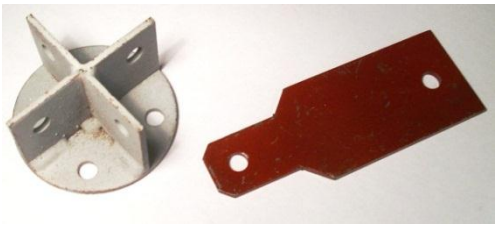
Bamboo space frame structures

Ingemar Saevfors, August 23, 2012

As can be seen in airports, exposition halls, and multipurpose facilities space frame structures are often used to cover large roof spans. The space frame design is based on nodes connecting pole members of a standard length in a three dimensional and triangular pattern in a way that resembles four-sided pyramids[1] between two horizontal grids. The free space between the lower and upper decks of the structure is often used for conduits, sprinklers and ventilation systems. The lower deck is ideal for supporting ceiling panels but often the structure is left uncovered and used as a strong architectural expression. Normally the construction system is based on steel components industrially manufactured at millimeter precision. The challenge is always the connector design when eight members are meeting in one point. Unfortunately these high tech construction modules come very expensive.

An interesting feature however, is that only a relatively short length of the pole members is needed and once an equal distance between the nodes is maintained the poles could take different shapes in between. This was the rationale behind « *La structure spatiale en bois de brousse* », a design for using local round wood in West Africa for school building roofs.[2]

Cantine, École suédoise, Pointe Noire, Congo Architect : Ingemar Saevfors



Habitropic´s
Space Frame Connector of welded flat steel

Obviously bamboo is a perfect candidate for this concept with the tubular form of the culm and there are already applications in Latin America. Again the challenge is to design a reliable pole connector to be produced at a reasonable cost. In addition the bamboo culm end is vulnerable to cracking and great care must be taken when transferring loads to the connector nodes.

Architect: Leiko Motomura, São Paulo, Brazil

[1] octahedrons

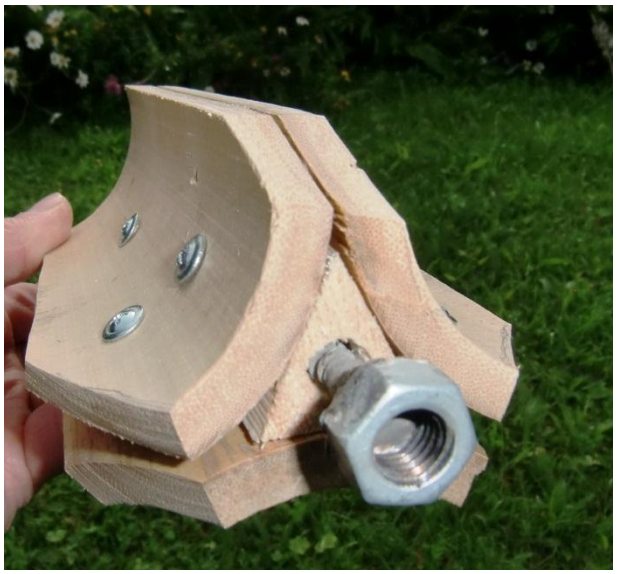
[2] Way back in 1982 Habitropic, a Swedish company founded by a few Africa veterans developed a connector system for locally available round wood poles. This technology was intended to be a low cost alternative for buildings with large spans such as schools, workshops, meeting halls, storage facilities…

Space frame structure for solar panels

Bamboo dimensional standard:
Purlin back-to-back assembly

We are currently developing a space frame roof structure with solar panels as the covering material. For this purpose the upper deck must be perfectly planar, hence a dimensional standard is required to get an equal height all over. The parallel, longitudinal cutting of a culm and then screwing the halves back-to-back works very well to make purlins. We have tested prototypes and this build becomes incredibly strong. The obvious risk of cracking seems to be eliminated if the bamboo is protected from rain and sun by the roof itself.

However, the upper deck members of the space frame structure are compressed by the weight of the roof and consequently subject to ***buckling*****.** In other words these members can yield in any direction and therefore the usual rectangular beam design (width x height^2) does not make much sense. Therefore we are exploring a three piece variety of the same back-to-back method.



Buckling resistant bamboo assembly

To address the challenge of narrowing eight member ends such that they can connect in one point, the shape of plastic PET bottles are used. The cut-offs have the perfect nose form and fit well with 10 cm diameter bamboo. A 10 mm diameter rebar with a welded-on nut is inserted and the whole configuration is filled with mortar. The plastic material could later be removed or left as "*coffrage perdu"*.

To reduce the weight of the mortar, expanded clay bubbles[3] are mixed in as the compression strength will still be within sufficient margins (10-20 MPa) for the necessary load transfer.

To avoid bending moments in the connection points the axes of the eight poles should converge as much as possible as explained above. A special connector device, "PET CROWN" has been designed for this purpose. Pieces from standard steel pipes and flat steel are welded

The "PET CROWN" space frame connector

together providing the exact angles for the space frame geometry so as to achieve the right connection point. With some training local metal workshops and "*les bricoleurs du quartier*" should be able to manufacture these components.

[3] Like the Haydite material in USA

Of course the welding quality of the steel parts has to be severely controlled but a simple test device based on a manual lever could be enough to simulate the max tensile stress. This factor depends obviously on the roof span and other parameters so some structural engineering is required. However, a standard layout for typical spans and loads could be provided as a low cost design alternative.

August 23, 2012
Ingemar Saevfors
ingemar@saevfors.se