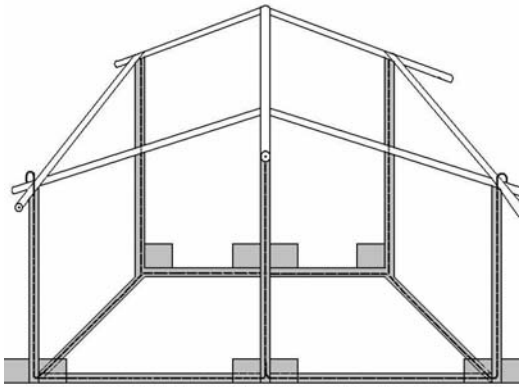


Bamboo Technology

- The challenge for HFH- Nepal was to proceed with costly houses as it has started working with Micro Finance groups and Village Banks. These families had got used to the habit of incremental loan system and the MFIs were reluctant to lend a huge amount to its members at once. Situation being such, if MFIs were to partner for Housing Micro Finance then they had to be assisted with cost effective housing as well as a technology that could help them for incremental improvement of their houses.
- Giving due attention to the above ‘Status Quo’ HFHI-Nepal having done its initial survey on construction methodologies available within the area started promoting bamboo technology as an alternative construction technology
- According to our discovery bamboo has been the construction material used in about 70% of the houses we found in the districts of the eastern part of Nepal. However it was evident to us that those houses were not done properly and have not followed the accepted scientific standards of construction technology – walls were not straight not reinforced and the bamboo is exposed to the effects of external elements such as sun and rain with no foundation to stand on steadily. As a result the houses looked poor and had to be repaired every year and therefore the age old bamboo technology has been looked down upon as inferior and suitable only for temporary shelter.

As **we discussed and opened up dialogue with the community** and showed them the advantages of bamboo and the steps that could be taken to improve the aspect of durability (duration and strength) of bamboo people started showing interest in using bamboo. With simple drawings and constant follow up and finally with model houses we could fill the technological gap by adding the scientific knowledge and technological expertise to enhance the traditionally accepted, user friendly, environmentally sound technology to make the locally available material- bamboo more accepted and the construction to be ***stronger, durable and more practical***

- Construction expertise demonstrated on the design of the house with a solid foundation with concrete reinforcement and rod inside the pillars tied to the roof so strongly thus lessening the damage and the risk in the face of natural disasters like earth quakes, strong winds or storms. This was the first eye opener for the community to talk differently and to accept HFH as providers of sound technology.



For greater understanding a Video on CD is attached as “Construction Technology in Nepal”)

Then to make bamboo durable, and therefore to be accepted by the community the treatment of bamboo was introduced.

Chemical treatment- Injecting



NATURAL TREATMENT BY SMOKE



In Ilam – east of Nepal in preparation for the 1500th house and to train Canadian Architects decent houses in Nepal.

Starting with a pilot program and expanding on the same, introduced families the new bamboo technology that is user-friendly, community-driven, environmentally sustainable, durable and conducive in different climatic conditions. Additionally it also provides alternative income generation activities through growing and harvesting bamboo.



Completed house in Nepal with the use of bamboo technology

The impact and challenges of using these building methodologies.

Impact

1. The immediate impact is on the number of families served as it is evident that there is a 6 fold increase in the number of families served per month eg. 10 houses to 61 houses per month
2. The program has become a 'community owned' program as the technology is known and owned by the community being it a heritage of the communities of Nepal especially the under privileged, neglected and the deprived community like the Choudry, Moussarie, Kumbal, Dalits. Women of these groups with their artistic and creativity will add beauty to their houses.
3. These have added pride and dignity to them promoting their own heritage and tradition.
4. Construction of houses has resulted in the increase of awareness of the need to protect the environment. The increased use of bamboo in construction will produce a 70% reduction of plantation timber used thus helping to reduce deforestation, encouraging new and existing bamboo cultivators to grow more bamboo, utilise wasteland, unused land and river banks, which will result in better soil conservation and mitigation of flood disasters.
5. Eight well renowned architects plus 4 journalists from Canada visited Nepal to learn this unique technology from Habitat, and their interest was so much that they initiated a special fund titled 'Canadian Architects Legacy Fund' and was instrumental in attracting more donors to help HFH Nepal.
6. As such, together with these architects HFH Canada formulated a proposal to seek funding assistance to set up a 'Bamboo Corrugated Roofing Sheet' Factory in Nepal to further promote the technology introduced by HFH Nepal and also to fill the gap of finding a better roofing solution. CIDA has agreed to fund it.
7. Eight women architects in Nepal have formed in to an Architects Club in Nepal to work with HFH Nepal as advisory committee of architects because of the innovation through bamboo and the impact they see especially on the lives of women.

