

# **BAMBOO HOUSING TRAINING WORKSHOP MANUAL AND CURRICULUM**

**Synopsis:** Exemplary manual and curriculum of a workshop held in Aizawl (Mizoram/Northeast India), including low-cost housing from Ecuador and high-end constructions from Colombia.

## **Detailed description of the technology**

### Preface

Among the multiple uses of bamboo, its utilization in the construction of buildings of various types is notable, as it addresses a basic human need viz. the need for shelter. A variety of building traditions have evolved in different places, as the technology of building with bamboo is influenced by numerous factors such as the various species and their characteristics, local uses and traditions, seismic factors, topography, soil quality, tools, etc. The scope of possible uses of bamboo in building construction, however, is enormous, ranging from emergency relief to low-cost and to permanent and high-end structures.

In order to address a common misconception about bamboo being the poor man's timber and being a temporary building material at best, bamboo constructions must boast the qualities, which each and every construction must comply with. These include safety and protection from natural disasters, endurance and resistance against atmospheric and other biotic and non-biotic agents, comfort for the inhabitants, easy maintenance, aesthetics and economy.

The present manual is based on a workshop carried out by the authors in Aizawl, Mizoram, in October/November 2001. The annex to the manual provides selected resource material from the workshop. It is the hope of the authors that this document would be used as a guide for future construction workshops which INBAR and other institutions may plan to carry out worldwide.

### IMPORTANT DEFINITIONS

**Target Group:** The group of people intended to benefit from the activity. Target groups can be defined on the basis of educational background, profession, training needs, cultural background etc., and can include government officers, specialists, professionals, workmen, craftsmen, or anyone interested in the topic or benefiting by living in a bamboo dwelling.

**Type of Construction:** Bamboo can be used in the construction of dwellings, community centers, schools, medical centers, etc.

**Construction System:** System of components and procedures permitting the construction of a building.

**Demonstration Models:** Small-scale models or reproductions enabling a better understanding of the building system.

**Building Elements:** Parts of a building such as foundations, structures, floors, walls, doors, windows, roofing, etc.

**Building Components:** Fundamental effective jointing giving a framed construction its structural integrity.

**Demonstrative Module:** Architectural structures more complex than a building component. They are neither an architectural component nor a constructive component of a building, but rather an independent element of less importance and volume which may be attached to or

separated from the main construction, such as gates, bus stops, temporary shelters, guard houses, etc. Said structures tend to be larger than building components.

**Model House:** a dwelling with its components: foundations, structure, paneling (walls and ceilings), flooring, roofing, electrical wiring, plumbing, doors, windows and paneling (walls and ceilings).

1:1 Scale Model: A real life model.

## 1. Preparation

### 1.1 Strategy: Defining the target group, focus and scope

The characteristics of the target group(s), i.e., previous knowledge, academic levels, skills, etc., will determine the focus and scope of the workshop. It should ideally be de-signed keeping in mind multi-disciplinary groups.

The workshop aims at training participants in such a way that they may build any type of construction with bamboo being its main component. It should therefore not focus on a specific type of construction (dwelling, school, community centre, etc.) but rather on the construction method. This includes understanding the material to work with, preservation methods, the steps to follow in order to accomplish a construction, and the tools to be used.

To adequately accomplish this, consultants should visit the site and familiarize themselves with the local people, their customs and traditions, well before the workshop. Interviews with counterpart(s), observation of building techniques, traditional tools and characteristics of local bamboo species, and ideally a gap analysis as regards participants' training needs can go a long way towards a well-designed event. This would also enable them to get to know the materials and tools available, as well as to visit and choose the location(s) where the theory and practice sessions will take place. It is also important to interview residents and to listen to their opinions regarding their needs and aspirations. The workshop agenda can be developed based on technical visits to various types of con-structions in the area while observing positive and/or negative aspects of traditional and local bamboo constructions.

The consultant(s) must be able to rely on the support and assistance from a counterpart with sufficient experience in regional/local construction systems, and ample knowledge on bamboo together with the ability to manage personnel and on-site crews. He should also be responsible for advising on and procuring ahead of time the materials and tools necessary for the workshop. The need for supervision requires that the counterpart be able to attend the workshop full time. An agreement (MOU) should be drawn up, which delineates the responsibilities of each of the cooperating partners.

Local government agencies must be tapped regarding building codes and future housing projects, together with practicing and teaching professionals. Multiplier agencies for knowledge dissemination should be invited in order to make the event more cost-effective. These could include urban and rural housing agencies, NGOs, etc.

Attendance to workshops should be limited to a maximum of fifty (50) persons and would depend on the number of consultants conducting the workshop, available space and other resources. A workshop should not last more than one week considering the fact that participants have to take time off from their regular work.

