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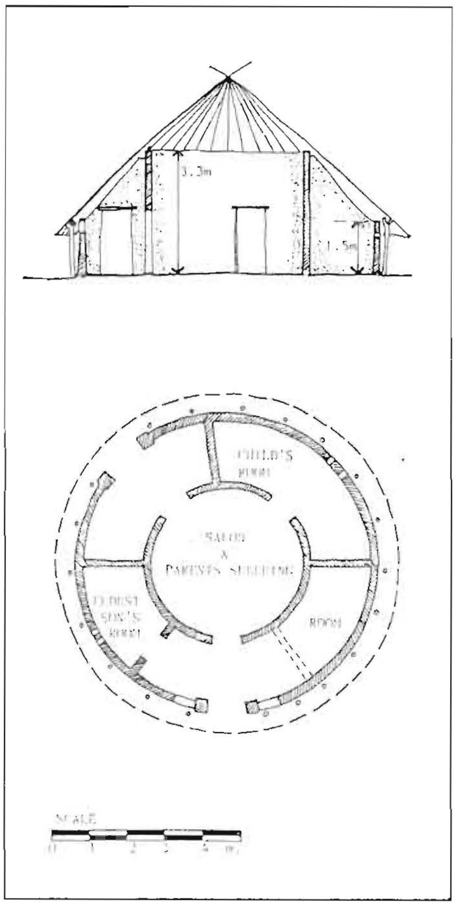
Limitations on Improving Earthquake Resistance: the Explotation of Local Materials."

A Case Study in Guinea-Conakry.

INTRODUCTION

Following the December 1983 earthquake (magnitude 6.3) in the Koumbia region of North West Guinea, Development Workshop was invited to assess building damage and to organise a programme to assist people in their ability to build houses which would stand up in the event of another earthquake. Before the earthquake the majority of people lived in round houses, built with mud, wood, bamboo and grass, (Fig.1.) A few people lived in houses built „en dur", using reinforcement, concrete, fired bricks, cement blocks, and corrugated sheeting. Local ability to achieve this latter type of housing was very restricted.

Traditional round house, Koumbia area.



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Damage to housing

Both the round houses and the few rectangular houses that were built with local materials had thin (150mm) load-bearing walls and thatched roofs. Of these, older houses usually had walls made of a wood and bamboo lattice framework, with mud packed into the gaps and plastered over the surface. These walls withstood the earthquake well, but had frequently been damaged by termites and were therefore unsound. More recently people had been building walls with mud blocks and no framing, and these, with little resistance to shaking, suffered badly. Were it not for the termite problem, the lattice wall would have been much superior. Buildings of „en dur" materials also suffered major damage, mostly as a result of bad workmanship and poor use of materials.

THE PROGRAMME

In planning the programme of assistance it was important to try and avoid working with techniques, forms or materials which, whilst performing well in terms of earthquake resistance, failed to be readily accessible to the local people who were the intended beneficiaries. The programme had also to take into account that, whilst for the time being the majority of people would continue to build with local materials and in traditional forms, there was nevertheless a growing minority who were changing from round to rectangular houses, and from local materials to construction „en dur".

The shortage at a national level of the materials needed for construction „en dur" and the money to pay for them was reflected in the situation in the Koumbia area. Locally, lack of both transport and skills for construction „en dur" reinforced the fact that any attempt to assist house reconstruction would have to be based upon the use of local resources, and especially if the people were going to be able to meet not just their immediate building needs but also their longer-term needs.

The programme comprised working with the local builders to develop with them building techniques which they found workable and acceptable. It led to the construction of several demonstration buildings, destined as houses for teachers. The purpose was not to demonstrate a model house, but to show techniques and principles which the villagers could use in the construction of larger or smaller, round or rectangular houses according to each family's need. Three basic house / construction types were chosen, reflecting the range in the materials people might use, and the shape of the house that they might wish to live in.

The house types were as follow:

I. A traditional round house form built with mud block, bamboo and thatch.

II) A rectangular house built with mud block, bamboo, thatch and some timber in the roof frame.