8. This initiative has increased the options for income generation as bamboo mats can be made and marketed as more and houses are built.

9. As demand for bamboo increases more people have started cultivating bamboo. The Faculty of Science and Technology, Purbanchal University, Birantnagar, Morang and the District Soil Conservation Office has started providing training to the community and monitoring the increase in production. This is mainly due to the fact that Habitat Nepal is setting up of a bamboo roofing sheet factory to cope with the demand in the increase of houses.

10. As a result of HFH staff providing training to the communities to treat and process bamboo, many families have adopted the art of bamboo mat weaving as it is a traditional practice.

11. Although local skilled labourers are experienced in constructing houses with bricks and bamboo they lack training in cost-effective methods. They also lack experience with building in stages, adherence to quality controls, construction codes and building strengths. With the training provided by HFH Nepal these people have improved on their skills and today one of the partners, Sahara Nepal does not need HFH staff to supervise and monitor the construction of the current year as they have their own trained staff and workers.

12. The District Soil Conservation office, has taken a lead with HFH and Sahara Nepal to provide education on the environmental impact of bamboo cultivation. Communities learn how bamboo has a significant impact on the environment by way of adding oxygen to the atmosphere, reduce soil erosion. By ways and river banks can be easily utilised for bamboo cultivation, which will in turn tone down floods and related disasters.

13. Additionally the District Soil Conservation Office and Sahara Nepal has taken the initiative for providing training to the community on planting bamboo along riverbanks as flood reduction measures in partnership with Disaster Management committee already in place in the districts.

14. The image and the recognition of Habitat's work in Nepal have not gone unrecognized. Its reputation for achieving results both in construction and in micro financing, creative leadership and team building drew up US\$25,000 from Canadian Architect Legacy Fund that chose Habitat as the catalyst partner in Nepal. The Fund was established as a revolving fund in June 2006 to mark the 35th anniversary of the founding architects who graduated from the University of Manitoba in Canada.

15. Three times Habitat International has focused on bamboo construction technology of HFH Nepal in its publications- Habitat World, Habitat Update and Asia Pacific News.

(Attached as "bamboo house appeared in <http://www.habitat.org/ap/news/2006/>")

In Nepal two TV channels and three news papers carried news articles on bamboo technology and today HFH Nepal has won a special place among many partners as an expert in bamboo construction.

16. In January 2007 HFH Nepal was invited to present a paper on cost effective and traditional technology at the INTBAU (International Network for Traditional Building, Architecture and Urbanism).

Challenges:

1. The biggest challenge faced was to change the mindset of the people to accept that bamboo construction is durable. Constant orientation and awareness program, distribution of educational materials and community group meetings have been helpful in addressing this issue.
2. Acceptance of “cement” and ‘burnt bricks’ as the sole durable construction material by the majority. Research findings and the model houses have been able to make a change on this though still it remains a challenge with all media and construction world being supportive of the same.
3. Less cooperation received from the village skilled labourers in promoting the bamboo technology. We have conducted many workshops and training and also have shown them the benefit they too receive if we improve on the bamboo technology.
4. The prevailing old houses depict a poor picture of bamboo technology. Therefore, people tend to see all bamboo construction as poor technology though treated bamboo is durable for more than 30 years according to research done.
5. Inability to build houses with bamboo in all parts of Nepal. We find that bamboo can be grown in most parts of Nepal but for the rest of the places where bamboo will not be freely available we have also designed houses with rocks and also with clay bricks (sun burnt) and daub with special technology to make them stronger and to the standards.

