

ARCH 384: Competition Elective
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“Although the past gives lessons it does not give whole answers to what must be done now”

Geoffrey Brown

Bamboo has a rich history of many uses, so much so, that between one-third to half the world's population intergrades bamboo into their everyday lives. (18 Smith) In many tropical and sub tropical countries bamboo dominates the natural and built environment, to the extent that twenty million tons of bamboo are harvested annually and over a billion peoples lively hoods are dependent in some way upon this natural material (157). The extensive global use of bamboo offers a vast amount of traditional and modern precedents to draw upon. Because of the vast information available, this paper will be divided into three sections; the first section will include the implication of bamboo and its benefits; I will touch upon the reasons why bamboo is often chosen and intergraded into the lives of people worldwide, some of the reasons includes the benefits of bamboo in terms of availability, economy, strength, and environmental sustainability. The second portion of this paper will deal with the structural benefits of bamboo, and will touch upon traditional uses in terms of wall systems, connections, floors and roof systems. In this particular project I have combined both traditional and modern systems to create a high performance wall system suitable for the cold climate in which this project is located, as will be discussed. Lastly this paper will cover a modern example that has influenced my design although it does not use bamboo it has traditional elements and composition that would lend itself easily to bamboo construction. I feel that this approach is the most suitable one, as it closely mirrors the approach I have taken in the design of my project. I began my work by understanding why one would chose bamboo and as I began to understand bamboo and its traditional methods I began to look at ways to incorporate this material that is traditionally used in the tropical and sub-tropical climates into a modern development located in the much colder climate of Cambridge Ontario.

Why Chose Bamboo

Bamboo is said to be one of the most used plants worldwide (Smith 157). With approximately 1,300 varieties, 75 species that cover approximately 25 million hectares in tropic and subtropical regions, it is easy to understand why bamboo is such a widely used plant. However the advantage of bamboo does not just stop at its availability, there are many other advantages, some of which include its ability to be easily assembled and dismantled, its versatility, high strength to



Bamboo Forest S. America

weigh ratio, and its ability to withstand natural disasters.

To begin with, bamboo is a material that tends to lend itself to being used as a structural member due to its great strength as to be later discussed. Each cane can easily be assembled and dismantled and replaced as needed. In many traditional uses bamboo is seen often used as housing for nomadic people its high strength and light weight make for a perfect building material for those who live off the land and move their homes frequently. However the uses of bamboo are not just limited to nomadic tribes, bamboo is a very versatile material that can be used in combination with a variety of other materials both natural and man made materials, such as raw earth and stone, and industrial materials, such as metal and concrete. Often both modern and more traditional buildings use a combination of different materials to compliment and create an ease of construction, for instance using bamboo as the main structural element with metal connectors that tie the structural elements together. The ability to use bamboo in combinations with other materials creates marketability for bamboo as a natural and renewable material that can easily be used as an alternative to other less sustainable materials.

In addition to being easily assembled and having versatility, bamboo has a very high building performance that is comparable to few other natural materials. One thing that really sets bamboo apart is that it is extremely lightweight and despite its apparent flimsiness bamboo has a surprising strength to weight ratio that is comparable to the strength of granite. (Smith 10) To further this bamboo has an extremely high tensile strength and an inherent stiffness, that is a result of the natural segments that occurs as the plant grows. It should also be noted that because of bamboo high flexibility and inherent strength, bamboo has an amazing ability to withstand earthquakes. As often seen in the aftermath of a typhoon in large Asian cities, pictures often show large steel and concrete structures completely destroyed and despite the damage to surrounding structures the bamboo scaffolding often times remains standing, its light weight and flexibility gives it an advantage over other heavy building materials during seismic activity. All of bamboo's benefits, being readily available, easy to assemble, light weight, high tensile strength and flexibility, makes bamboo a great material for a variety of uses that includes but are by no means limited to: scaffolding (up to 70 stories high), bridges

(that span up to 40 m), break walls, homes, and roof structures over large gathering spaces.

Yet despite all the benefits of bamboo, locally it is often dismissed as a ‘poor man’s’ material as it is often associated with the rural working class. Being an ultra economical material, in part due to its rapid growth, bamboo may become a key element in helping to solve the problem of housing the growing population in the developing countries. One example can be seen in Ecuador, where in one such project, families are given the tools and land to literally ‘grow their own house’. Within five years the land where the bamboo was planted is harvested and on that same land the house is built, using the same bamboo the family had tended to for the previous five years. This example is just one of many where bamboo has been used to solve key housing problems.

