BAMBOO CONSTRUCTION MANUAL

FOR SINGLE-STORY HOUSING

INBAR
INTERNATIONAL BAMBOO AND RATTAN ORGANIZATION

INBAR BAMBOO CONSTRUCTION TASK FORCE

Base

HILTI FOUNDATION

A collaborative project of the
International Bamboo and Rattan Organization
and **Base Bahay Foundation, Inc.**

EDITORIAL

Bamboo Construction Manual for Single-Story Housing

Base Bahay Foundation, Inc.

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FOREWORD FROM INBAR

Bamboo, often called “green gold” due to its exceptional strength-to-weight ratio and rapid renewability, offers a sustainable housing solution across the world’s tropical and subtropical regions. This manual provides step-by-step guidance for designing and building single-story bamboo dwellings, combining traditional knowledge with modern engineering principles. By standardizing best practices, it aims to empower architects, engineers, builders, and communities to harness bamboo’s potential for creating the resilient and low-carbon housing.

Over the years, bamboo construction technologies and practices have continually evolved. Many challenges still remain, such as limited market acceptance, inadequate workforce capacity, and lack of standards. However, with continuous research, innovation, and South-South cooperation, we can unlock bamboo’s full potential to create a green and safe built environment.

We hope that this manual will serve as both a reference and inspiration for a new generation of builders, contributing to a future where bamboo construction is recognized not as an alternative but as a mainstream material.

FOREWORD FROM BASE

Base Bahay Foundation, Inc. (BASE) and the International Bamboo and Rattan Organization (INBAR) have collaborated to develop a manual that not only provides comprehensive information about bamboo in sustainable construction but also advocates for its incorporation into mainstream building practices.

Abundant in the Global South, bamboo is a local, renewable resource that BASE utilizes to provide comfortable, sustainable, affordable, and resilient homes for underserved communities. This approach helps in responding to the global housing shortage while also offering nature-based building solutions addressing climate challenges.

Moreover, BASE continuously partners with various organizations to innovate and propel the use of bamboo in construction. Evolving from a "poor man's timber" to "green steel," bamboo is a strong material with many great features, and, with the right technology, it is a viable option for sustainable construction.

Join us as we BUILD BEYOND TODAY.

ABOUT INBAR

Established in 1997, the International Bamboo and Rattan Organization (INBAR) is an intergovernmental organization that promotes environmentally sustainable development using bamboo and rattan. INBAR's mission is to improve the well-being of producers and users of bamboo and rattan within the context of a sustainable bamboo and rattan resource base, by consolidating, coordinating, and supporting strategic and adaptive research and development.

It is currently made up of 52 Member States across the developing areas of Africa, Asia, and the Americas. In addition to its Secretariat Headquarters in China, INBAR has five Regional Offices in Cameroon, Ecuador, Ethiopia, Ghana, and India. INBAR was recognized as an Observer to the UN General Assembly in 2017, which makes it possible for INBAR to speak for bamboo and rattan at the UN platforms.

INBAR

INTERNATIONAL BAMBOO AND RATTAN ORGANIZATION

ABOUT BASE

Base Bahay Foundation, Inc. (BASE) is a non-profit organization based in the Philippines. It was initiated by the Hilti Foundation, which provides alternative building technologies to enable a network of partners to build comfortable, affordable, disaster-resilient, and sustainable homes with social impact. BASE develops technologies using locally grown and renewable materials to create housing envelopes and designs suited to the needs of local communities. In 2021, BASE launched the Base Innovation Center (BIC), which serves as an industrial space and technical laboratory venue for research, development, and testing programs on bamboo and other alternative building materials and technologies.

The opening of the BIC paved the way for the collaboration of local and international researchers and specialists from universities and organizations worldwide, to work on alternative green building materials and technologies for sustainable construction. BASE through the BIC also provides multi-level training courses that engage other institutions and individuals to further propel the adaption of these alternative technologies for the future.

Base

ABOUT THE HILTI FOUNDATION

The Hilti Foundation is a philanthropic non-profit organization based in Liechtenstein. The Foundation is a joint initiative of the Martin Hilti Family Trust and the Hilti Group. The Foundation was established in 1996 to support the research of underwater archaeologist Franck Goddio. Since then, the work of the Hilti Foundation has expanded considerably. Its mission is to enable people to lead independent and self-determined lives.

Together with a network of international aid organizations and partners, the Foundation has pursued sustainable goals and focused its efforts on the following thematic areas: Music for Social Change, Affordable Housing & Technology, Economic Empowerment as well as Emergency Relief, and Maritime Archaeology. The main focus of its activities is on developing and emerging countries.

HILTI FOUNDATION

A worker from the Kawayan Collective in Dauin, the The Philippines, conducting a quality check on bamboo poles before using them in construction

Interior of the housing project in Polomolok, South Cotabato, The Philippines, a project of Base Bahay Foundation and Mahintana Foundation

SUMMARY

This manual provides a detailed guide of how to construct a single-story bamboo house using a Composite Bamboo Shear Wall (CBSW) system. The CBSW system is an innovative construction method that integrates full bamboo culms with modern connection techniques and is protected with exterior plastering material. This guide outlines a step-by-step process, from the production of treated and structurally graded bamboo culms and the prefabrication of CBSW components to the prefabrication of roof trusses, ensuring high quality control. Site preparation and foundation work can be conducted in parallel, streamlining the process and allowing for rapid installation of structural systems on-site. The subsequent chapters provide a guide to the roofing, plastering, and finishing.

In addition, this guideline details best practices, common pitfalls, and key considerations when seeking to effectively use structurally graded bamboo in housing construction. Note that this manual is specific to single-story housing and does not cover other types of structures.

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CHAPTER 1

BAMBOO AS A CONSTRUCTION MATERIAL

Bamboo is a fast-growing woody-stemmed grass belonging to the Poaceae family with over 1,600 species found all over tropical and sub-tropical region of the world (Vorontsova et al., 2016)

CHAPTER 1:
BAMBOO AS A CONSTRUCTION MATERIAL

Bamboo plants are classified into three tribes: Arundinarieae (temperate woody bamboos), Bambuseae (tropical woody bamboos), and Olyreae (herbaceous bamboos) (Liese and Kohl, 2015). The common species that can be used for construction falls into the Bambuseae and Arundinarieae tribe.

Figure 1 shows a map of common bamboo species used in construction.

Species that can be found in Central and South America: *Guadua spp., Dendrocalamus* spp., and *Bambusa* spp.; in Asia: *Bambusa* spp., *Dendrocalamus* spp., *Phyllostachys* spp., and *Gigantochloa* spp.; and in Africa: *Oldeania* spp. and *Oxytenanthera* spp.

Some bamboo species have been introduced in some regions for cultivation: in Europe—*Phyllostachys* spp., North America—*Guadua* spp., and Australia—*Bambusa* spp.

