promise of beauty resulting from a stripping down to the bare essentials of structure. The natural curvature where the root becomes the pole is used with striking results visually and structurally. The ZERI pavilion was one of the few places in the fair where one didn't have to pay to occupy space, the huge overhangs were immediately packed when the daily rains began. In such a respite, many only then took notice of the truly natural beauty surrounding them.

Almost nobody noticed the deft use of recycled coke bottles that keep the mortar from coming out the ends of the handrails. Filled with mortar, the clear plastic looks like stone.

Scale is hard to feel in 2d images. These are 4 photos, taken with a 28 mm lens, digitally stitched together.

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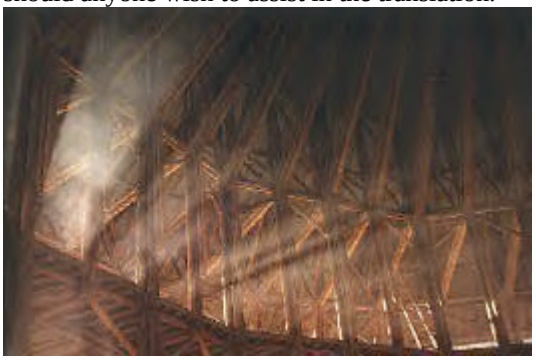
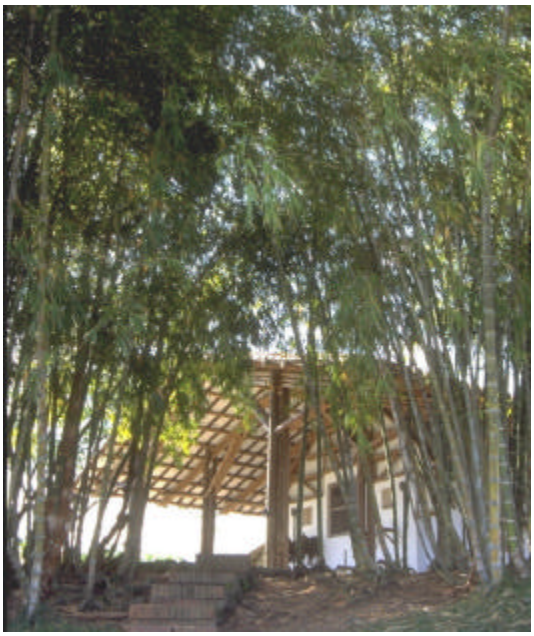
In a move that will now enable bamboo building through most of the world, the extremely thorough German engineers and fair organizers subjected the design to extreme structural testing. The authorities stated they would only accept either hundreds of pages of calculations (the criteria and formulas for which, are too conservative to approve such a structure), or full-scale testing. So, the 19,700 square foot building was built in Colombia first and passed. The high strength-to-weight ratio of the hollow bamboo kept the structure very light while still allowing much redundancy. The whole project was only possible because of the joinery system. (see the Bamboo chapter of *Alternative Construction*, edited by Lynne Elizabeth and Cassandra Adams (ISBN # 0471249513). Ten ton loads placed at the edge of the 7.5 meter (26 ft.) cantilevered roof caused a movement of just 5 centimeters (2 inches), almost all of which came back after the load was removed. It was enough to allow an identical structure for Hannover. A building permit was received the day before the fair began. The author has a copy of the original German test results should anyone wish to assist in the translation.



This image, taken by a ZERI photographer, captures the piercing quality of light



In Colombia, a 'guaduale' planted at the when this Velez building was built from the plant's predecessors

The idea for the pavilion was being formed at about the time of the earthquake in January 1999, in the coffee/bamboo-growing heart of Colombia. Nearly all of the several thousand people who died, were killed by falling concrete and brick. Throughout the region, 75% of the buildings collapsed. All of the recent bamboo work was unscathed. The town of Pijao, built almost entirely of bamboo, lost only one person - and he lived in a concrete house. Further from the epicenter, Barcelona, a town of 7,000, built of concrete, suffered tremendous damage and lost 48 inhabitants. Bear in mind that some of the older lashed bamboo structures were close to 100 years old, obviously never engineered or treated with preservatives. There was no grading or sorting to use only culms 5-7 years old – yet, still, they survived. Optimized bamboo structures could literally have saved every life in a place where bamboo poles are by far the cheapest building material.

The surprising innovation of a bamboo-cement composite roof board (www.taiheiyo-cement.co.jp)

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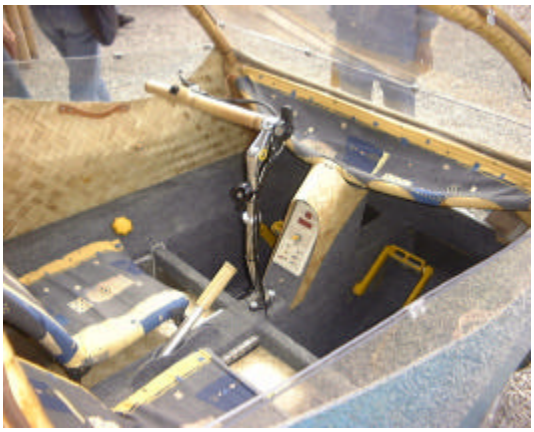
In the author's opinion, to succeed against earthquakes, structures need an appropriate combination of flexibility and resistance. The U.S. building codes are designed in a linear way to relate rigidity to strength. The Northridge quake showed that extremely rigid steel connections fail dangerously in relatively mild temblors. We think of horrible quake damage as only possible in faraway places with inadequately reinforced, "inferior" formulations of concrete, responsible for the deaths of tens of thousands of people. The problem is, we've only just recently agreed that rigidity only works up to a point. After that, resistance is futile – so to speak. Research into improving the performance of bamboo and other high strength / flexible natural materials is not just useful, it is imperative.

A 500m² bamboo floor was also included in the pavilion, supplied by Elephant Parkett GmbH (www.elephantparkett.de),

Bamboo table by Linda Garland, Will Hooker, Pintor Sirait, Alicia Romero on mezzanine floor of bamboo

Unlike all other participating pavilions, there was no country bankrolling this project, the budget was truly meager. The cost of testing was equal to building a third pavilion. Having built it in Colombia, then in Germany, non-profit ZERI paid over 2 million dollars for these "three" structures.



The electric bamboo car – using woven mat for the body, and poles for the frame – allowed easier transit around the fair.

The volunteer tour guides were the people who really made it work. To save money, several lived together in a shipping container several hours away from Hannover. They just simply believed in the project and seemed to be having a great time of it. It's almost enough to give one hope.

It was known from the beginning that the structure would not be able to be dismantled because of the mortar poured into the joints. Despite great lobbying efforts to find an alternate use on the original site, the pavilion was destroyed in early 2001 to make way for a parking lot. An inglorious end to a building that spoke so eloquently of our potential future.