Bamboo and the Environment

Bamboos ability to be quickly and easily assembled, it is light weight, height strength to weight ratio, high tensile strength, inherent stiffness, ability to withstand seismic activity and potential to solve the world housing crisis makes bamboo a truly versatile material. Yet bamboos importance as a natural material becomes even more obvious as we enter the twenty first century, as the general population becomes more aware and concerned over the impact human activities have on the global community. There has been an increasing trend in environmental consciousness, more now than ever there is a growing demand for better building materials that have a longer life span and less of an impact on the global environment. Building practices play a very important role in the activities that threaten the planets vital balance. According to Simio Vélez, an architect who dedicated his career to studying traditional bamboo structures and the integration of bamboo into modern architecture, there is an awareness to ‘reduce and eliminate unsustainable patterns of production and consumption in the building industry.’ (Vélez 19) Further to this Vélez goes on to state that there are two different practices that eco-builder generally falls under. The first of these practices base their principles on recycling and using building materials that come from a recycled source, while this attempt to reduce waste is valid it still requires a great deal of energy to recycle material. The other approach is to try to eliminate or reduce materials that require an intense process to manufacture for instance: steel, cement, aluminum, concrete, plastics and other synthetic materials, all of which require a great deal of energy and resources to create;

instead by using natural materials that do not require industrial processing such as: raw earth, or bamboo. Examples of this type of work can be seen in works of Hassan Fathy, who is both an architect and philosopher, his work that took place during the 1950's and 1960's can be seen in village of New Gournah and is clearly outlined in his book, Architecture for the Poor: An Experiment in Rural Egypt. He was the first architect outside of the west to theorize and practice ecological architecture in poor and rural countries, by deliberately building using only local resources. He founded a system of operational ethics in the third world and created an understanding of the importance of vernacular architecture. By using local renewable resources such as bamboo the environmental impact of industrial materials can be avoided, and in many places bamboo can replace them all together while at the same time protecting the slow growth forest that were being devastated by using non renewable methods of foresting.

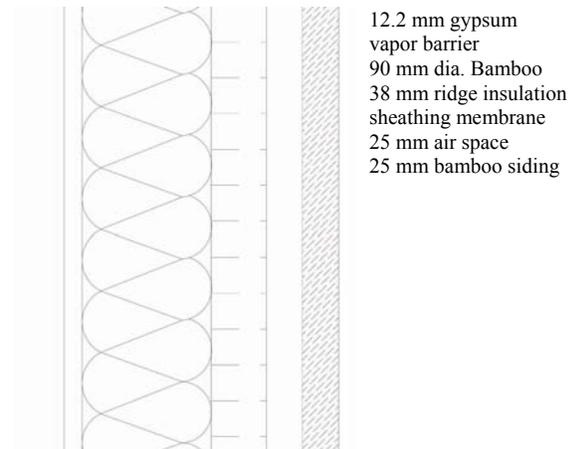
Traditional uses of Bamboo

Many cultures across Asia and Latin America have used bamboo to create shelters for centuries. These homes range from very simple and easily constructed huts consisting of one or two rooms that accommodate all of lives daily needs and at the same time protect the occupants from animals, intruders and the weather. While other examples are monumental and are often elegant buildings that serve a variety of uses, in almost all these cases whether it be the simplest hut structure or complex buildings, the knowledge of their building construction has been passed down for generations, and all have been put through the test of time. It is the simplicity of the 'hut' that has inspired my design. In many cultures the house is seen as a place of protection from hostile forces. In my design I have created a village of sorts along the bank of the Grand River, a place for the weary traveler to rest. Traditionally, villages out of necessity have been situated along waterways, providing a place for drinking water, a path to travel and means to engage in commerce. Like many traditional villages, my village sits on stilts above the flood plain, protecting it against the potential dangers of the river, a river that had at one point brought prosperity to the city of Cambridge, the same river that has also brought on disaster. Each residence has a simplicity and efficiency of design similar to that of the traditional bamboo hut, but it is also modern as will be later discussed, this portion of the essay will primarily focus on traditional means of assembly and the influences it has had on this particular design, although it should also be noted that due to the cold climate in

Cambridge the huts that usually exist in tropical or subtropical climates cannot be assembled in the same manner and I have used a combination of bamboo and traditional Canadian housing techniques. The book Grow Your Own House, by Simon Vélez, breaks down traditional bamboo architecture into simple architectural elements such as walls, windows and doors, connections, floor and roof assemblies. Each of these elements will be outlined below, and a discussion will follow that included if and how the traditional elements have been incorporated into my design.