Node punching, part of the Bamboo Treatment Process

Drying of bamboo poles, part of the Bamboo treatment Process

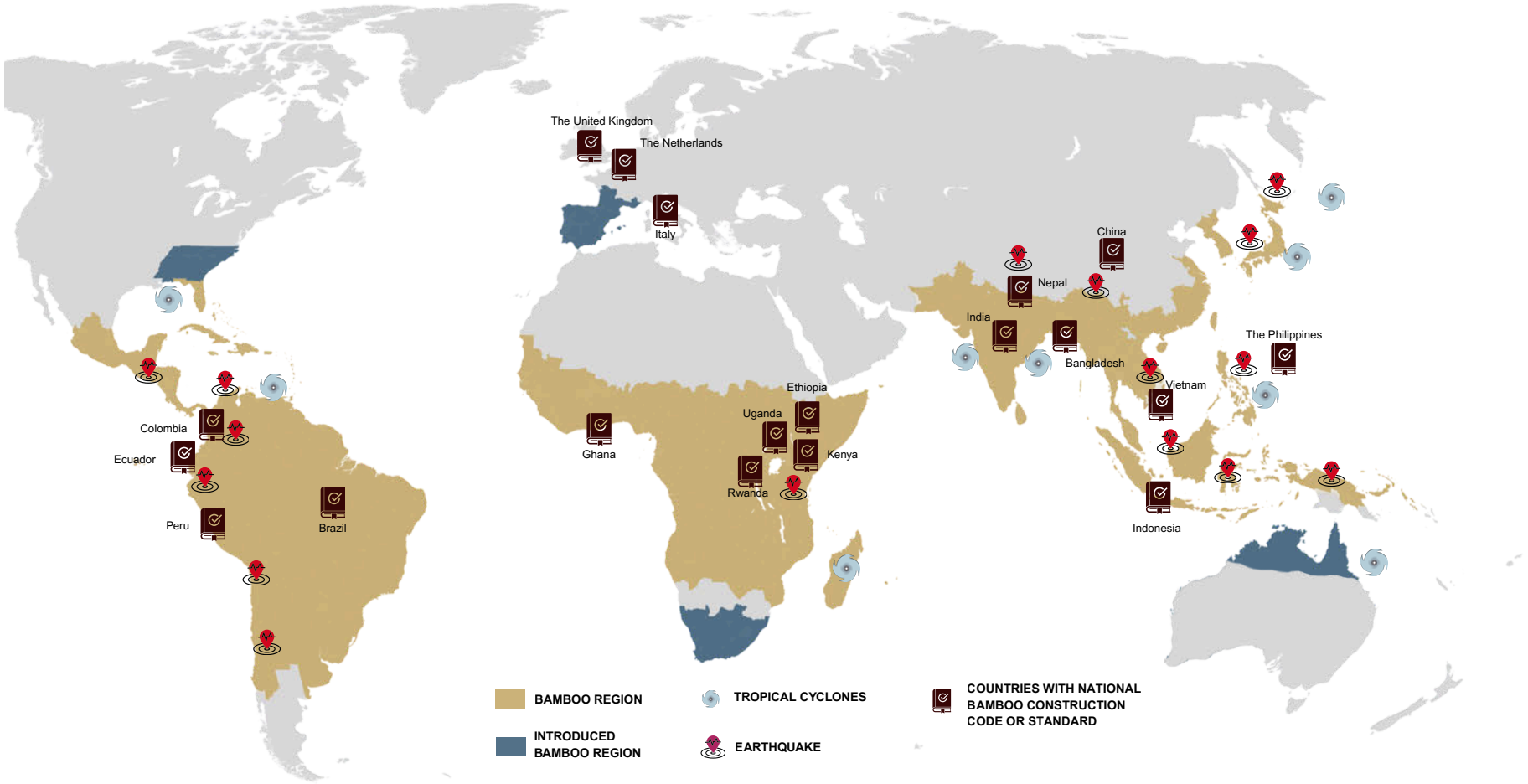


Figure 1. Bamboo resources, countries with national bamboo construction code or standard, and natural hazards around the world

BAMBOO SPECIES COMMONLY USED FOR CONSTRUCTION

Phyllostachys pubescens
Bambusa perveriabilis
East Asia

Dendrocalamus asper
Guadua angustifolia
Bambusa vulgaris
Global

Bambusa merilliana
Southeast Asia

Dendrocalamus hookeri
Bambusa nutans
South Asia

Bambusa oldhamii
Southeast Asia, Central America

Bambusa blumeana
Southeast Asia, East Asia

Bambusa balcooa
South Asia, South Africa

Bamboo is seeing renewed interest all over the world as a viable construction material that may be used to meet the overwhelming need for housing.

Bamboo is abundant in socioeconomically developing regions around the world. These same regions often face the risk of natural disasters like earthquakes and tropical cyclones (see Figure 1 on the previous page).

Its abundance makes it an ideal and affordable alternative to conventional construction materials (e.g., concrete, masonry, and steel). This makes it more likely to be the material of choice for those who build their own houses.

Features

Affordable Solution — Houses made of bamboo cost 20–30% less than conventional masonry houses of the same size, providing a higher chance of achieving well-constructed houses.

Safe — Bamboo is lightweight, making it naturally resistant to earthquakes. It can also be designed to resist tropical cyclones (i.e., typhoons, cyclones, and hurricanes).

Good Thermal Comfort — The hollow nature of bamboo culms provides thermal insulation that helps maintain the comfortable indoor temperature of houses (Wang et al., 2018).

Accessible — Bamboo poles grow and mature within 3–6 years after plantation and can be harvested every year afterward, providing a stable source of income.

Environmentally Friendly — Houses made of bamboo have a 60–80% lower carbon footprint than conventional masonry houses (Bundi et al., 2024).

A local farmer harvesting bamboo that will be processed in a nearby treatment facility

Parts and Applications

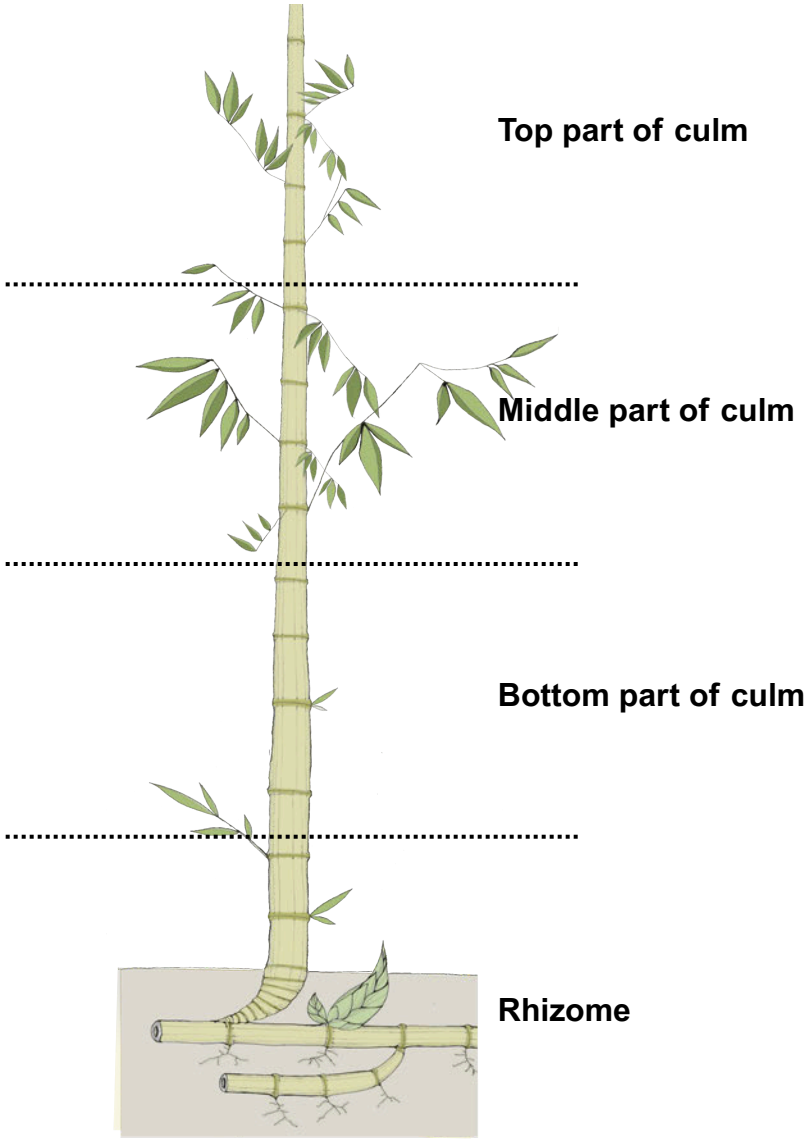


Figure 2. Parts of a bamboo plant

The bamboo plant consists of several shoots growing from an underground rhizome (Figure 2). The shoots, referred to as culms, are usually hollow with a tapered diameter.

Bamboo culms of age three to six years are used for construction. Different parts of the culms are suitable for different components of a house (Minke, 2016) (Figure 2). The bottom part of the culm possesses the largest external diameter and wall thickness. Accordingly, it is used for columns in housing and large spans of beams. The middle part of the culm has a smaller diameter and thickness compared to the bottom and is used for structural beams, rafters, trusses, and purlins. The top part of the culm possesses the smallest external diameter and wall thickness. It is used for wall cladding, slats for walls, and other roofing works.

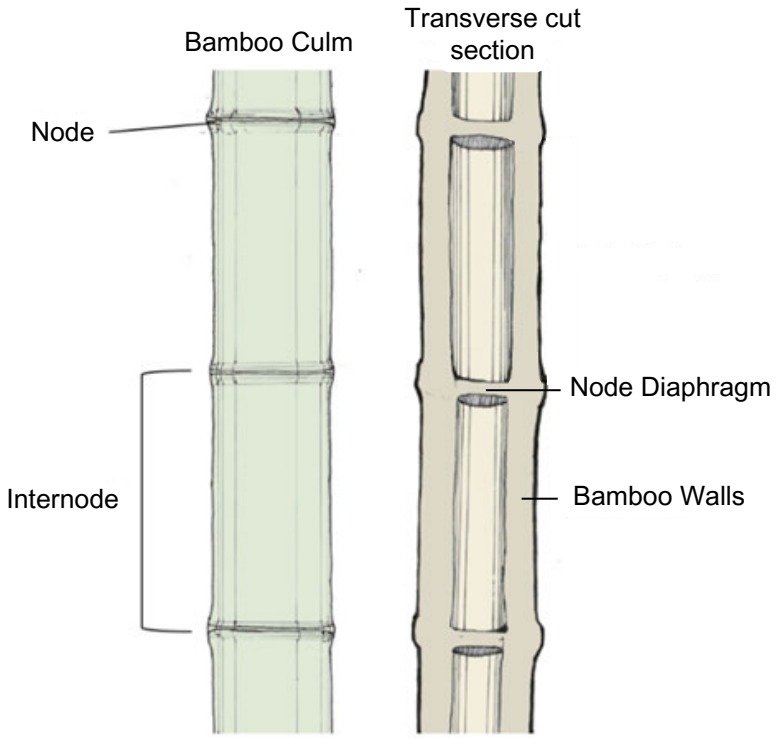


Figure 3. Anatomy of a bamboo culm

Parts and Their Applications

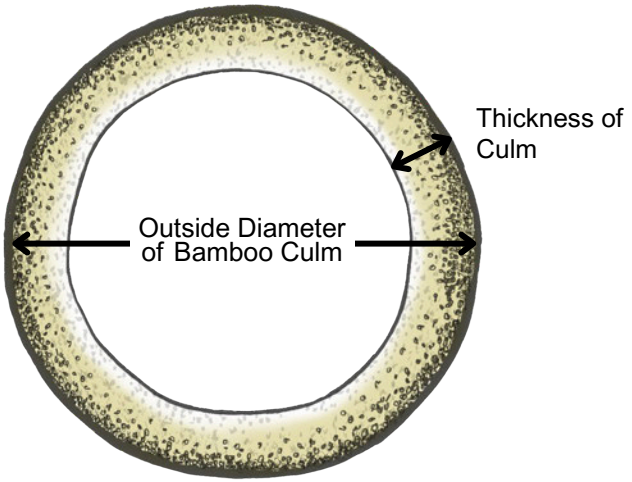


Figure 4. Cross-sectional view of bamboo culm

Figures 3 (previous page) and 4 show the anatomy of the culm, comprising the nodes, internodes, node diaphragm, and bamboo walls. The fibers contribute to the overall strength and rigidity of the culm. They increase in number from the inner to the outer skin of the bamboo culm cross-section. The bamboo culm is composed of internodes with varying lengths depending on the species and the location where the section is from.