A housing training workshop should not be overly ambitious. Building a model house is an option, but it is not a requirement for a successful workshop. Therefore, depending on time

and available resources, there may be alternative options such as:

- Building bamboo dwellings prior to the beginning of the workshop.
- Not more than two (2) weeks before the workshop a small dwelling may be begun and concluded during the workshop.
- Building only part of a dwelling (e.g. a completed bedroom)
- Improving a local dwelling might be a relevant contribution to the community.

## 1.2 Logistics checklist

In order to prepare a workshop, it will be helpful to draw up a checklist of everything that needs to be taken care of, including division of responsibilities and deadlines. The following is a rough guideline, which will require adaptation in a given situation. A steering group consisting of international, if applicable, and local organizers should be established for the purpose.

### 1.2.1 Location

Generally, accessibility including communications and transport infrastructure and civil amenities are important considerations when planning for a workshop. Bamboo housing training workshops, however, may require to be carried out in remote places where these conditions can rarely be met. The workshop organizers and support staff need to ensure adequate and sufficient:

- assistance to international participants (invitations for visas, relevant information on climate, travel, security issues, vaccination requirements, etc.)
- accommodation, preferably close to the workshop site (theory and practice sessions)
- local transport, to and from the workshop site
- meals, preferably close to the workshop site
- workshop site facilities:  
conference room(s) with sufficient seating capacity and audiovisual equipment,  
facilities for practical sessions (work places, tools, materials, etc.),  
ventilation, the possibility of darkening the conference site, electric power or the availability of generators, and water
- communication facilities (phone, fax, Email, Internet).

### 1.2.2 Resources

#### 1.2.2.1 Human resources

Organizers and local support persons are responsible for planning, preparation and implementation of the workshop. The respective responsibilities for administrative and technical matters, procurement, etc., arise from the planning process and need to be assigned clearly. During the workshop, a secretariat responsible for handling and facilitating all aspects of running the workshop smoothly needs to be set up. The necessary human resources for the bamboo housing training workshop include:

- Organizers (international and local), responsible for:  
administrative and financial aspects,  
assistance to participants and resource persons,  
organizing technical and support personnel,  
purchasing the necessary materials and tools,  
providing the audiovisual, communications and photocopying equipment,  
handling all unforeseen matters.
- Resource persons (architects, engineers, builders, agency and NGO representatives,

community leaders, etc.), responsible for:  
assisting those organizing the workshop in developing the agenda,  
preparing all printed material as well as audiovisual material necessary for the presentations and practical sessions,  
requesting beforehand all equipment required  
preparing a list with the specification and numbers of tools required,  
preparing a list with the materials needed for the practice sessions,  
whenever the construction of a model house is planned, sending the architectural and structural drafts beforehand -with details and installations- together with all technical specifications and with the amount of materials,  
attending the planning meetings for the theory and practice sessions,  
organizing the work groups, taking into account the various working methods,  
advising the work groups on design work and practices,  
attending support and discussion round tables,  
preparing the evaluation,  
preparing the reports and manuals resulting from the workshop.

- Support staff:  
Conference technical and managerial support,  
Masons, carpenters, craftsmen, etc.

A variety of government departments concerned with bamboo development at the various stages of the production to consumption spectrum may be considered for providing counterpart services and for co-financing the event. These may include forestry, agriculture, housing, industry, tourism, etc. Apart from official departments, a special effort must be made to tap into the resources of NGOs and private sector businesses.

If it is decided to construct a model house, this may have implications for the training of masons, carpenters and craftsmen. Moreover, this is always an ambitious goal and may require construction to begin well before the official inauguration of the workshop.

#### 1.2.2.2 Material resources

Compared to a cut-and-dried and theory-based workshop, a bamboo housing training workshop requires a range of materials, which can pose a significant challenge to the organizers, especially in a remote locale.

- Equipment, materials and tools for construction and for practical training sessions:  
Specification and quantification of tools and construction equipment will result from the planning process and will have to strike a balance between the availability of local materials and tools and the requirements of the resource persons. Allow for a sufficient period of time for this purpose. Construction materials should be procured well before the beginning of the workshop, preferably locally, as the utilization of locally available materials is one of the objectives of promoting bamboo houses. Materials for practical training sessions may have to be obtained during the workshop, depending on participants' requirements as to design and practical sessions.

- Audiovisual equipment: This is very much standard equipment and includes overhead projector, slide projector, PC and LCD projector, liquid marker boards, projection screens, laser pointer, paper board, video equipment (VCR, DVD player, TV monitor), etc. As bamboo housing training workshops may tend to take place in remote locations, availability of certain items may be restricted. Resource persons should be aware of this and be prepared to use low-tech means of presentation.