Walls

To begin, walls can be created in a variety of different ways, the simplest being vertically arranged whole canes tied together, canes can also be split into strips and arranged either vertically or horizontally or they can be woven. Other more complete methods include using bamboo as a skeletal structure and filling



the voids with clay or in some cases concrete. Other more complete methods include using bamboo as a skeletal structure and filling the voids with clay or in some cases concrete. Both methods are often seen in low cost housing projects in Latin America, however due to the climate in Cambridge none of these above methods are suited to the colder climate as they offer little insulation. The approach I have taken was to use bamboo as a skeletal structure (with each cane 600 mm off center) and rather than filling the voids with clay I have used batt insulation, resulting in an R-value of 12. The bamboo itself has had its ends filled with concrete to allow for a connections point for the and layer of 38 mm of expanded polystyrene insulation is drilled into the concrete, it should be noted that the concrete is used to ensure the bamboo does not splinter, and the canes themselves have had blown insulation applied to increase the R-value of the wall and also to minimize thermal breaks, a sheathing membrane is then applied to act as a rain screen, there is a 25mm air space, and finally horizontal prefabricated bamboo siding is applied. This approach uses a combination of bamboo and traditional Canadian home construction. The benefit, being that bamboo is a quick growing resource that grows

much quicker than trees that are traditionally used, and also bamboo produces less waste when being processed as there is no bark to remove.

Windows

Often bamboo homes are fitted with modern windows or in the case of many tropical countries the windows are apparatuses that are used to enhance ventilation, in Japan a majority of these apparatuses are emphasized with ornamental lattice that covers the opening. The purpose of the lattices is two fold not only does it create an attractive interplay of light and shadow it also acts as a privacy screen and at the same time provided some sense of security. In my project, modern operable windows are

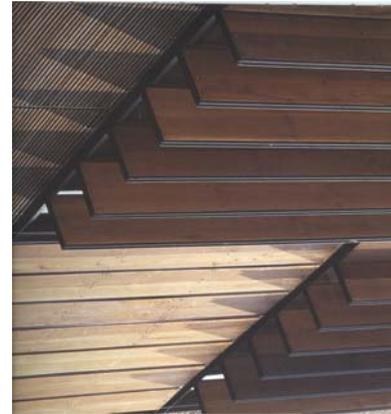
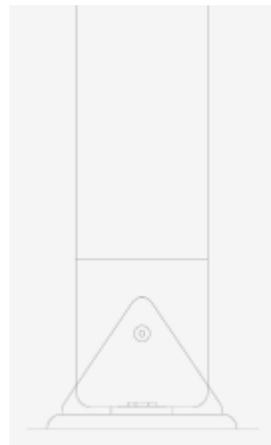


Fig 1. (LIM 147)

used to maximize the lighting and solar gain. A bamboo shutter system is also incorporated into the design for reasons similar to the Japanese lattice, firstly it is used to ensure a defused light and protect from unwanted glare, it provides a degree of privacy and lastly the shutters prevent unwanted solar gain in the summer months and when closed in the winter evening they keep in heat. An example of the shutter system can be seen in Fig 1.

Connections

As discussed above unlike wood, hollow bamboo can not be nailed or screwed together as it will easily splinter, and also unlike wood, bamboo does not come in nominal sizes and the dimension of each cane will vary greatly. The means of connecting bamboo varies world wide and ranges from techniques developed by nomadic cultures in south-west China and north Thailand that



pin connection

traditionally uses ropes and cords made of bamboo rind and palm fibers to more modern techniques, techniques such as the one developed in Germany that allows for standardized linkage. (109) This system developed in the Laboratory of Training and Development of Prototypes (LOTOP), uses heavy load bearing caps on the ends of each cane, that can be tightened and adjusted to suit the individual canes diameter, these caps

are designed to absorb pressure and pass it down the cane to the connector elements that then absorb the stress of the materials. In this project I then an approach that combines both modern technology and traditional knowledge. As noted above the wall systems incorporate a wall system that is often used in most Canadian home construction but uses bamboo instead of wood studs. The element of my project uses bamboo as columns that support the structure from which the curtain wall is hung. These columns use a simple and traditional pin and socket connection, once again with the ends of the canes are filled with concrete to prevent splinters, but also to hold in place a metal peg that is inserted parallel to the cane to provide a greater stability and allow the cane to be subjected to greater forces, which are then transferred to the main structure through a load bearing cap at either end of the cane.