III) A rectangular house built with a reinforced concrete frame and walls of fired brick, with a corrugated roof on a timber frame.

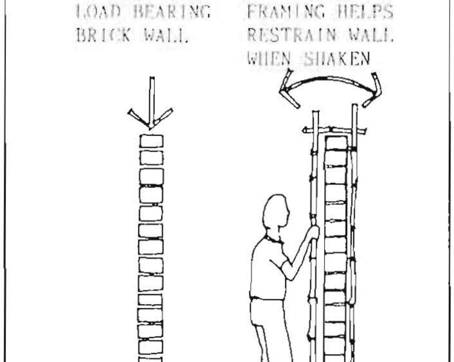
These demonstration buildings were sited in four seperate villages in the damaged area. By the end of Development Workshop's input four buildings with local materials were structurally complete, and eight others were scheduled for completion by the Guineans on their own. Construction with „durable" materials required improvement in quality rather than any real innovation, and as such the rectangular house type built with „durable" materials is not the subject of this paper. However, for both the building types using local materials there were a number of weaknesses which required innovation as much as improvement in quality.

Wall construction with mud and bamboo

As noted above, the walls made of mud plastered over a wooden frame provided resistance to movement and damage caused by an earthquake. They had the drawback that the structure of the wall was made of organic materials and therefore easily destroyed by termites. Termite attack left the wall weak even though the outer coating of mud plaster might show little sign of deterioration, and therefore little need of repair. On the other hand, the walls made out of mud blocks, whilst not destroyed by termite attack, had little resistance to any movement or shaking, particularly because they were very thin. This latter type of wall will, however, last a long time under normal circumstances when no movement occurs and when suitably protected against moisture.

It was therefore necessary to develop a building system that made use of the mud block's potential long life and stability under normal conditions, but which also incorporated the benefits of having a wooden or bamboo frame which could provide resistance to movement or collapse during an earthquake. The system had to address the problem of termite attack, and avoid the need to rebuild after the organic materials have been destroyed. One basic concept was developed for both the round house and the rectangular house built with local materials.

A minimal foundation was used, the main purpose being to protect the mud from ground water. The walls were built with mud blocks and mud mortar, one block thick according to local practice. This wall provided the load-bearing structure to support the roof frame and the ring beam that it rests on. Lattices of horizontal and vertical bamboos were placed on both sides of the wall and tied tightly together by wires passing through the wall. This enveloping lattice restrains the wall in the event of movement, with the intention that at least the occupants will have time to escape outside in the event of an earthquake. The mud walls were plastered before the bamboos were attached. The bamboos are intentionally left visible (unlike in the traditional wall where they are buried inside the wall) so that the house owner can see when they are rotten and replace individual bamboos without touching the structure of the building, simply by undoing the attaching wires, removing the destroyed bamboos, and replacing them with new ones, (Fig. 2).



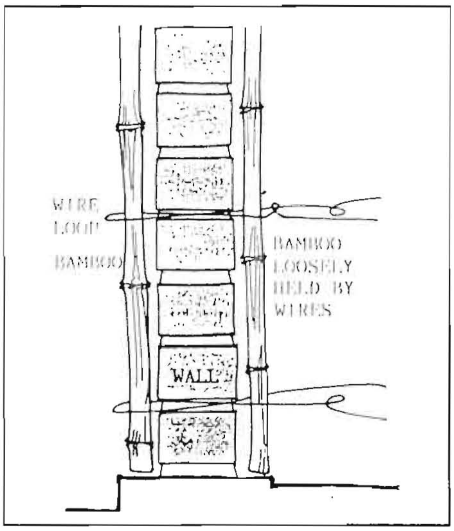
Concept of mud block wall and removable bamboo framing

(Illustration from the training manual [Norton 1986] prepared for use after the programme.)

The junction between the bamboo framework on adjacent walls is important on both the round and rectangular buildings, but particularly at external corners, where an additional vertical bamboo is placed over the joint of the horizontal bamboos.