Note: Flowering nature — Flowered bamboo culms are not suitable for construction.

Different Bamboo Structures

Bamboo can be positioned and organized into various structural systems to build magnificent and aesthetically pleasing buildings or bridges. The structural system refers to the organized framework of components that together provide stability and rigidity to a building. Major types of structural bamboo systems include the truss, braced frame, free form, framed structural system, and shear wall system.

Bamboo Bridges – Most of bamboo bridges have multiple culm configurations. Bamboo culms are arranged to form structural units supporting each section of the bridge. The arrangement of the sections allows the structure to support large spans with minimal material. (Figure 5)

Figure 5. The Jenny Garzon Bridge designed by Simon Velez, located in Bogota, Colombia

Braced Frames – Bamboo structures connected using diagonal components (Figure 6) similar to truss, which prevent lateral sway. Diagonal brace elements are used to prevent deformation and provide high lateral stiffness.

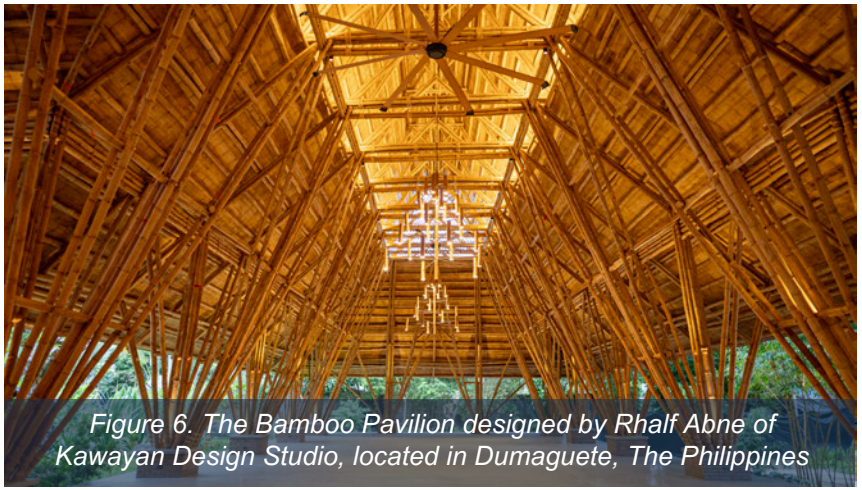


Figure 6. The Bamboo Pavilion designed by Rhalf Abne of Kawayan Design Studio, located in Dumaguete, The Philippines

Structures Made with Bamboo Slats – Full bamboo culms are split into strips called bamboo slats, connected with mechanical fasteners, glue, or pins to form structural members. These members can be in the form of a grid pattern, weaved pattern, pressed bamboo slats, or pinboo, which consists of multiple slats joined together by bamboo pins. With its inherent flexibility and its bending-active behavior, it can be formed into curved shapes and free-form structures (Figure 7).

Figure 7. Colibri Temple in São Paulo, Juquitiba, Brazil (Photo from: Jaime Peña Arias)

Multi-story Structures – Multi-story structures commonly require increased stiffness to resist lateral loads. The strength of lower floors shall be adequate to resist the loads coming from the upper floors. The required strength and stiffness is provided by the combination of vertical and diagonal orientation of bamboo columns composed of single or multiple culms. (Figure 8).

Figure 8. Sharma Springs Residence by IBUKU in Bali, Indonesia (Photo from: Tim Street Porter and IBUKU)

Structures Made of Engineered Bamboo Products – Structural components for frames, trusses, shear walls and slabs to resist lateral loads can be made of engineered bamboo products, such as glued laminated bamboo (GLB), bamboo scrimber, Glubam or cross laminated bamboo and timber composite (CLBT). By using hot and cold compress technologies, selected bamboo elements are processed into engineered bamboo products with uniform sizes, greatly reducing variability on their dimensions and mechanical properties. A case of multi-story framed structures made of GLB, Glubam and CLBT is shown in Figure 9.

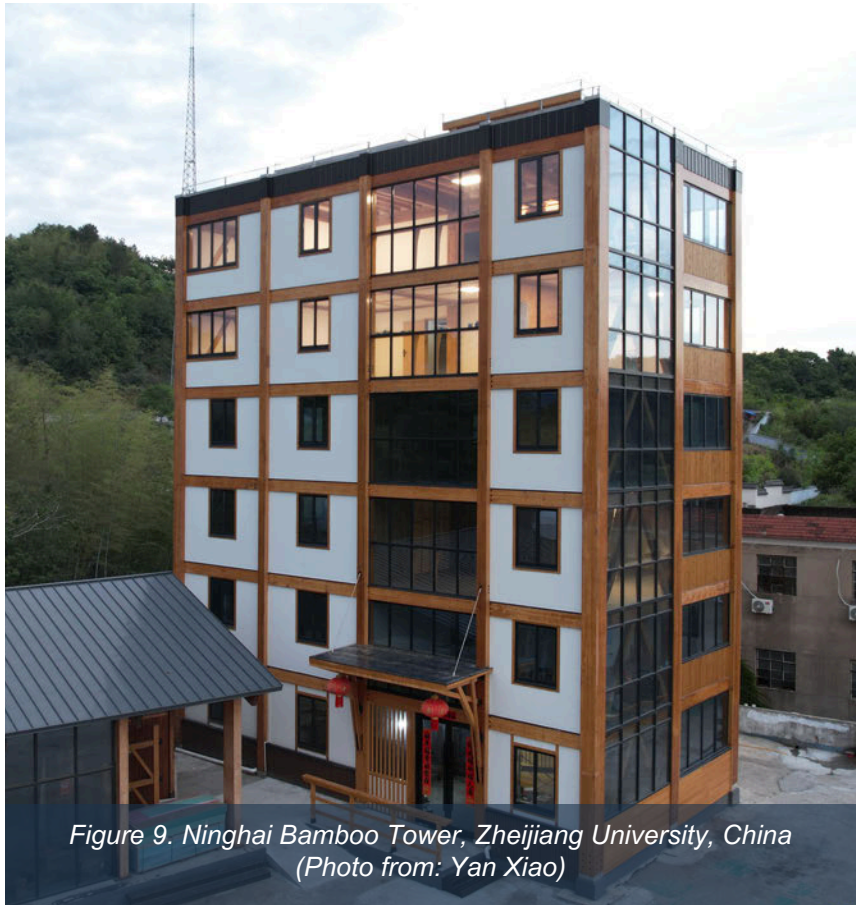


Figure 9. Ninghai Bamboo Tower, Zheijiang University, China (Photo from: Yan Xiao)

Composite Bamboo Shear Wall (CBSW) Structures – This structure consists of shear walls joined together to resist gravitational and lateral loads caused by heavy winds or earthquakes. CBSWs, such as *bahareque encementado* from Latin America and Cement–Bamboo Frame Technology (Figure 10) from the Philippines, are structural shear wall systems used for bamboo structures (Kaminski et al., 2023).

This technology is the result of hundreds of years of development and has a rich history from its early typologies up to the modern typologies, which take engineering and scientific approaches to provide stronger, well-built houses.

Figure 10. Housing project of Base Bahay Foundation in partnership with Operation Blessing in Tacloban, The Philippines

Historical Overview of Bamboo Shear Wall Systems

Early Years

The use of bamboo in building construction has a long history, with its presence evident across the globe. It has long been considered a fundamental material of choice for organic and vernacular architecture due to its availability and fast-growing properties (Figure 11).

Figure 11. 3D model of a typical vernacular house in Southeast Asia (model reference from SketchUp 3D warehouse uploaded by Arnold Ferrera)

1500s

Tabique Pampango and Quincha
Bamboo-based construction in each region is distinguished by its geographical and cultural characteristics. In the Philippines, Tabique Pampango is a light wall panel system made from woven bamboo strips, plastered with lime (Figure 12). The system is used on the upper story of the Hispanic Filipino houses.

