Overview
This paper is intentionally sketchy about specifics because of the many variables involved for someone to try to replicate the work here: bamboo species, age, curing method, wall thickness, bolt size & material, mortar type, and especially design variables. This work is very buildable and that by knowing some of the details of the way Velez works, we might begin applying some of his methods in the U.S., especially with smaller structures for which permissions can more easily be received. Larger structures should involve Mr. Velez – there is no substitute for experience.

Velez is a graduate architect, from the University of Colombia in Bogota. He has completed over 60 projects using a controlled palette of concrete, bamboo, mangrove wood, woven palm mat lathing (or expanded metal lath) and clay roof tile. This view is up at a ceiling through the palm mat lath.

In Velez’ designs, roofs framed only with bamboo are capable of cantilevers as long as 28’ (above). Especially intriguing when considering how much weight is in his standard roofing of clay tile set in a full mortarbed – he feels the heavy roof is needed to combat the high winds, exactly the opposite of conventional wisdom in the U.S. Clearly, we have much to learn.

The two critical breakthroughs Velez is able to teach us relate to the bolt joinery with filled internodes and the approach which uses no sheet goods (such as plywood) to achieve extraordinary shear strength in high wind and earthquake areas.

In the image above from the book, Tropical Bamboo, one can see a rare simulation of what Europeans saw when they first came to this part of the Andes.
continuous, feathery guadua forest. While the botanists have classified several sub-species of Guadua, Velez feels that many of the plants are the same species, and it is the different climate and soil type, which have great effect on plant characteristics and pole quality. For example, Bogota is too cold: a little too high in elevation (2600 meters) for Guadua to grow. His source of poles is in the lower elevations outside the city, but there is a significant structural difference between the 8-inch (20 cm.) diameter coastal Guadua and the preferred 4-inch (10 cm.) which grows in poorer soil and slightly cooler temperatures. When Velez works in neighboring regions and countries, he brings a supply of the favored bamboo with him. Learning the appropriate microclimate for each strain of each species is one of our most arduous tasks in the U.S.

Velez has developed a very interesting model for building experimental structures. He builds only with his own well-trained crew of workers, so he is able to constantly draw upon past successes and failures in detailing. He intentionally keeps drawings simple, usually freehand on single sheets of 8x11 graph paper. Full-sized details are mocked up on-site or are referenced from the memories of past jobs.

In traveling with Velez, I saw numerous original drawings sprinkled over the jobsites. Because he is free of the contentious architect/contractor
relationship, his drawings are done completely to serve the building.

To Velez, the building is all that matters. If absolutely required, the client must obtain Building Permits, but he won’t help. Velez views every moment’s delay as an impediment to the most important task of building. Detailed drawings are seen as another delay. The client is shown very few drawings. What is important is that the client maintains absolute faith in his ability to execute the work.

He keeps that by making drawings that embody the intent of the structure.

Most useful are the section views which are usually repeated through the whole building.

The clearest concept to be seen in his drawings is the necessity for balance. These cantilevers are very large, but maintain an obvious center of gravity over the support.

All joinery is done with bolts, he never uses tying because the bamboo shrinks and the joints become slack. Sometimes the bolts are reinforced with straps where the forces are the greatest.

His experiments have made his buildings exercises in statics - keeping most of the members in tension, but where compression and shear exist at the bolted joints, he fills the internode with mortar to keep the bolts from crushing the walls of the bamboo.

With many of his center-bearing trusses (posts close to the middle of the truss), the point of great strain is the very ridge. Across the ridge Velez puts a steel strap which is bolted through the bamboo on either side. In stress tests, it is this strap or the bolts which fail. He has yet to see the bamboo fail.
The only substantial publication of his work is a book published by Rizzoli call Tropical Bamboo, now out of print. If you can find a copy at a library, it is the best source for giving a context to Velez’ work. In it, Velez wrote, “At the beginning of this century, two successive fires in Manizales razed only the upper-class houses. The rebuilding of the city center and cathedral saw the first use of concrete and marked the demise of the use of bamboo or any kind of wood. Ever since, in Colombia, bamboo and wood have been synonymous for slums and misery.”

When he does a structure that he considers experimental, he charges little and tests at full scale. Clients don’t let him test those structures to failure like he wants, they live in them.

These images show that bamboo used as bamboo, taking advantage of its unique qualities is capable of so much more than solid wood. We can begin to transition to the use of structural bamboo in this country by building structures half as big as these and still feel confident in the integrity of the material.

It is important to note that in Colombia, the wealthy are now accepting a material that is inexpensive and associated with poor people.

Pound for pound, the Guadua has a better tensile strength than steel. The structural strategy is to design trusses which take advantage of the tensile strength of bamboo, then, where the inevitable shear and compression loads exist, the internodes, through which bolts are placed, are filled with concrete.

A passive solar, bamboo-framed house where the mortar and plaster is put to good use as thermal storage.

Velez believes traditional joints are unreliable. If structures are to be plastered, organic ropes can’t be cinched up in 3 months when the bamboo shrinks or in 2 years when the humidity rots the rope. Guadua is so strong and will definitely continue to shrink and
He advocates a rigorous approach to structural engineering where the stresses are spread out more evenly throughout the structure. That way, in theory, many of the bolts could actually be removed because the structure is in static equilibrium. Just the key joints are reinforced with concrete.

One of his first structures, with no preservatives. The beetles which immediately attacked, ate the soft, starchy interior of the bamboo and then exited, having done no structural damage because all the strength is derived from the bamboo’s hard outer shell. (Powder-post beetle infestations in temperate, thinner-walled species like *Phyllostachys* can be much more devastating.) His early designs shared the characteristic of this barrel-vault truss, which put components primarily in compression.

Photos of Velez’ design of the Colombian Pavilion built for the year 2000 Hanover Exposition can be found at [http://www.zeri.org/](http://www.zeri.org/) Imagine, a 9000 square foot public building of bamboo. German tests showed that ten ton loads at the end of the trusses deflected 5 cm. The expo runs through October.

(photoby Luis Camargo of ZERI)

Lessons learned
Velez’ methods of work are, in many ways, different than those in use here. Some of the key components we can come away with include the strong scientific basis of the design – he considers bamboo a “high-tech” material, deserving of very rigorous detailing. His intuitive ideas come from long experience with the qualities of the material.
Above all, bamboo structures which employ these long spans are still quite new and I urge extreme caution. Because just one flawed, uninformed design can cripple future building possibilities, we should all err on the side of being too conservative and overbuild redundant systems guaranteed to be the last to collapse in catastrophic events.

"Fish-mouth" joints on both ends of a line of poles make precision a necessity.

Velez’ new office under construction

An art gallery with a bed made of guadua.