The interventions that are underway to ensure the sustainable use of these building methodologies in future.

With HFH Nepal's initiative HFH Canada in partnership submitted a proposal to CIDA to set up a bamboo plant to produce bamboo corrugated roofing sheets and has been approved for funding. The factory is being set up. This is being a great achievement as bamboo roofing will be a new material in Nepal as no one else manufactures them. We have not been meeting a long felt need for a roofing solution that is environmentally and economically viable.

Be able to assist families without them having to pay back a lot to HFH as HFH will invest still less comparatively.

In order to continue with the introduced technology we have already drafted the construction manual and some videos to be helpful for the home partners as well as the skilled labourers to understand and learn better.

This in turn will assist the partners to build the capacity of their staff and HFH Nepal will closely work with those to build their capacity as well.

We are in a process of developing the quality standards and architecturally recognized designs to suit different parts of Nepal. Already formed advisory committee consists of Architects and engineers who are an asset on this venture.

Promote income generation related to bamboo technology and to grow still more bamboo in partnership with the government both local and central, and also introduce the same to the MFIs and the Village Banks. This is also one of the objectives of the proposal submitted to EU seeking funds for a broader program while at the same time to assist housing related activities to benefit many more families.

A way forward in making housing affordable:



(280 Sq.ft house, Stone foundation, Bamboo wallplastered with cement



330 Sq.ft.house, Stone foundation, Bamboo wall plastered with cement



(280 Sq.ft. house, stone foundation, Bamboo wall in timber frame with cement plaster and tin sheet roof)



294 Sq.ft. house, stone and concrete foundation Concrete pillar

“WE HAVE NOT INHERITED THE EARTH FROM OUR FOREFATHERS, BUT WE BORROWED IT FROM OUR CHILDREN”

Alternative construction materials

There is a myth to accept burnt bricks, cement and reinforced Concrete as the *only* material that helps constructing durable houses. In general concept, use of cement and sand in maximum quantity are the reason for durability of house. Nevertheless, they are costly and not so affordable to the poorer families. On the other hand when we look back into our history and traditions both in Nepal and all of South Asia we see a difference. Clay, lime and stones have been the best used materials to build massive structures and palaces in the past and those have lasted centuries and withstood natural calamities.

What do we learn from this scenario? We are challenged, especially those who are involved and shares expertise in construction, to come out with some innovative yet scientific methods, techniques and alternatives to overcome the housing problem that has direct impact on 40% of the total population who live in inadequate housing in Nepal and more than 60% of the rural population of Nepal plus all slum dwellers in the urban areas of Nepal. (Source: *Five Year Business Plan, HfHI-Nepal. 2005*).

This manual suggests some of those materials that we have worked well so far with great success though initially it was challenging to change the mindset of the people. BUT we have overcome.

Guidelines for Selection of construction materials:

1. Study of prevailing condition of house which is going to renovate or, new construction.
2. Keep record of materials which may be used after dismantling (if old house is going to dismantled)
3. Survey for different kind of materials which are locally available for construction.
4. Short-list of available materials and record their prevailing rates.
5. Make comparison with different BOQs presented in this book.

What we have presented here will not suffice to overcome all the issues at the field level. Therefore if you need further assistance please contact Engineering Department of HFHI-Nepal.

"We can't solve problems by using the same kind of thinking we used when we created them"

Albert Einstein

Some of the alternative materials we do work with for cost effective housing:

1. Bamboo
2. Sunburn Bricks
3. Stone Boulders
4. Local wood

1. Bamboo:

Bamboo is a non timber evergreen plant that is mainly distributed in subtropical and tropical zones. Bamboo grows fast and has a high regenerating rate. Once planted, bamboo has new shoots every year. Usually bamboo can be harvested for culms purpose in the third and following years. Bamboo is both a decorative and a structural member. For shelter purposes bamboo culms between 60 to 100 mm diameters are generally adopted, which means that most of the bamboo species available are within this range.