In Peru, Quincha is a building construction system consisting of wall frames made from woven bamboo strips, branches, and cane, plastered with adobe, mud, or clay.

Figure 12. 3D model of a tabique pampango wall constructed on the second story of a convent structure

1800s

Traditional Bahareque
Guadua bamboo's availability across the Americas played a big part in the development of the bahareque. It is a traditional building construction system consisting of a bamboo frame clad in a matrix of flattened bamboo and wire mesh, plastered with soil (Figure 13).

Figure 13. 3D model of traditional Bahareque structure showing the wall components

1980s

Bahareque Encementado
The introduction of new materials, such as cement and steel, led to the development of modified bahareque systems. Among them, *Bahareque Encementado* was able to take full advantage of the workability and hygienic properties of cement, as well as the usage of stronger metal connections (Figure 14). In 1988, this system played a huge role in the Costa Rican Bamboo Project, demonstrating its structural advantages through a series of engineering tests and the transfer of technology from Colombia. The Costa Rica National Bamboo Project was able to construct 5400 houses intended for low-income families across the country.

Figure 14. 3D model of Engineered Bahareque structure showing the wall components

1999

Colombian Coffee Belt Earthquake
An earthquake hit the coffee region of Colombia (Figure 15), killing 1200 people and destroying over 50,000 masonry structures with economic losses estimated at more than USD 2 billion. However, the majority of the Bahareque structures survived with minimal damage, highlighting its seismic advantage over masonry systems. This event became instrumental in changing the public perception of bamboo as an alternative building material.

Figure 15. Map showing the epicenter of the Coffee Belt Earthquake in Colombia

2002

The First Bamboo Standard
The NSR 98 of Colombia: Cement-rendered Bahareque One and Two-story Houses is the world's first standard on structural uses of bamboo as a building material. In response to the 2007 Peru earthquake, research on bamboo housing led to the 2012 release of E 100, a standard outlining material properties, design methods (influenced by Colombian and Ecuadorian codes), and construction practices, including bamboo-timber shear walls.

2015-2018

Succeeding Bamboo Standards
In 2016, Ecuador adopted NEC-SE-GUADUA, a national code governing the design, construction, and maintenance of buildings using *Guadua angustifolia* bamboo species. Meanwhile, India's IS 15912:2018 is a national code that provides guidelines for the structural design and use of bamboo in construction, covering aspects such as material properties, grading, design of members (beams, columns, trusses), and connection details. It focuses on traditional bamboo elements but does not include composite bamboo shear walls or cement-bamboo panel systems.

Bamboo ISO

In 2004, ISO 22156 was published to provide basic design guidance for construction using round bamboo poles/culms. In the same year, ISO 22157 was established to provide guidelines on the determination of physical and mechanical properties of bamboo. ISO 22156: 2021 and ISO 22157: 2019 were updated, and a new ISO 19624: 2018 was published for guiding how to grade round bamboo culms for structural uses.

Present

Technology Transfer and Scaling

Efforts are being made to scale up the application of Composite Bamboo Shear Wall Technology (e.g., *Bahareque Encementado*) as a mainstream construction system, particularly in regions vulnerable to tropical cyclones and earthquakes. Since the 2000s, INBAR has undertaken development projects and conducted technology transfer as well as capacity building with partners and communities in a number of bamboo-growing countries. Research and non-profit organizations, such as Base Bahay Foundation, Indian Plywood Industries Research & Training Institute (IPIRTI), Konkan Bamboo and Cane Development Centre (KONBAC), Tripura Bamboo and Cane Development Centre (TRIBAC), Kenya Forestry Research Institute (KEFRI), and FOB Consult Limited, are capitalizing on the material and system's potential through research collaborations that will help further innovate the technology and make it more accessible.

Housing project in Tacloban City, The Philippines of Base Bahay Foundation and Operation Blessing

Construction of CBFT house in Nasugbu, Batangas, The Philippines

CHAPTER 2

PRE-CONSTRUCTION REQUIREMENTS OF A CBSW HOUSE

Prior to construction, the selection and processing of bamboo poles into a structural grade are essential to ensure the durability of the house.

In general, a variety of factors, including processing, treatment, and intended use, can affect the condition and qualities of bamboo. Proper harvesting, drying, processing, and manufacturing methods are critical to optimize bamboo products' functionality and durability across a range of uses.

By following the recommended harvesting, grading, and treatment process in this chapter, workers can efficiently build a house that is of high quality and can withstand the required windspeed and seismic load.

CHAPTER 2: PRE-CONSTRUCTION REQUIREMENTS OF A CBSW HOUSE

Requirements for Bamboo

Harvesting

Only mature bamboo culms aged three to six years (depending upon the species) are used for construction.

Culms that are under three years old have high water and starch contents and are more likely to split. In addition, they are more susceptible to insects and fungal attacks.

Bamboo harvesting

Grading Process

Freshly harvested bamboo culms are not suitable for construction. As natural materials, they possess defects (e.g., insect damage, cracks, etc.) and considerable variability in their geometry (e.g., diameter, out-of-straightness imperfections, etc.). Therefore, they are first graded, which is the process of sorting culms according to selection criteria. The criteria identify dimensional, visual, geometric, mechanical, and/or physical properties that reflect bamboo's structural strength or capacity. In other words, grading removes defects and reduces the natural variability in the geometry of the culms. As a result, the graded population is of uniform quality and free of defects that can adversely affect the structural behavior. For this reason, understanding the process of bamboo grading provides a great opportunity for producers and end-users to ensure the quality of the material that they will be using. *(Refer to Annex A: Grading Process)*

Chemical Treatment of Graded Poles

Untreated bamboo culms are susceptible to insect infestation and fungal attack. The lifespan of bamboo can be prolonged by applying an effective chemical treatment. Among the various treatment methods available around the world (Gauss, 2020; NMBA, 2006), such as heat, chemical, and mechanical treatments, this manual recommends chemical treatment by soaking the bamboo poles in borax–boric acid solution.

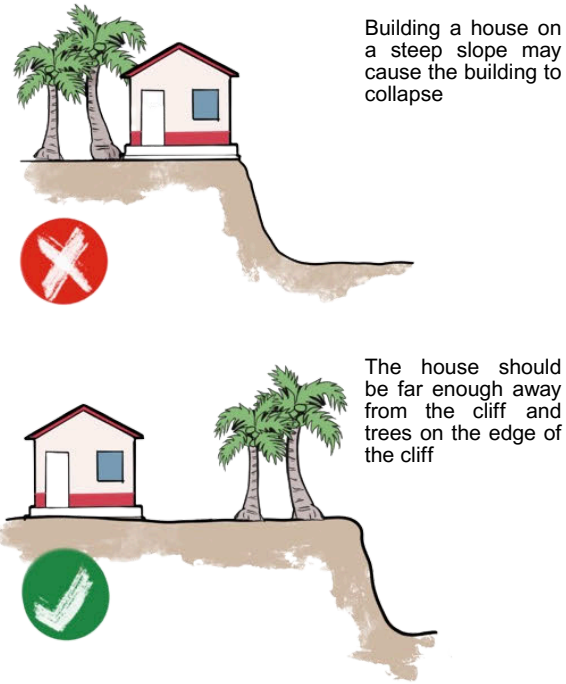
The chemical treatment process should start within one week after harvesting bamboo poles to minimize infestation.

Bamboo treatment

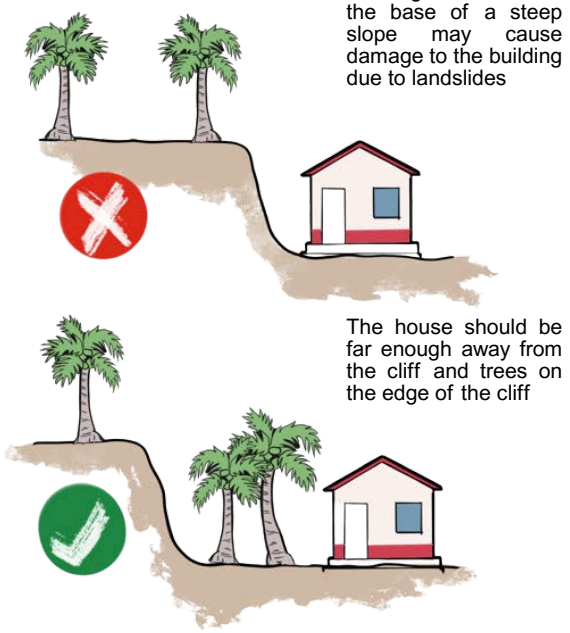
General Design Considerations

Choose a Safe and Stable Location

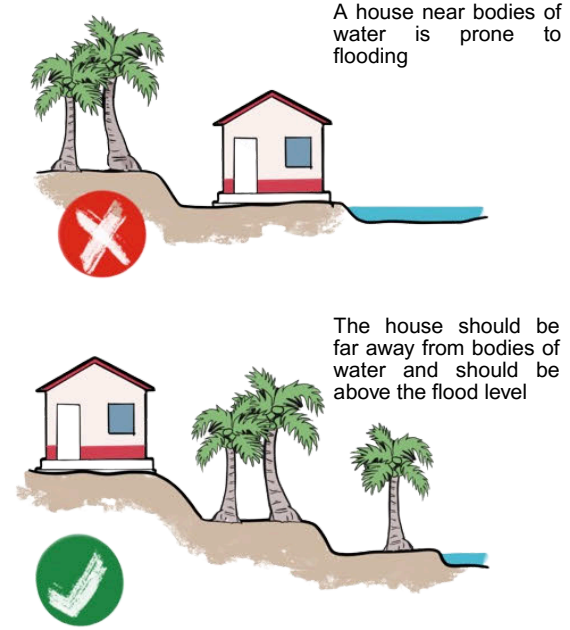
AVOID building on top of a steep slope



AVOID building at the base of a steep slope



AVOID building near a shoreline or river bed



Plan for Storm Surges and Tsunamis

Some of the most destructive impacts of typhoons and earthquakes are caused by storm surges and tsunamis. Unfortunately, building a small home that can withstand the powerful flow of water and debris from these events is challenging. If you reside in a low-lying coastal area, you may be vulnerable to one or both of these hazards. It is advisable to select a location outside of high-risk zones. If this is not feasible, it is crucial to acknowledge the risk and be prepared to evacuate in event of a major storm or earthquake that could lead to a surge or tsunami.