- Participants will generally need to stay in touch and communicate with their home base. Especially in remote locations, communication facilities including phone, fax, Internet and Email (temporary accounts) may have to be provided timely and specifically for the event.

### 1.3 Marketing the event

Apart from capable resource persons, a relevant curriculum and stimulating contents, the success of the workshop depends heavily on promoting the event across the spectrum of stakeholders. It cannot be assumed that there is always a natural tendency to share knowledge across different government departments and to include also the non-government sector. Although local advertising is the responsibility of the local counterpart, the steering group in charge of organizing the event is well advised to look into and to ensure balanced participation by local, regional and international stakeholders. Last but not least, the need for further dissemination of knowledge as a follow-up to the event requires that key multipliers (agencies, NGOs, community leaders, business associations, etc.) are informed and invited to the workshop.

Depending on the scope of the workshop, national or international promotion of the event is the responsibility of the national and international sponsors, as applicable, using the range of available media including web sites, Newsletters, etc.

## 2. Implementation

The workshop concept is an interactive one, allowing for participants' inputs and creativity while infusing the audience with ideas and inspirations, which can then be moulded into new approaches combining local traditions and 'exotic' elements.

The objective is to familiarize participants with general and basic concepts of bamboo treatment, utilization and handling. They should not intend to copy foreign construction methods but rather learn about diverse traditions and tools, adopting and adapting them for their own purposes.

The workshop features three main modules viz. (i) theory, (ii) design and construction of jointing systems, and (iii) design and construction of complex structures. Modules (ii) and (iii) each have an evaluation component, which can be watersheds, separating dreams from reality. Throughout modules (ii) and (iii), participants and resource persons interact closely.

### 2.1 Module 1: Theory

Theory sessions consist of lectures by resource persons and participants' contributions, perhaps interspersed with field demonstrations to maintain the attention curve. These sessions, particularly the participants' contributions, need to have chairpersons or moderators to manage the sessions and to limit them to the time allotted to them. Discussions can be held at the end of the sessions.

- Resource persons' lectures. Suitable subject areas for theory sessions could include the following:

- History of the use of bamboo as a building material,
- Bamboo utilization and local traditions,
- General characteristics of bamboo and especially of local species,
- Natural and chemical preservation methods,
- Moisture and drying techniques,
- Construction systems,
- Building techniques,

Seismicity considerations,  
Lack of and/or need for building codes,  
Social aspects.

- Participants' contributions. This will involve participants by giving them opportunity to suggest and discuss topics of interest to them and by sharing experiences. It will also contribute to a better understanding of local issues.

## 2.2 Module 2: Design and construction of selected jointing systems

Design sessions are essential for a thorough understanding of the concepts presented and taught during the theory sessions. This enables participants to grasp, realize and in some cases improve on the teachings of their fellows. By being free to choose the subject, they become more involved and inclined to share their experiences, allowing them to question established concepts while acquiring further knowledge.

### 2.2.1 Working groups

Design sessions are best done in working groups of no more than 8 persons. If people with different backgrounds (e.g., city planners, architects, engineers, craftsmen, students, etc.) are attending the workshop, it is best to divide them among the groups, instead of organizing them according to their specialties. Each group should choose a spokesperson to present the results of its work. The resource persons supervising the group work will specify the topics to be discussed as well as the time allotted for that purpose. Participants should follow the presentation techniques established earlier.

### 2.2.2 Design evaluation

Group designs will be evaluated in plenary sessions. Evaluation by resource persons should be done in an encouraging fashion so as to pinpoint the best work and highlight innovations shared by participants. This adds an element of competition to the workshop. At the end, designs should be handed over to the resource persons for documentary purposes.

## 2.3 Module 3: Design and construction of specific and complex structures

### 2.3.1 Models

New working groups should be formed for this purpose. Group exercises include the building of various multi-purpose structures (e.g., a kiosk, bus stop, gate, etc.) because the solutions groups develop can be used in the future to improve the concepts of roof-ing, to increase spans or in other types of construction. Merely building a model house might set limits and keep the mind from wandering and dreaming. The purpose of this type of session therefore is to design a variety of structures, which will grant a broad understanding of the constructive system.

For the practice sessions, participants will be required to design and produce 1:1 scale models of construction elements or of stand-alone constructions which must, however, be feasible in the time span available. As with the design sessions, groups should appoint spokespersons that will represent the groups and explain each group's work at the end of the session.

The practical sessions will require backstopping and assistance from experienced craftsmen, etc., as not all participants are familiar with the manual aspects of working with bamboo, including proper handling of tools and materials. The risk of accidents and the need for protective clothing have to be pointed out. A First Aid kit is a must, however.