Bamboo is widely used as a basic timber for rural housing. It is used as poles, purlins, trusses, rafters, mats for wall/ceilings/roof, frame of doors & windows and fence posts, especially in tropical countries. Though it is a natural product, the presence of large amount of hemi cellulose, starch and abundance of moisture makes it highly susceptible to biodegrading agent like white-rot, soft-rot, brown – rot, group of decay fungi and stain fungi and insects like borers and termites. In rural areas people are using bamboo without treatment. So it doesn't long last and this has created a myth in the minds of the people that bamboo is not a durable construction material. But with a simple treatment on bamboo the strength and duration of bamboo could be as long as 25 -30 years. (www.caneandbamboo.org)

Species:-

Most of the large bamboo species available in Nepal are said to be appropriate for housing structures. It is important to have culms between 60 and 100mm diameter for structural member of housing. Select only fresh and light grayish green colored bamboo which is almost matured and avoid using culms with signs of deterioration or infection.

Harvesting considerations:

1. Choose only those bamboo which are more than 3 years of old and it can simply determine by observing the color of the culms has changed from clear and shiny green to Grayish green and white bands at each node that have almost disappeared with replacement of gray bands.
2. As chances of attack by fungi will be more while moisture content is large so it is better to harvest bamboo in dry season.
3. Always cut the bamboo 20 to 30 cm above the ground or just above the first node.
4. Always use sharp tool or saw to avoid damaging of bamboo.
5. Keep the bamboo aright with support of other trees or on such arrangement for two to three weeks which helps to reduce the starch content of culms and as a whole it helps to reduce the chances of attack by insects or Bostrichidae and Lyetidae beetle.

Treatment of Bamboo: Bamboo can be treated mainly two ways)

1. Non chemical Treatment
2. Chemical Treatment

1. Non-Chemical Treatment:

Traditionally the following treatment methods are adopted.

- a) Water immersion treatment
- b) Smoking
- c) Using diesel (*Source: National Building Code-1994*)

a) Water immersion treatment:

Normal practice followed in many bamboo producing areas is to immerse freshly cut bamboos in running water for about three to six weeks and keep it them for at least one week. By this treatment starch from bamboo is leached out making the culms immune to insect attack.

b) Smoking:

This method is simple and effective .In this, bamboo are kept in a temporary smoking chamber to destroy starch by allowing smoking until they have a slightly dark color on its surface.

c) Using Diesel:

Dry bamboos, both whole and split could be treated with light diesel oil by dipping in to.

1. chemical treatment:

Several permanent treatment method are available to protect bamboos and from insect attack and fungal attack. These methods are both preventive and remedial. For such kind of treatment many kind of chemicals are in use like creosote oil, Borax and Boric Acid.

- a) Internodes Injection :** Internodes injection for whole bamboo (poles and columns) 20-25ml Creosote oil poured through 6mm hole in each inter node, the hole is closed with wax or putty. It is rolled once in two days for a week before it is put to use. The oil gets absorbed through the inner walls through the cross structural area, this treatment is used for dry bamboo.

b) Diffusion process:

In diffusion process freshly felled culms or bamboos having moisture content of above 50% are kept submerged in preservative solutions for 1-2 days followed by stacking under shade for 10 – 15 days. To treat dry bamboo culms, they are be wetted before content will be about 50%. Split bamboos are also could be treated in this way and this way this treatment is more effective in split bamboos and slivers. By puncturing or drilling holes near the internodes before submerging them in preservative solution, treatments could be carried out for whole bamboos. The hole thus made can plugged with putty after taking the bamboos from the treating solution before they are stacked. This method will enhance penetration of treatment solution in whole bamboos. Preservatives which could be included – Boron, compounds, Copper chrome – Arsenic (CCA), Copper chrome – Boric (CCB), Acid copper chrome (ACC) (*Reference: www.caneanbamboo.org*)

Split bamboo in preservation solution

Picture # - 15

Possible building structures and points to be remembered:

Mainly bamboo are used as various construction material in housing as from foundation to the top. It may either be used as reinforcement on sub soil foundation, as horizontal tie member for plinth, lintel, and top of wall as well as rafter and purlins of roofing work. From ancient time different architectural buildings are made up of bamboo. In this present scenario of eastern rural and sub urban part of Nepal, most of the houses are made up of bamboo as variety of structures. Generally from technical point of view, bamboo is stronger in tensile member but it may also be used as column with some of engineering techniques. It is recommended that it is not wise to use bamboo as horizontal member on more than 10-12 feet without middle support and only to be used after treatment as mentioned above. By special care and treatment, it prolongs the age of structural bamboo up to 30 to 40 years.