Verify that the Soil has Adequate Strength to Support the House

For a single-story CBSW house, there are two types of soils that should be avoided:

<u>Clayey Soil or Very Sticky Peat</u>
This type of soil is usually found near the coast and sometimes near rice paddies or fishponds. This type of soil has the following characteristics:

- Sticks to your hands and is difficult to wash off.
- Smells musty and rotten.
- Dries out slowly
- Shrinks when it dries out.
- Breaks up or crumbles easily when it is dry.
- Contains organic matter such as small fibers or seashells.

Sandy Soil that is Loose or Saturated with Water, like Quicksand
This type of soil is commonly found near beaches or riverbeds. To check if you have this kind of soil, try pushing a 12-mm-diameter steel bar into the ground. If you can push it more than 30 cm by hand, the soil might not be strong enough to support your house.

Note: If you encounter either of these soil types, it is advisable to relocate to a different site. However, if relocation is not an option, you might be able to excavate the unsuitable soil and replace it with compacted fill using better soil or a mixture of gravel and soil.

Soil bearing investigations are rarely required for single-story residential construction except when a history of local problems provides evidence of known risks (for example, organic deposits, landfills, expansive soils, seismic risk). Table 1 below provides a conservative relationship between the soil type and load-bearing value. These presumptive soil bearing values, however, should be used only when the building codes do not require geotechnical investigation reports.

Table 1: Presumptive Soil Bearing Values by Soil Description (International Code Council 2024)

Presumptive Load-Bearing Value (kPa)	Soil Description
70	Clay, sandy clay, silty clay, clayey silt, silt, and sandy silt
95	Sand, silty sand, clayey sand, silty gravel, and clayey gravel
140	Gravel and sandy gravel
190	Sedimentary and foliated rock
575	Crystalline bedrock

Designing composite bamboo shear wall houses involves adhering to standards to ensure structural integrity, safety, and sustainability. Here are the key design standards and guidelines to consider:

Structural Standards:

- **ISO 22156:2021** for structural design for one- and two-story buildings using full-culm round bamboo
- **Colombian NSR-10 Titles E and G** present methods for the structural design of bamboo connections and cement bamboo shear walls.
- **Andean Standard** for the design and construction of one- and two-story houses in cemented bahareque

Designing a composite bamboo shear wall house involves several important considerations to ensure structural integrity, durability, and environmental sustainability.

Structural Layout

CBSW panels mainly resist lateral loads in their in-plane direction. CBSW panels of sufficient lengths are placed in two perpendicular directions to resist the required lateral loads (Figure 16).

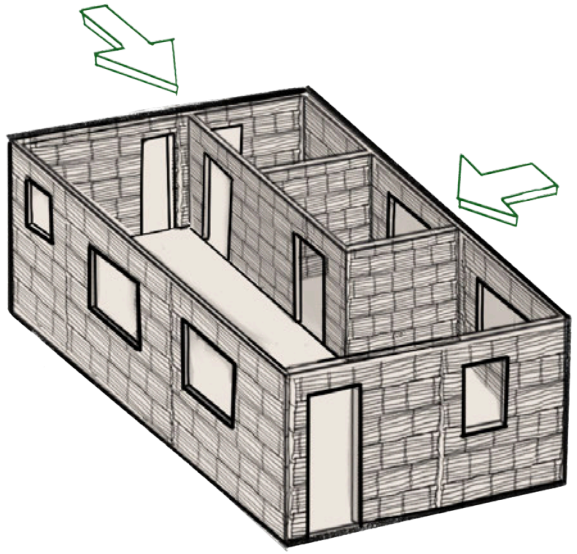


Figure 16. Distribution of structural walls

Layout is one of the main aspects in creating disaster-resistant houses because an irregular shape can result in both increased wind and earthquake forces. Thus, CBSW panels are arranged symmetrically to minimize torsional effects (Figure 17).

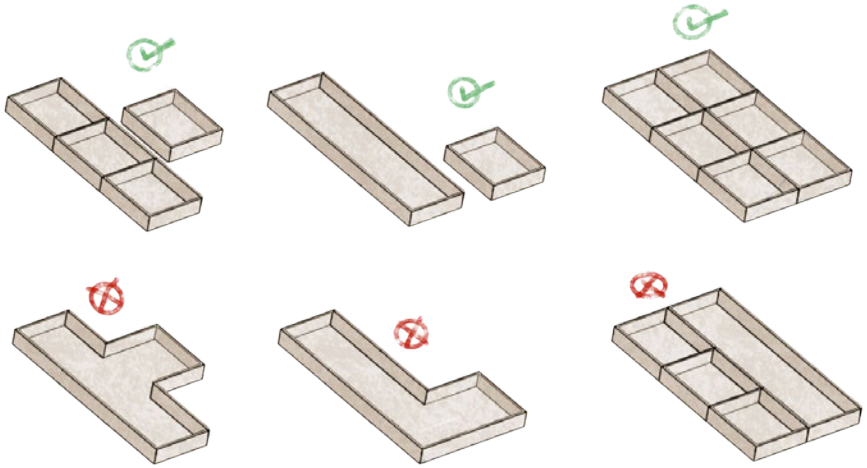


Figure 17. Floor plan irregularity

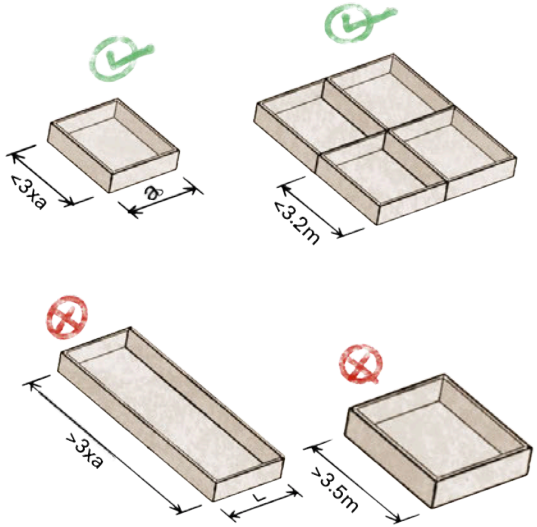


Figure 18. Aspect ratio

Consider these points in choosing your house layout (Figure 18):

- Choose a uniform and symmetrical layout like a square or short rectangle.
- Avoid long and narrow structures where the length of the wall is more than three (3) times the width.
- Every length of wall more than 3.5 m should be supported by a cross wall or brace.
- Provide seismic gaps to convert irregular plans to regular configurations.

Integrating the porch roof into the main building roof (Figure 19) can increase the wind uplift pressure under the deep overhang, which may be sufficient to cause failure of the roof structure and endanger the main building. Veranda roofs are not continuous with the main roof but are firmly anchored to the main building (Figure 20).

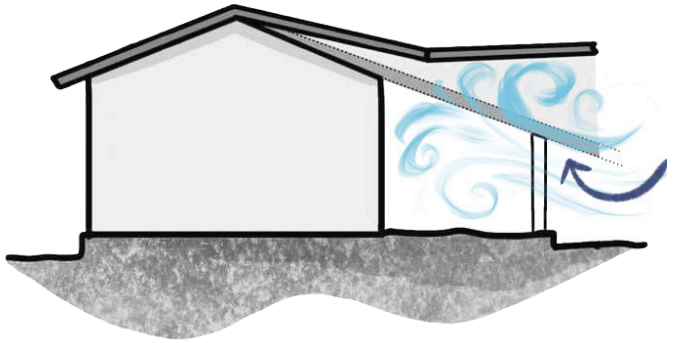


Figure 19. Design to avoid

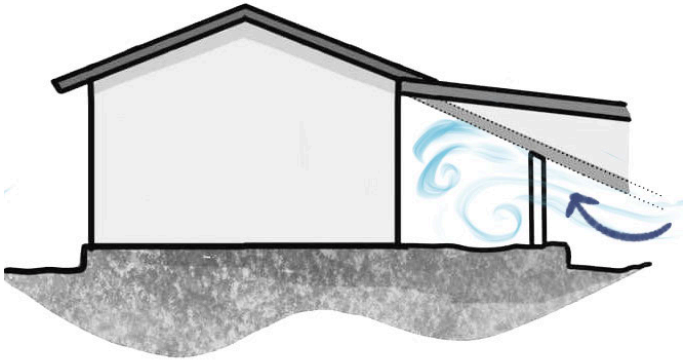


Figure 20. Recommended design

Wall Requirements for Seismic and Wind Safety

Unbraced CBSW systems are suitable for regions with low tropical cyclone and seismic activity and should not exceed one story or 3 meters in height. Braced CBSW systems are recommended in regions with moderate to high earthquake and tropical storm risks. In all instances, the recommended panel height-to-length (H/L) ratio should be less than 4.0, and the maximum vertical stud spacing should be 600 mm.