Following are a few issues to consider when it is decided to construct a model house:

- The plans -with specifications and quantification of materials and tools, together with constructive details- must be developed beforehand in order to give sufficient time to local counterparts to prepare for the workshop.
- Making a model house requires sufficient time. Therefore, its size will depend on the duration of the workshop. Hence, it may be advisable to build only a part of the house. Another matter to consider is whether said house is simply a design or practice exercise to be scrapped or used for a specific purpose later.
- Workshops will always tend to be too short to build a complete model house. On the other hand, beginning the construction before the workshop will not allow participants to partake in those first steps. Also, considering the total number of participants, they will have to be organized in groups, taking turns, in order for everyone to share in the construction of the model house.
- Another option might be to schedule the workshop solely for the construction of a specific model house. However, the number of participants would have to be limited and the theory sessions would have to be kept short.

### 2.3.2 Evaluation of models

As with the design sessions, group works will be evaluated in plenary sessions. Presentation of the models will be the responsibility of the groups' representatives. They will be required to report on the design and building process, the main parts of the model, its problems and pertinent solutions. The resource persons will then critically assess the work and point out strong and weak points.

### 3. Workshop evaluation

With a view to improving future similar events, it may be useful to evaluate the workshop from the point of view of the participants, the resource persons, and the organizers/sponsors, respectively. Such evaluation sessions should be kept short and could address inter alia the following issues:

- Positive aspects of the workshop
- Aspects which could be improved at similar events
- Resource persons, interactions between resource persons and participants
- Theory sessions
- Design sessions and results
- Practice sessions and results
- Technical and personnel support, facilities, materials and tools supply, accommodation, food, logistics, interaction between participants, etc.
- Participants' attendance
- Resource persons' suitability

### 4. Recommendations

The present Manual provides an outline and recommendations for the implementation of bamboo construction workshops, to be carried out in various places in the world. The Manual does not provide a blueprint, however, and must be adjusted to local conditions, to existing human and financial resources, to the physical and mechanical characteristics of the local bamboos, and most of all to the local customs and traditions.

Last but not least, this is a workshop aimed at participants with various degrees or levels of knowledge and/or expertise in the field of bamboo construction and in the handling of tools.

They can contribute greatly to the workshop. Their potential must be utilized and care must be taken not to stifle creativity and initiative by a paternalistic approach. Together, participants and resource persons will be complementary in spreading knowledge about bamboo construction.

Annex:

Selected Materials of the Workshop on 'Affordable Bamboo Housing in Earthquake-prone Areas'

Contents

1. Theory Sessions
2. Practice Sessions
  - 2.1 Design / construction of selected jointing systems
  - 2.2 Design / construction of specific and more complex structures

1. Theory sessions

1.1 History of the Use of Guadua in Colombia and Ecuador

Bamboo has always been present in American history, particularly in Colombia and Ecuador. Archeological and archeobotanical investigations have shown many uses of this material for over a thousand years.

A bamboo culture has been present in Colombian and Ecuadorian history in many different ways: in popular traditions, religion, recreation, music, cooking, agriculture, hunting, fishing, weapons, and other uses, many of them similar to those in Asia.

Bamboo has been used since ancient times in Ecuadorian rural architecture.

Spanish army ships were initially built with timber by carpenters, who then became urban builders and began using bamboo as an alternative construction material. Inadequate bamboo construction, however, has become a symbol of under-development and misery.

Modern bamboo technology began in America with the investigation and publications by Oscar Hidalgo in Colombia, Jules Janssen in Holland, Walter Liese in Germany, and in Asia with the work done by Dr. Lionel Jayanetti and Mr. Follett, who compiled different constructive systems using bamboo.

The work carried out by Simon Velez and other architects set the base for a bamboo technology that can be adapted to local conditions and specific bamboo characteristics.

We do not intend for our experiences to be used as blueprints but as examples that need to be adapted to local needs.

The *Guadua angustifolia* species stands out among the bamboo genus because its structural properties, such as its resistance-weight ratio, exceed some wood species and are comparable to steel and other high technology fibers. However, *guadua* covers approximately thirty species which are grown in all Latin American countries, with the exception of Chile and the Caribbean Islands, from Mexico through Argentina.

*Guadua angustifolia* is a renewable resource and contrary to most tree species it reproduces vegetatively. It grows fast, approximately 11 cm a day, reaching a maximum height of 30 m in six months. Its growth exceeds that of other native species of the region. *Guadua* reaches its maturity stage during the fourth year.

1.2. Improved Construction Systems in Ecuador and Colombia

We want to share some construction experiences with bamboo in Ecuador and Colombia. Prefabrication made large-scale production possible, reducing wastage and requiring less time



for building by using light structures made of timber and bam-boo.

These systems increased community participation. Occupants and beneficiaries can build their own houses and other community constructions without having to use complex or special tools.

In Colombia, we were able to observe recently how nature, especially during earthquakes, shows us the need to evaluate our own needs; thus emphasizing the problems associated with importing foreign technology instead of relying on the local culture and solutions.

