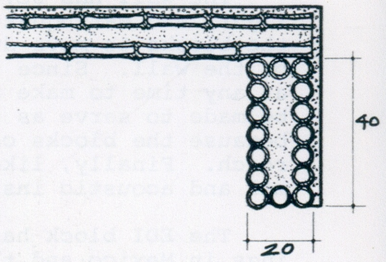
Science Cabinet #1
V. Economics
1. PREVI: composite
Bamboo Foam Beam

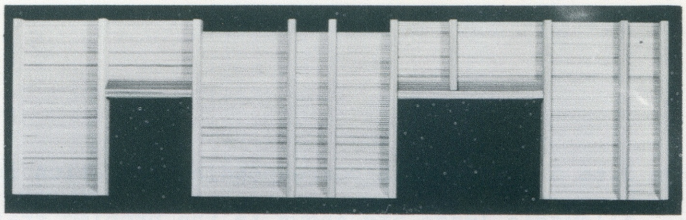
COMPOSITE BAMBOO FOAM BEAM



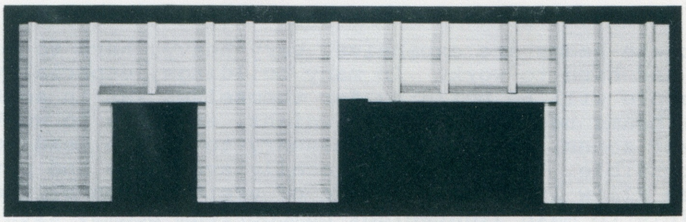
IN THE PROYECTO EXPERIMENTAL HOUSE, all beams are rectangular section boxed beams, 20 cm wide, 40 cm deep, and 5 meters long. The beams are made of 6 cm bamboos, placed over plywood templates, with a core of two lb. density polyurethane fire-retardant foam, foamed in place. The bamboos are pinned and and spot glued together at 50 cm intervals, with epoxy glue and wooden dowels.

The framing model is shown below. The second storey floor beams are all supported by interior partitions or columns, and have clear spans of 3 meters or less - except in the family room, where they span 4.50 meters between shear walls and impost blocks, and are spaced close together to make up for the long span. The roof beams span the full 4.80 meters between impost blocks, and are spaced at intervals ranging from 1.50 to 2.40 meters.

The second storey floor is designed to carry 200 kg/m^2 (bamboo foam plank 15 kg/m^2, sulphur cement topping 45 kg/m^2, second floor partitions 50 kg/m^2 and live load 90 kg/m^2). The roof is designed to carry 80 kg/m^2 (bamboo foam plank 15 kg/m^2, thin topping 20 kg/m^2 and live load 45 kg/m^2). To put a third



Second storey ceiling



First storey ceiling

storey on the house, additional beams will need to be inserted (they can be slipped onto the impost block easily), and the topping on the roof increased.

At these loads, the beams have a deflection of less than 1/360 of the span, and can safely be plastered. (See table on page 207 below). Families who do not like the appearance of the exposed bamboo can plaster them.

THE GENERAL PATTERN IS:

Context:

Short spans and light loads in countries where bamboo is abundant and cheap.

Solution:

Beams may be made of bamboos (pinned and glued with epoxy) to form a box which is filled with plastic foam. Spans may range from 3 to 5 meters with corresponding variation in beam spanning. Allowable loads are shown in the problem statement.

Problem:

Concrete beams are expensive, very heavy, hard to move around, and hard to work. In many buildings, especially those where people will be building for themselves (as in self-help housing) beams need to be light weight, and easy to work. In earthquake zones, it is also necessary to reduce dead loads as far as possible. If bamboo is locally available and petroleum resources allow local manufacture of urethane foams, then it is possible to make lightweight bamboo/foam beams, with excellent structural characteristics.

We have built three different beams of this type, and tested them. It is clear from our tests that bamboo/foam beams of this type are about as strong as softwood beams of the same size. The most serious problem is deflection. Bamboo is extremely strong in tension, and the urethane foam makes the beam section rigid; but the bamboos tend to slip past each other in horizontal shears.

In the third of the three test beams, we pinned and spot glued bamboos together with epoxy glue and dowels. This test beam was 20 cm wide, 40 cm deep. We tested it over a clear span of 3.50 meters. At a uniformly distributed load of 1300 kilograms the deflection reached 0.8 cm after an hour, and showed no sign of further creep 24 hours later.

We may use the formula:

$$\text{Deflection}_{Max} = (5/384)WL^3/EI$$

to obtain a value for EI, and extrapolate the following figures for maximum allowable uniform loads, at various spans:

Clear span between supports (meters)	Maximum allowable uniformly distributed load, for beam deflection less than L/360 (kg).
3.00	2200
3.50	1620
4.00	1240
4.50	980
5.00	800

(where the design criterion is L/240, for unplastered conditions, these loads can be increased by 50%)

These beams will cost 100 soles per meter (compared with about 200 soles per meter for comparable reinforced concrete beams), and weigh about 20 kilograms per meter (compared with 50 kg per meter for a reinforced concrete beam of similar strength). Furthermore, these beams can be cut with simple tools: they can easily be lifted and installed by two men.

It is important to note that the beam type described here is by no means the last word in composite bamboo/foam beams. Much development is needed to explore others which use different indigenous materials in place of bamboo, other foams like high-density sulphur foams, and new glues and bonding agents. The sketches illustrate some of these possibilities. For discussion of urethane foam manufacture, see page 213.