Floor

In the simplest of cases the floor of a bamboo structure consists of whole bamboo canes arranged parallel to each other and attached together by a cord. Today bamboo is often seen in finished flooring used instead of hardwood floors, in part because of its warm color but also because of its rapid growth and natural ability to withstand wear and tear. In this case I have chosen the modern prefabricated bamboo flooring system for both its aesthetic and environmental qualities. The floors themselves are sitting on piles driven into the riverbank and bearing the load onto the bedrock. The floors are then frame in a traditional method used in wood frame housing, only instead of using wood for the floor joist, I have chosen to use laminated bamboo joist, filled with batt insulation and bamboo sub-flooring.

Roof

Bamboo roofs generally have the appearance of floating, these large overhangs are required in the tropical climates to protect from the rain and prevent unnecessary solar gain. In the beginning of this design I was really inspired by examples of such works including the more modern examples of Vélez work, as seen in my early sketches, I played with many different types of gable roofs, however none of these original ideas followed through in my final design, and I chose to use a more contemporary flat roof.

(see Fig 2)

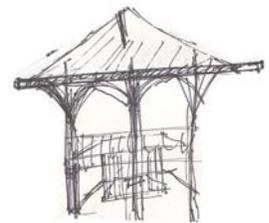


Fig 2

Modern Influences

The modern influences on this project and are not made of bamboo; they do however incorporate traditional elements and composition that could easily lend itself to bamboo. One major influence is Simdhu Hadiprana's pavilion Buall Asah located in Puncak Indonesia (see Fig 3 & Fig 4). This project carefully interweaves building site. and culture while offering traditional lessons within contemporary architecture. The project is situated in amongst tall pines, and hovers above a man made pond. The most influential part of this project is its simplicity and unassuming nature, it is fluid in the separation between indoors and out.



Fig 3. (LIM 140)

This particular pavilion is build as part of an assembly of buildings designed to train staff and facilitate meetings, the building is a very simple eight meter by eight meter square placed on stilts and hovers over the waters surface creating a sense of lightness. Compositionally there are four pavilions that are organized in open configuration with over lapping views, linked by an open corridor. The composition of this project makes it effective in delivering a sense of connection within the complex of four pavilions, but also with the outside environment.



Fig 4. (LIM 143)

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My project is similarly organized in an open configuration, with every unit sharing a similar view of the Grand River; although similar all the views are also unique

as the perspective and elevation from the river is in constant flux as one moves through the project. Each residential pavilion in my project is connected to the other pavilions by a system of ramps that brings the occupants closer to the river as they travel downwards, with each level offering a panoramic view of the Grand River and the river side developments of Cambridge, as well each level offers a place to rest and access to a water feature. One of my main goals was to create an immediate and direct relationship between the occupants of the space and their surrounding landscape, while providing access to the generally under utilized waterway. Hadipana feels that design should be dedicated to place and history without being trapped by the latter (Lim 150). I second applaud Hadipana's feeling, Cambridge has a strong history and at one time a strong connection to the Grand River, today the river is contained by large wall and city has largely neglected incorporating the river into its overall urban plan. (see Fig. 5) I really wanted to create a project that is based on the river, so much so that unlike other projects in Cambridge it faces the river, I have torn away the walls that contain the Grand and have built onto its riverbanks in hopes that it will act as a catalyst to bring activity back to the waterway.



fig 5. Grand River

(<http://www.architecture.uwaterloo.ca/cambridge/index.html>)

Conclusion

The Grand River is a breath taking historic waterway that cuts its way through the heart of Cambridge, although it is no longer a means of financial prosperity the river has the potential to become a beautiful backdrop for the many historic sites that line the banks of the river. The choice of bamboo, although not a typical building material for Cambridge its versatility and high strength to weight ratio makes bamboo a viable sustainable building material for this particular project. My project although not traditional, has its roots in traditional bamboo architecture, and through the study of both traditional and modern architecture I hope to break the physical barrier that limits the physical interaction between the city of Cambridge and the Grand River.

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