The last earthquake which occurred on January 25th, 1999 in the Colombian coffee region indicated the fragility of bad constructions built with seemingly strong materials, having displaced guadua and wood in urban centers located in high seismic risk areas. On the other hand, the resistance and sustainability of bahareque constructions were evident and silent witnesses of the disasters around them; since they have remained standing not only during the last earthquake but also through other earthquakes that have occurred through the years. This has attracted attention from architects and engineers who should keep in mind and learn about the excellent physical-mechanical properties and great adaptability of bamboo allowing the development of earthquake-resistant construction systems.

Due to the low weight of bamboo, said constructions are more resistant to earth- quakes. Some components may fall down such as wall mortar, however, the house itself will remain standing and its inhabitants will be safe, as observed in Colombia and Costa Rica.

Guadua is a noble and resistant material with which efficient constructive systems can be developed. Some minimum norms for construction projects should be developed, for example, design protection, generous eaves, humidity protection ('good boots and a good hat'), appropriate anchorage, as well as parameters regarding structure design and practical training for construction workers.

### 1.3 Case Study: 'Hogar de Cristo' Foundation - Ecuador

The 'Hogar de Cristo' Foundation began its activities thirty years ago by building one house per day. Today it is building fifty houses per day, however, it could build up to one hundred units per day or more, should it become necessary. For example, when the El Niño phenomenon occurred in 1998, the Foundation built eight thousand houses in three months.

The houses are given to families -specially to female-headed families - having incomes ranging between \$ 0.85 US to \$1.00 US per day, thereby offering them a dwelling and/or an immediate temporary shelter which, given the Ecuadorian economical situation, may become a permanent solution. The cost per house depends on the family's economic situation and on the number of children. The highest price is \$350 US, payable over a period of three years, with no interest but with a \$10 US down payment, making it probably the cheapest house in the world.

Throughout South America, common disasters such as earthquakes, volcanic eruptions, flooding and fires leave thousands of people homeless.

In Ecuador, the Foundation has always been present whenever such things have happened, as well as local and international NGO's, other friends of the country and the local government.

#### Technical aspects

This is a prefabricated handcrafted constructive system using timber and split bamboo as the main elements, to be built on the family's lot, with conditions similar to those in Aizawl, or flood-prone sites commonly seen in Ecuador.

The self-supporting panels are of utmost importance in this constructive system, using a timber structure (5 m x 5 m) finished with split bamboo on one side. A panel can be made in ten minutes; thus, in eight hours, between thirty and forty panels can be made. The floor, roof structure, windows and doors are made from wood. The roof covering is made with sheets of fiber reinforced with cement or with metal sheets. Four non-trained persons can build a house on site in four to eight hours. Its size will depend on the family size and there are four different types of houses available:

- 3.20 x 6.40 m (6 panels)
- 4.00 x 6.40 m (6 panels)
- 6.40 x 6.40 m (8 panels)
- 4.80 x 4.80 m (8 panels)

Each owner must build the columns or stand the house as a palafitte structure. However, ground permitting, they may subsequently build the ground level with bricks.

Nevertheless, there are some disadvantages which should be pointed out: the materials used are not previously preserved as this would increase the cost of the house, making it unaffordable for the family. The house must be improved, by making inside divisions and supplying basic services, usually non-existent where the typical beneficiaries of such houses are located.

In spite of these disadvantages, the production capacity, the lower cost and the payment facilities make it the only alternative at this time for people living in conditions of extreme poverty.

Because of its social commitment, the 'Hogar de Cristo' Foundation is known worldwide, and has been rewarded by the Social Habitat Foundation from England, by the Ecuadorian Government, and acknowledged by its users trust.

#### 1.4 Works of Juan Carlos Jaramillo in Colombia

##### Social Interest Dwelling: construction

This is a prototype house, the design of which was donated by architect Simon Velez to several local agencies as well as to INBAR for the purpose of giving greater status to social interest housing (term used in Colombia for low-income housing).

Its construction is slightly pyramidal, thus increasing structural strength in order to support increased roof weight. The initial construction has no inside divisions, which depend on the dwellers' needs and economic reach. There could be a single large space or up to four bedrooms.

The same house was built for the National Federation of Coffee Growers, the difference being that its roofing consists of a double roof which affords thermal properties but raises the price of the house.

##### 'Parque de la Vida' Auditorium: design

A park was built in Armenia, capital of the Quindio department in Colombia, rendering homage to life while highlighting water as life's main element. There, between cascades and lakes, people may enjoy green spaces where the constant sound of water invites them to think, to rest, to practice sports and to travel through their imagination.