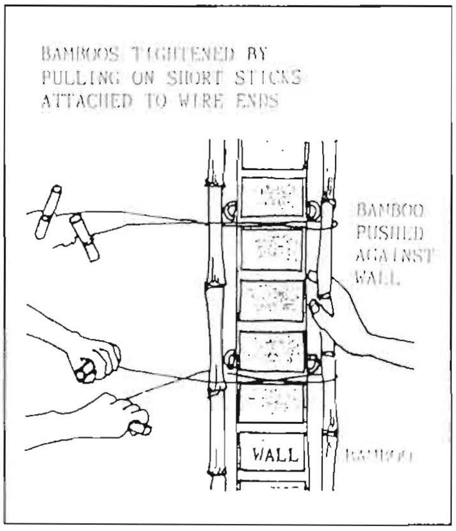
The wall building process

The mud walls were built up with mud mortar. As each third course of block work was laid, an assistant, following behind the mason, pierced a small hole through the damp mud mortar and passed the two ends of a piece of wire through the hole, so that on one side there was a loop large enough to take a 40 mm diameter bamboo, whilst on the other side two tails of wire hung out of the hole, for attaching round a bamboo later on. Once the walls were finished, they were plastered with mud and the framing could then begin.



Initial placing of bamboo framework

The vertical framing used whole bamboos cut to the right length beforehand. Each bamboo rested on the foundation and projected at least 200 mm above the top of the wall so that it could be attached to the ring beam and roof framework. On one side a vertical bamboo was passed through the wire loop, whilst on the other side a second bamboo was loosely held in place by twisting the two wire ends round it, (Fig. 3). These verticals were placed at a maximum of 0.8m centres. Every bamboo on one side of a wall was matched by a corresponding bamboo on the other side, directly opposite it.
Split bamboos were prepared for the horizontals, by smoothing off each half round split face so that it will lie flat against the surface of the wall. The horizontal bamboos were then slid along betwen the vertical bamboos and the wall, and resting on the wires at every third block course. When all the bamboos were in place, two short sticks were attached to the wire ends. While one man pushed against the wall on the side of the loops of wire, another took the two short sticks and pulled the wire tight, twisting them to secure the frame, (Fig. 4).

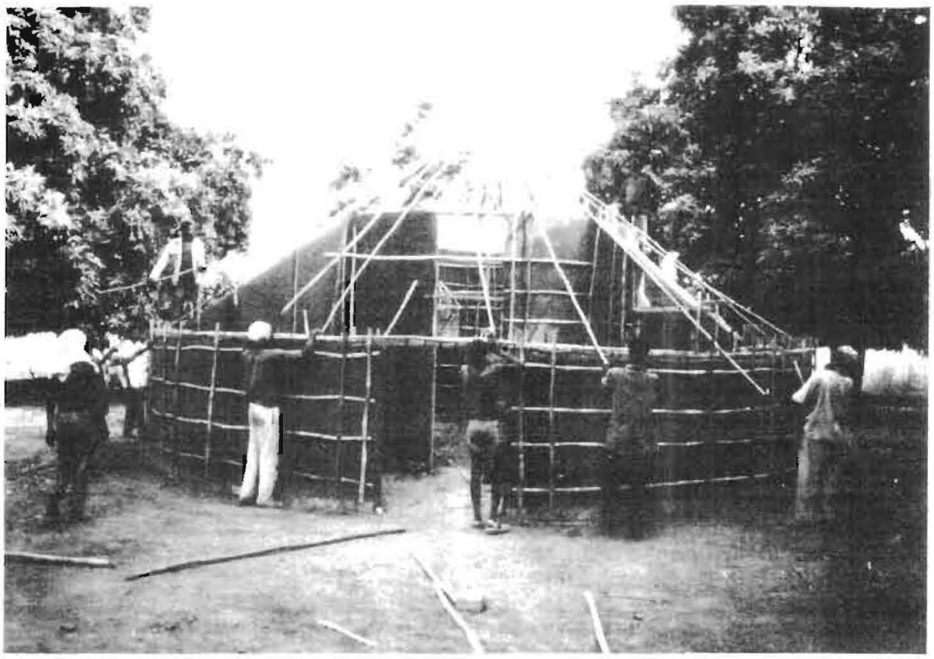


Securing the bamboo framework

When the bamboos were tight against the wall and the wires secured, the sticks were removed from the wire ends for use on the next pair of wires, and the loose ends of wire were tucked away neatly behind the bamboos. To make sure the bamboos would lie flat against the wall, the process of tightening was started half way up the wall and then continued at the top and bottom. On top of the wall a short transverse bamboo was laid and tied to the verticals, and the ring beam was then placed on top and attached. When the wall framing was in place, the roof framing was assembled and attached to the wall frame, and the building then thatched in the traditional manner, (Fig.5).