The structural frame system arrangement in Figure 21 is for regions with low tropical cyclone and seismic activity.

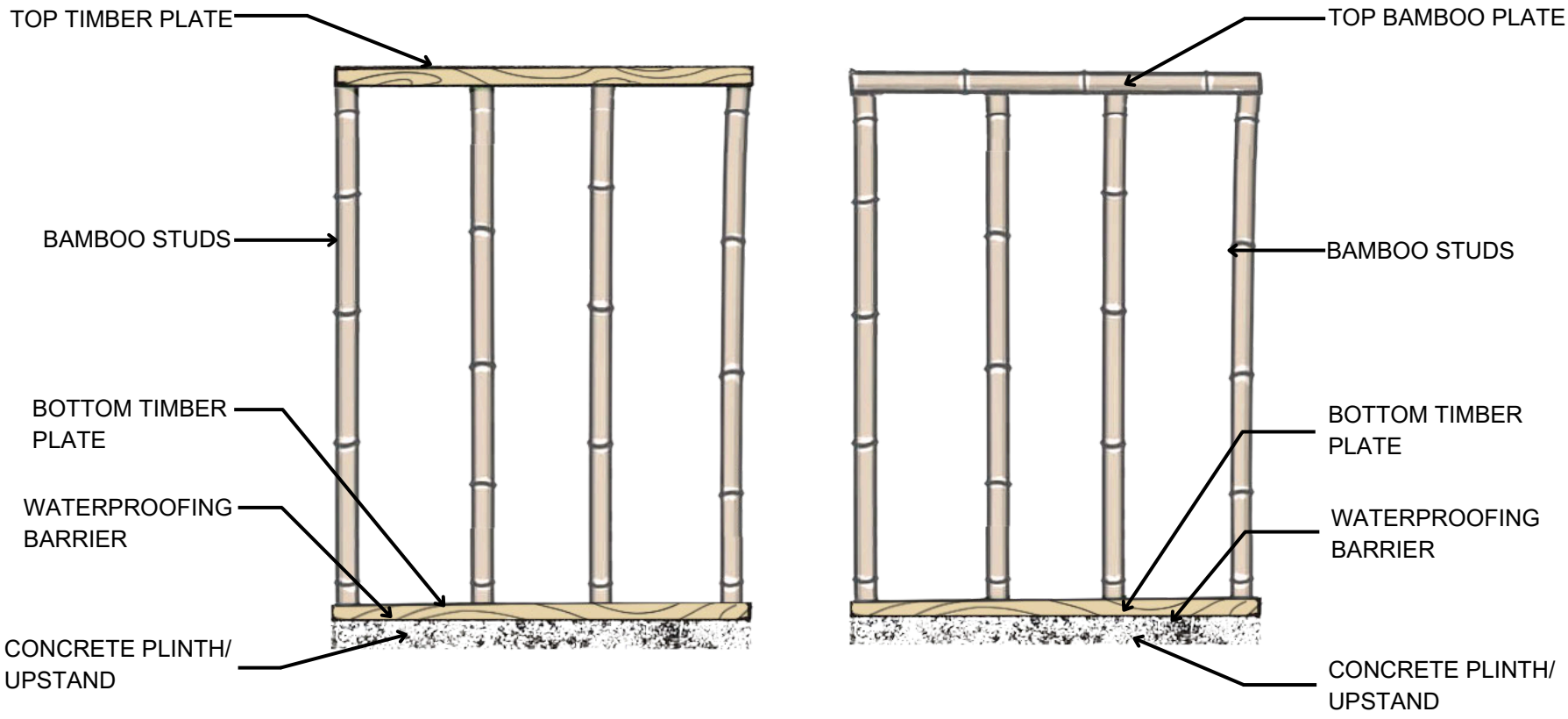


Figure 21. Recommended CBSW structural frame system for regions with low tropical cyclone and seismic activity

The structural frame system arrangement in Figure 22 is recommended for regions with moderate to high tropical cyclone and seismic activity, such as the Philippines, Japan, Indonesia, Mexico, Chile, China, and others.