Fabrication: - cutting, joints and finishing:

The dimension and size of the bamboo are mainly depends on structural component and loading. While designing any shelter or house, the built up area as well as the spacing between two partitions is more important. 11 feet to 15 feet between two partitions generally are suitable without having a support in between. In bamboo houses generally, the slant of the roof of GI or corrugated bamboo roofing sheet are used so the height will have to be maintained not more than 8 feet on lower side and 11 feet on top side. For the different purposes on housing bamboo can be fabricated as follows:

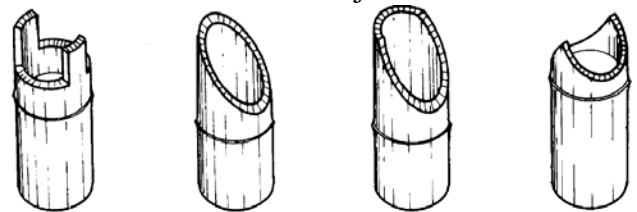
Picture # - 16

Bamboo Column



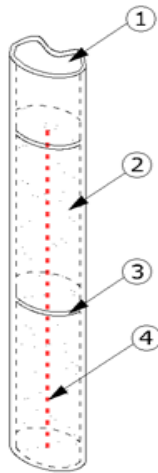
SN	Member	Recommended size Diameter in mm	Standard length in feet	Remarks
1	Post for Columns or vertical members	80 to 100	9.5 to 12.5	Recommend to be used in pack of four to give more strength as shown in the Pic.#-15
2	Horizontal members like tie of plinth, Lintel and wall top.	80 to 100	7.0 to 15.0	Recommend to be used in pairs to give more strength.
3	Roofing bars as rafter and purlins	60 to 100	12.0 to 15.0	Base bars should have thicker and stronger bamboo as compared to upper bars which are used for clamping J-hooks.
4	Split for tatty wall	Below 60	More than 4.0	Recommended to use the upper part of bamboo which may not be used as structural member.

Only basic carpentry, Masonry tools and skills are necessary for the construction of bamboo houses. Figure below shows end profiles of bamboo poles for use in construction. For the joints and other clamping points these kind of cutting or fabricating is preferred. With clear instruction and proper workmanship we may get such a kind of joint arrangement with using steel clamps and nut arrangement.



In the proposed bamboo house the columns are constructed from whole bamboo poles. The poles are fixed at the level of foundations/plinth. For this purpose the end 500 mm of

the pole is injected with cement based mortar and reinforced with a steel bar- see Figure # 5. The bamboo should be reinforced in this way before mounting them in the foundations.

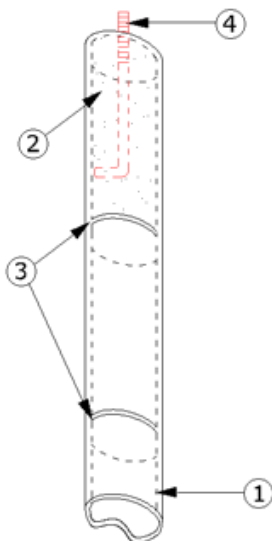


- ① Bamboo pole column diameter min Ø100 mm
- ② Cement based mortar infill
- ③ Removal of transverse diaphragm of bamboo culm
- ④ Mild steel bar Ø10 concreted inside the bamboo of length 500 mm

Figure # - 5

All bamboo columns are connected at the top to a timber or bamboo with some steel plate. This beam has a rectangular cross section for timber and hooking arrangement of reinforcement from bamboo. The bamboo pole column is connected to this beam through an anchor bolt.

The anchor bolt is embedded in the pole where cement based mortar is injected- see Figure # - 6.



- ① Bamboo pole column diameter min Ø100 mm
- ② Cement based mortar infill
- ③ Transverse diaphragm of bamboo culm
- ④ Anchor bolt concreted inside the bamboo min Ø12