CONCLUSIONS

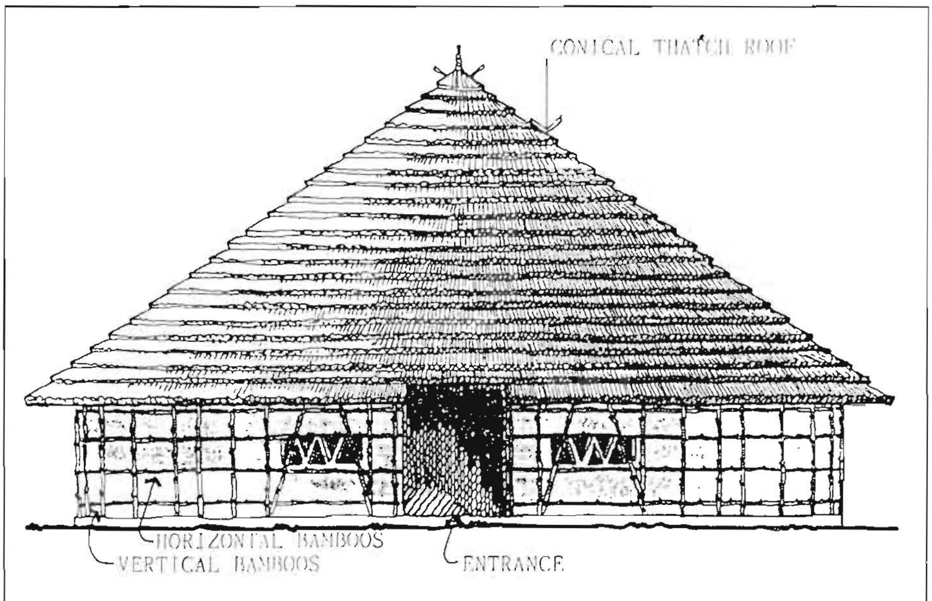
The purpose of this case study is twofold. Firstly it illustrates a programme and a technique for increasing the earthquake resistance of thin mud wall structures, and thus it may be of some relevance to others faced with a similar situation to that described in this paper. But the second purpose is perhaps more important, and is concerned with the distance between the



reality of what many poor people can afford and achieve on the one hand, and the existance and development of techniques and materials which are able to meet a specific need - in this case, to provide safe shelter. The reality is that for many people the options for how to improve the quality of their shelter are extremely limited, by their lack of means, by their poor access to materials, and in many cases by the insecurity of their situation. The issue then is not primarily how to identify or develop techniques which will, for example, make earth wall construction safer in an earthquake, but it is rather how to ensure that any techniques which are introduced are both accessible and capable of adaption to meet local and individual needs and the abilities of each family. To do this entails achieving a compromise between what is technically desirable, and what may be practically applicable. In the Koumbia programme the whole system of using bamboo to frame the walls was refined during the practical programme, which took an initial concept and adapted it in the course of the programme to suit the local conditions. This meant that there was little opportunity for testing under simulated earthquake conditions. Similarly, the foundations of the local material buildings were intentionally made as minimal as possible in order to reduce cost to locally realisable levels, even though more substantial foundations would have helped to tie the base of the building together: the shortage of transport severely restricted local ability to obtain materials suitable for the foundations. It would have been of little help locally to introduce or develop ideas which, although technically desirable, were beyond the resources - material, financial, or human - of the local population.

REFERENCES

NORTON, J (1986). „Manuel de Construction Parasismique en Guinée", Development Workshop, Toronto.



Completed demonstration round house