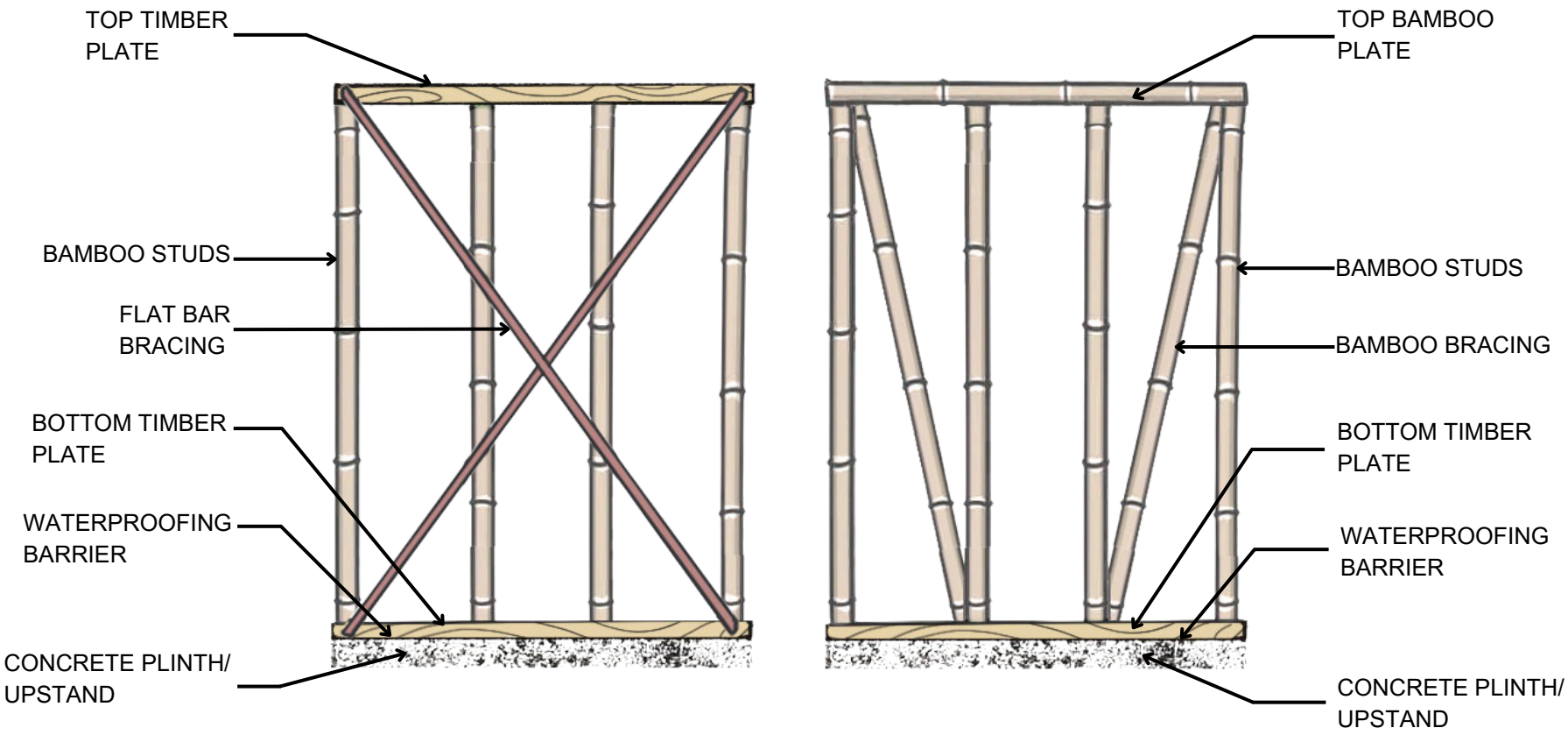


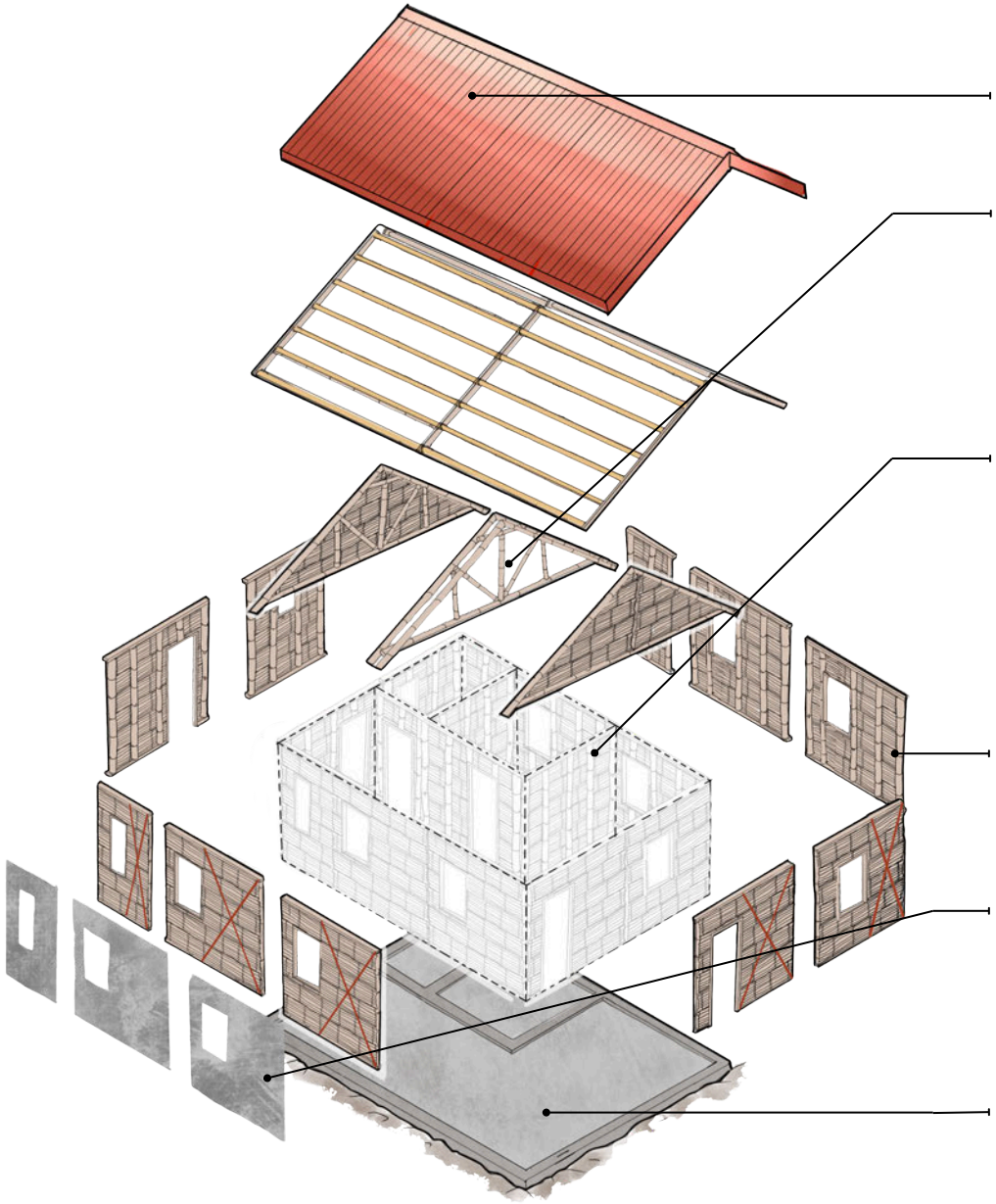
Figure 22. Recommended CBSW structural frame system for regions with moderate to high tropical cyclone and seismic activity

CHAPTER 3
CONSTRUCTION PROCESS

A composite bamboo shear wall (CBSW) house employs an innovative design of the bamboo walls, finished with mortar plastering to provide a strong structure that is both environmentally friendly and cost-effective. The sample project will serve as the reference house for all subsequent construction processes described in this document.

CHAPTER 3: **CONSTRUCTION PROCESS**

Composite Bamboo Shear Wall (CBSW) Bamboo House



1. Roof Cover
The roof is equipped with galvanized iron (G.I.) sheets to protect the house's interior from weather conditions like rain and sunlight and to prevent water infiltration. For additional thermal comfort, flattened bamboo might be used beneath the roof sheets as insulation.

2. Roof Frame
The roof frame components such as trusses, rafters, and purlins are made of treated bamboo and joined together by engineered connections such as bolts, nails, or screws tailored to the specific wind zone.

3. Bamboo Wall Panel Frame
The wall panel frame is constructed using vertical bamboo studs with top and bottom plates typically made of wood and joined together with modern mechanical connections such as bolts, nails, or screws. In some systems, bracing is used, especially in seismic and typhoon-prone regions. The damp-proof membrane separates the frame from the upstand.

4. Wall Cover System
A matrix made of flattened bamboo nailed to the wall panel frame, and galvanized steel chicken mesh nailed to the matrix acts as reinforcement. In some systems, an expanded steel mesh such as rib lath acts as both the matrix and the reinforcement, nailed directly to the frame.

5. Wall Cladding
The wall panels covered with cement to reinforce the bamboo. This cladding protects the structure from long-term exposure to harmful natural elements.

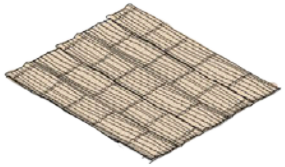
6. Concrete Flooring and Foundation
Foundations are made with reinforced concrete strip footing, masonry foundation wall, and reinforced concrete plinth beam. This design raises the house to prevent floodwater infiltration. Additionally, a vapor barrier is used to protect the panels from soil moisture damage.

Materials and Tools

The materials and tools required for the construction of the sample single-story bamboo housing consist of commercially viable materials and sustainable bamboo resources. Some of the equipment is optional and intended only to provide a faster and more accurate construction process.

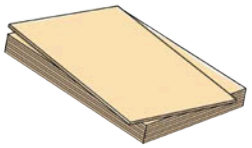
Materials

Bamboo Poles



Flattened Bamboo

Timber



Plywood

Flat Metal Bars

Threaded Rods

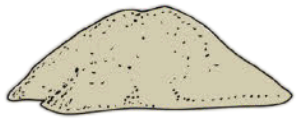
Bolts, Nuts, and Washers

Nails

Bamboo Stakes

Umbrella Nails

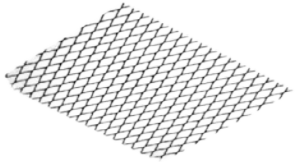
Cement



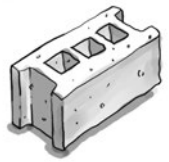
Sand

Gravel

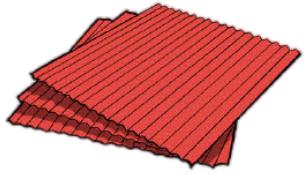
Steel Wire



Chicken Wire Mesh

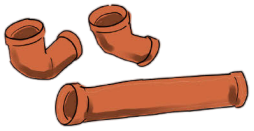


Masonry Units



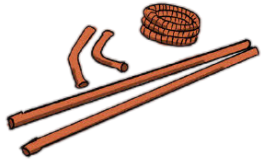
Roofing Sheets

Tek Screws



Plumbing Conduits

Painting Materials



Electrical Conduits

Tools

Nylon String

Measuring Tape

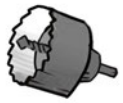
Leveling Tools

Protective Gear

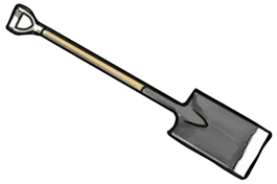
Hammer

Cut Saw

Grinder



Hole Saw for Fishmouth



Shovel

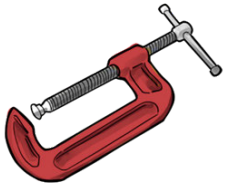
Machete

Chisel

Cross-cut Saw

Rakes

Finishing Rakes

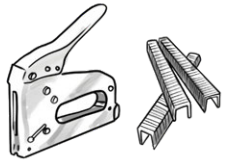


C-clamps

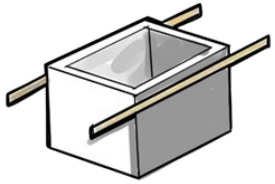
F-clamps

Wrenches

Drill Bits



Stapler and Staples



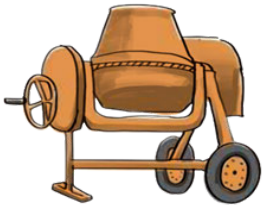
Measuring Box

Plumb Bob

Mortar Pump

Pliers

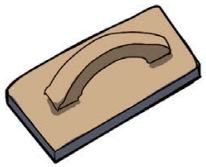
Rebar Bender



Concrete Mixer

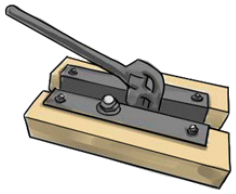
Rubber Mallet

Cement Trowel



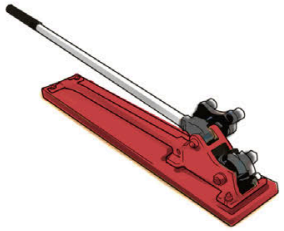
Float

Plastering Hawk



J-bolt Maker

Theodolite (Optional)



Rebar Cutter

Compactor (Optional)

Basin

Cordless Jigsaw

Pail

Power Drill

Cutting Disc

Safety Guidelines and Checklist

Personal Protective Equipment (PPE)

1. All workers must wear appropriate PPE, including hard hats, safety vests, steel-toed boots, gloves, and eye protection.
2. PPE should be inspected regularly for damage and replaced as necessary.