Its auditorium rests in a natural depression of the land, and the steps begin at the foot of the auditorium. Across from the pond, an acoustic shell was built, seemingly floating on the pond

and which does not clash with the landscape but blends in naturally due to its autochthonous and characteristic materials, allowing a wide view of the park.

The structure is basically a sample of propping-up guadua, giving the sensation of a great eave and making it look much lighter than it really is.

Service Station:  
design and construction

By using the same structural concepts applied in the acoustic shell of the 'Parque de la Vida' Auditorium, it was sought to give special identity to guadua itself in a local rural hotel becoming part of its decoration. Another service station such as this has never been built, as the minimum safety norms do not allow such a construction.

Tourist Information Place:  
construction

The Quindío department has historically been an agricultural department in Colombia, coffee being its main product. For the past few years, tourism has become a new industry generating excellent income. This has been made possible by its unequalled landscape, with mild weather and temperatures as diverse as its population. The enormous lodging potential consists of using old coffee country properties kept in excellent shape for tourists wanting to get away from the noise and pollution of large cities.

The departmental government decided to build some small tourist information booths, strategically located at the entrance roads to the department. They were to have an eye-catching and easily identifiable architecture. In order to accomplish this, traditional construction was carried out with inclined brick walls and its roofing made with guadua and mud tiles as a symbol of regional identity.

Country House 'Puerta del Sol':  
design and construction

This is a country house built in the traditional system of 'confined brick', using guadua as roofing structural element, as well as in the columns of corridors but only in open spaces. It is an 'L' shaped construction, completely introverted due to safety considerations by the owner, since it is a house only for weekend use.

Split bamboo was used over the guadua structure, then covered with cement mortar, supported by chicken mesh, which today is called cemento bahareque. The air between the inside of the house and the fiber-cement roofing material helps maintain coolness during the day.

The house, built before the 1999 earthquake, was located very close to the epicenter but was one of only five other houses which showed no damages. The houses surrounding it, and which had different constructive systems, were completely destroyed making it necessary to shelter their residents in the large family room for the first days following the earthquake.

'Los Cafeteritos' Kindergarten:  
design and construction

This project rose from the 1999 earthquake, as a quick and economic solution to meet the need for harbouring 100 children aged between 6 months and 7 years.

Prefabricated guadua panels, originally made in a shop, were installed and supported on a 60 cm height confined brick wall base, in line with the lower structure which helps all other elements to correctly transmit their loads to the structural walls and granting protection to the

guadua.

Furthermore, guadua and mud tiles were used for the roofing, being an integral part of the landscape. Other open structures such as the dining room were built on site, beginning with concrete pedestals and ending with widely covered generous eaves.

In this project, guadua became the dominant element, evident in the construction and in the furniture while keeping to scale with the children.

Its characteristic natural elements, helping it blend with the vegetation, and its textures, colours and scents help children recognize their own spaces in an unconscious way, transmitting cheerfulness and dynamism while fostering their potentials and development.

This is a UNICEF project in the small town of Barcelona, Quindio, assisting the children of two schools which collapsed during the January 1999 earthquake. The children had been attending classes in makeshift classrooms in tents next to a heavy traffic inter-departmental road.

Vein mesh and cement mortar were used in the walls, covering both sides of the guadua while leaving an inner space for thermal and acoustic insulation of the classrooms.

The roofing was done similarly; however, a waterproof asphalt cloth was placed over the mortar, then a wood skeleton supporting the mud tiles which were tied on it.

Light and ventilation enter the classroom through a central element placed in the middle of the roof, translucent, and made from iron.

The general design consists of 18 classrooms, distributed as a cloister with a great central patio. Construction was completed in four months and, at present, there are 1200 children attending.

Project for University Campus:

'La Gran Colombia' University in Armenia

Designing and Construction Advisor

The 'Gran Colombia' University in Armenia decided to move its Schools of Architecture and Agricultural Industry to a lot located in the outskirts of the city. Therefore, its School of Architecture is in charge of carrying out the designing, since it will be the first university to be built in guadua.

Designing is carried out by a group of students during their Designing Workshop, and Juan Carlos Jaramillo is one of their supervisors.

### 1.5 Natural and Chemical Bamboo Preservation Methods

Preservation is essential, as guadua is susceptible to insect attacks such as termites.

Preservation must be carried out in order to modify the chemical composition of the stems, making them unattractive to biological agents and/or preventing their development.

#### Natural preservation

Bamboo, as an organic element, is receptive to progressive destruction caused by attacks from microorganisms, bacteria, xylophagous insects and other factors that may limit its life span as part of a construction or furniture. Therefore, in order to extend its life span, it is extremely important to perform some kind of preservation.

Said preservation may be carried out in twoways: a) traditional or natural, b) by using chemical elements.

#### Selection of adequate bamboo culms

Bamboo preservation should begin at the time of culm selection. Bamboo culms should meet the following conditions:

- Be of the right age, that is, have reached a mature stage.
- No cracks or holes produced by birds or insect attacks.
- No twists.

Age determination is carried out in an objective manner by observing certain bamboo characteristics such as:

- Absence of sheaths.
- Culm having lost its original green color, being partially covered with circular and whitish stains from lichen, as well as from mosses and other epiphytic plants

In the case of guadua, the aforementioned characteristics indicate that a culm is mature, having reached between 3 and 4 years of age, and is ready to be used.

As time passes, the culm turns completely white, indicating that it is over 5 years old, hence no longer usable in construction.

In America and other countries (India, China, etc.) the most efficient method of preservation is that carried out in the plantation itself, immediately after harvesting.

Said procedure, called 'cured in the bush' both in Colombia and Ecuador, consists of the following steps:

- Selecting bamboo as mentioned above, then cutting it above the first knot.
- The cut culm is then leaned in an inclined position against a neighbouring bamboo culm, while supporting its base on a stone, brick or on the stump of the bamboo having been cut.
- The culm, with its branches and leaves, is left in this position for two to three weeks.
- The culm is then placed horizontally and its branches are removed, taking care not to hurt the culm nor tearing the branches off the culm.
- It is then transported to a well ventilated and covered place in order to proceed to the natural drying before it is ready for use.

The aforesaid procedure yields naturally and adequately preserved bamboo culms. During its stay in the plantation, progressive drying occurs and the inner culm starches and sugars ferment and turn into alcohol which is a natural antiseptic interfering with the propagation of microorganisms.

In Ecuador and Colombia, bamboo thus obtained is said to be 'acidulated or vinegary'.

#### Other methods of natural preservation

There are additional traditions and customs in various countries for determining the right conditions for culm harvesting.

Bamboo is usually cut:

- In the moon's waning phase.
- During night hours and at dawn
- Under conditions of low river, lake or other water source tides close to plantations.
- In the dry season.

Botanists and scientists disagree on the accuracy and significance of these methods.

#### Preservation using smoke, heat, immersion in water and other liquids

By using smoke:

Bamboo culms are exposed to smoke from kitchens or smoke produced otherwise for that purpose.

Smoke covers bamboo with soot and heat causes destruction or lessening of the starches contained in parenchyma cells, in the so-called pyrolysis process.

Smoke is generally obtained from resinous wood or bitter bark trees in the Amazon region.

By using heat:

Bamboo culms are heated in specially controlled bonfires, which causes a chemical transformation and dries the culm.

The drying leads to an increased hardness and specific weight of the bamboo culm.

By immersing in water:

The procedure of water immersion -either in ponds or rivers- causes starch to leach; thereby making bamboo less susceptible to insect and microorganism attacks.

By immersion in other liquids

In some regions of the Amazon jungle, bamboo is usually preserved by immersing it in liquids obtained from certain high tannin content plants such as the mangrove tree (Verbenaceae) and the Yrunde'y (Astronium balansae), among others.

Due to its astringent properties, the tannin of those plants, together with albumins and starches contained in bamboo, forms non-decomposable compounds.

Drying

Drying bamboo in shady and well-ventilated places decreases the moisture content of the culm to the level of humidity of the surrounding air. This treatment prevents cracks, and inhibits the growth of fungi and attacks from microorganisms. Drying bamboo consequently enhances its durability.

Chemical Preservation

Chemical preservation comprises a variety of processes to increase the useful life of bamboo. There are numerous publications on various chemical preservation solutions, most of which are polluting or toxic not only for the people applying them, but also for the dwellers and users of furniture or crafts preserved in such a manner.

Investigations carried out in different countries have shown that a water solution of borax and boric acid, also known as TIMBOR (tetrahydrate disodic octoborate and boron salt), in a proportion of 1 kg borax and 1 kg boric acid per 100 liters of water is efficient.

The aforementioned preparation is one of the less polluting chemical solutions being non-toxic, economic and having good results. Following are three different manners of applying it:

a) By horizontal immersion:

Bamboo culms are immersed in the above-mentioned solution while considering the following aspects:

- Bamboo should be dry (between 15% - 20% moisture)
- Bamboo should have been previously perforated -either in its main inner core (through 12 mm diameter perforations) or through 10 mm diameter side perforations - 2 per node.
- Bamboo must remain immersed for a minimum of 24 hours.
- Bamboo must then be dried vertically for adequate diffusion of the solution for a minimum of 6 days.

b) By vertical immersion:

Bamboo is placed vertically in order to achieve the aforementioned diffusion of the preservative solution, by following these steps:

- The main inner core is previously perforated, by means of a 12 mm di-iameter steel bar.
- The last lower node is left unperforated.
- Having been placed vertically, bamboo culms are completely filled with the preservative solution.
- The nodes are refilled daily as the level of preservative solution decreases.
- Once the level remains even, the last lower node is then perforated.
- Bamboo may be placed in a shallow pool of the solution which can then be reused, provided the levels of the original mixture are guaranteed.

c) By the 'Modified Boucherie' method:

This method, also called 'sap replacement', is carried out in the following manner:

- Bamboo to be preserved is placed slightly tilted (10% - 15%).
- Rubber connectors are attached to the upper ends of each bamboo culm.
- The connectors are linked by means of hoses to an air compressor previously filled with the preservative solution.
- Upon starting the compressor, the solution is forced through the capillary ducts of the bamboo walls, expelling its sap and substituting it by the preservative liquid.
- When the acidity indicator shows that the sap has been expelled, the process is interrupted and bamboo is then dried horizontally until it reaches the level recommended (12% - 15% moisture).

It is of utmost importance to observe that this procedure be applied during the first eight (8) hours after bamboo has been cut, since the bamboo channels or capillary ducts close up as a consequence of drying. Said drying also begins as of the cutting time and, should it continue, would interfere with the flow of solution.

#### Demonstration of preservation methods

Preservation of bamboo is not a standard procedure in many areas where bamboo is used for building purposes, thus adding to the poor image of bamboo as a temporary material. Hence, chemical treatment using fumigation was shown to familiarize participants with this important aspect. The exercise was supplemented by a short theory session where traditional non-chemical and other preservation systems practiced all over the world were discussed.

#### Other contributions

Local or regional resource persons' contributions will naturally vary according to local priorities. Below are some examples of the presentations made at the Indian housing workshop by resource persons:

- Construction Systems in India
- Bamboos of NE India: Plantation, Utilization
- Status of Seismicity in NE India and Earthquake Disaster Mitigation
- Design Tool for Bamboo Building
- Activities of Selected Agencies, NGOs, etc., in the Bamboo Housing Sector

Participants also contributed a significant number of presentations, based on their background and experiences, including construction systems in India, discussion on advantages and disadvantages, and proposals for improvement. Presentations were mostly informal and sometimes ad hoc and are, therefore, not documented here.

#### 2. Practice sessions

The theory sessions were followed by two separate design sessions, each one involving its own practice session.

## 2.1 Design and construction of selected jointing systems

In construction, there are usually various types of joints among the structural elements requiring individual solutions. However, they will be more easily solved if they follow a one and only standard system to guarantee safety and make construction easier. Initially, during the design sessions, participants were given the opportunity to study bamboo by cutting, drilling, and joining, etc., since it was, for some of them, the first time to handle the material and tools. Once the drafts and scale models of the structures proposed were completed, each of the groups began constructing a prototype, with the guidance of a resource person.

Work groups were formed for the design sessions, consisting of not more than eight persons each. A design practice exercise was suggested, requiring each group to develop a general construction system for a dwelling, which the groups would then explain in plenary sessions. Participants were to develop their design based on previous presentations by the resource persons, relying on their own experiences and their knowledge of traditional systems. Each group selected its spokesperson. Resource persons acted as moderators where and whenever required.

Designs were first made on paper and, once a specific joining system was chosen, they were realized on a 1:1 scale (real life model) for plenary presentations. Each group's work was evaluated by the resource persons and discussed in plenary sessions.

## 2.2 Design and construction of specific and more complex structures

It was agreed to have the groups build multi-purpose structures because the solutions developed could be used in the future for improving the concepts of roofing, increased opening spans, or any other construction segment. The simple building of a model house might set limits and not let the mind wander and dream. The purpose of this type of session was to design a variety of structures, thus granting a broad understanding of the constructive system.

New groups were formed for practice sessions. They were given their tasks for 1:1 scale models by the resource persons:

- a bus stop,
- a temporary and movable construction for meetings, with adaptable seating capacity,
- a three-dimensional gate,
- a small pavilion with predefined openings.

Practice sessions were carried out with the support of the resource persons as well as technical personnel to assist with the correct handling of tools, etc. Activities included the construction of various components such as joints, floors, walls, etc., on a 1:1 scale after the first design session. There was also construction of small-scale exhibition models for discussion and later construction to be carried out on 1:1 (real life) scale after the second design session.

Parallel to the four working groups, the construction of the model house was continued. This had been started before the workshop in order to be completed at the end of the event. The goal was only partially achieved due to delays in material procurement, etc. However, work on the model house provided a highly stimulating experience to some participants who were given the chance to divide their time between working groups and model house construction.

**Source(s):** INBAR TOTEM: BAMBOO HOUSING TRAINING WORKSHOP MANUAL by Jorge Moran (Ecuador) and Juan Carlos Jaramillo (Colombia)