Construction Site Access and Egress

1. Clearly marked and unobstructed access and egress points should be maintained.
2. Workers must use designated pathways and entrances to access the construction site.

Emergency Procedures

1. Emergency exits and evacuation routes must be clearly identified and accessible.
2. All workers should be familiar with emergency procedures and evacuation plans.

Communication

1. Establish a clear communication system among workers, supervisors, and management.
2. Ensure all workers understand and can communicate effectively in case of emergencies.

Tool and Equipment Safety

1. Regularly inspect and maintain all tools and equipment.
2. Ensure workers are trained in the safe operation of tools and machinery.

Site Preparation, Staking, and Layout

Importance of Accurate Alignment
Accurate alignment and squareness are critical for the successful execution of the construction project. These ensure that the building is correctly positioned on the lot. This section provides a step-by-step guide to achieving precise alignment and lot measurement.

Materials and Tools

- Nylon String
- Measuring Tape
- Leveling Tools
- Protective Gear
- Hammer
- Cut Saw
- Theodolite for Line-and-Grade (Optional)
- Cross-cut Saw
- Compactor (Optional)
- Bamboo Stakes
- Nails

Step-by-Step Alignment Procedure

A. Clearing the Site

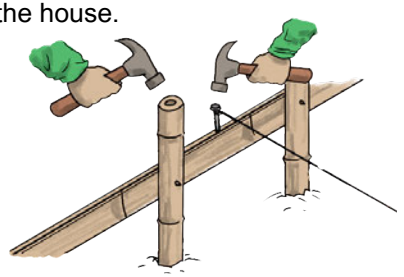
1. Begin by clearing the construction site of any debris, vegetation, or obstacles.
2. Establish temporary fencing around the site to control access.

B. Establishing Benchmarks

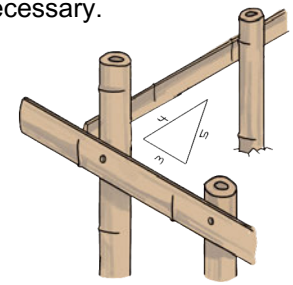
3. Set up benchmark points using a theodolite and leveling instruments.
4. Measure and record elevations at benchmark points to establish a reference for subsequent measurements.
5. Level the ground via cutting and filling.

C. Marking Corners and Boundaries

6. Use surveying stakes and measuring tape to mark the corners and boundaries of the house.

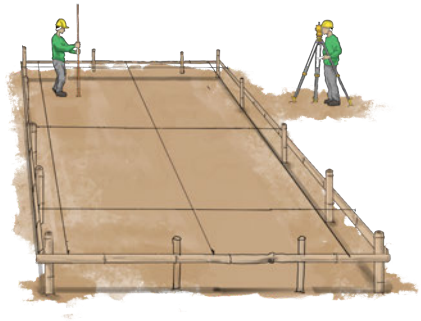


7. Double-check measurements and squareness using the 3-4-5 rule, measuring one side for three units and the adjacent side for four units, where the hypotenuse or the line connecting the ends of the two adjacent sides should be equal to five units. Make adjustments if necessary.



D. Quality Control and Inspection

8. Conduct regular inspections to ensure accurate alignment.
9. Verify measurements.
10. Document any adjustments made during the alignment process.



Foundation Works

The foundation works for CBSW housing follow the usual construction methodology for masonry-based construction, which includes continuous wall footing that will support the shear wall system. The foundation usually consists of the wall footing, a vertical extension made of hollow blocks to encase the backfill, and a concrete plinth beam with extruding rebar dowels that will support the CBSW panels.

Materials and Tools

- Nylon string
- Measuring tape
- Leveling tools
- Protective gear
- Hammer
- Rebar bender
- Concrete mixer
- Rebar cutter
- Compactor
- Cement
- Gravel
- Concrete hollow blocks (CHBs)
- Sand
- Plywood

Step-by-Step Foundation Works

A. Excavation

1. Check the building grid lines' layout for the footing of the exterior and interior walls.
2. Determine the minimum foundation requirements as provided in Table 2.

Table 2: Minimum Foundation Size

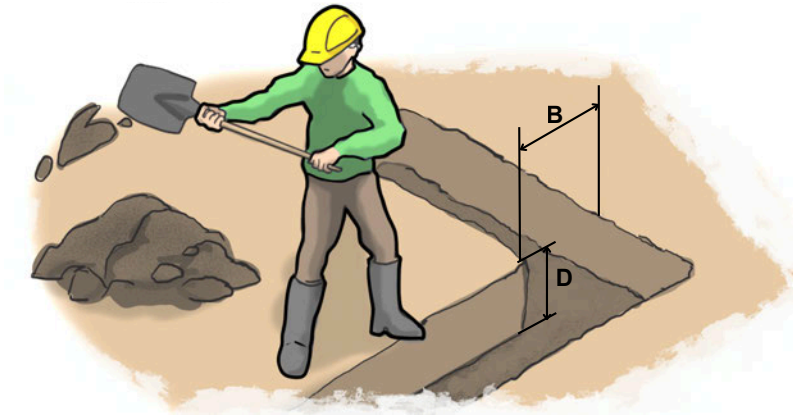
Roof Live Load (kPa)	Soil Bearing Capacity (kPa)	Wall Footing Size		
		Width, B (mm)	Thickness, t (mm)	Depth, D (mm)
0.6	70	350	150	350
	95	300	150	350
	140	200	150	350
0.75	70	400	150	350
	95	300	150	350
	140	200	150	350
1	70	400	150	350
	95	300	150	350
	140	200	150	350

Note: Depth (D) of the foundation shall be increased until both conditions are met:

a. A competent layer of soil is encountered.

b. Organic materials are not present in the soil.

3. Dig or excavate the wall footing trenches, considering the minimum width and minimum depth specified in Table 2. Make sure that the trenches are aligned vertically and horizontally with respect to the layout. Remove stones or other obstacles during excavations.
4. Check elevations and make sure that the excavated trench bed is leveled or at the same elevation.



B. Gravel Bedding (Wall Footing Trenches)

5. Check elevations of excavated wall footing trenches.
6. Remove debris/rubbish and other waste materials.
7. Pour gravel bedding materials into the trenches with a minimum thickness of 50 mm.

C. Application of Soil Treatment (Soil Poisoning) to the Wall Footing Trenches

8. In a container, mix the soil treatment solution with water. Verify the mixing ratio with the supplier.
9. Apply the mixed solution to the trenches using a sprayer or sprinkler. Make sure that all trenches are applied with the solution.

D. Fabrication and Installation of Footing Rebar

10. Use the recommended footing reinforcing bar as specified in Table 3.

Table 3: Recommended Footing Reinforcement

Wall Footing Size (Wxt)	Longitudinal Bar	Transverse Bar
350x150	3-ø10 mm	ø10 mm @ 250 mm
300x150	3-ø10 mm	ø10 mm @ 250 mm
200x150	2-ø10 mm	ø10 mm @ 300 mm
400x150	3-ø10 mm	ø10 mm @ 250 mm

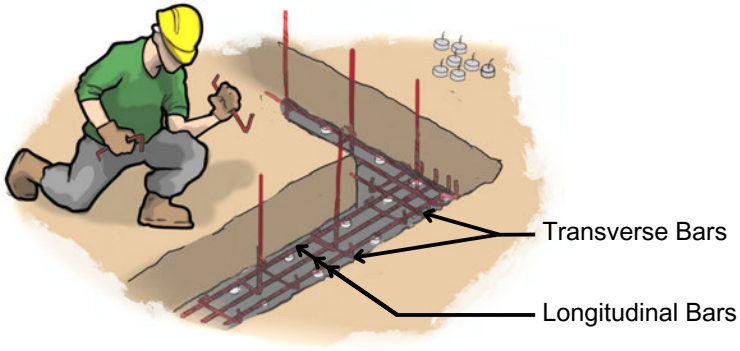
Note:
1. Minimum 28th-day compressive strength, f'c=21 MPa
2. Minimum rebar yield strength, fy=275 MPa

11. Cut the longitudinal bars and stirrups/transverse bars, and then fabricate considering the length and spacing specified in Table 3. (Note: Always consider the bar bending and hook of the stirrups.)

12. Install the fabricated wall footing rebar in the wall footing trench with a concrete block spacer to maintain the concrete cover and check for alignment. Make sure that the longitudinal and transverse rebars are properly tied with one another.

E. Fabrication and Installation of Foundation Wall Vertical Rebar

13. Use the minimum vertical rebar of 10-mm-diameter.
14. Cut the vertical bars, and then fabricate, considering the height of the foundation wall required. (Note: Always consider the bar bending and hook of the stirrups.)
15. Install the fabricated foundation wall vertical bar along the center of the wall footing, considering the maximum spacing of 600 mm.

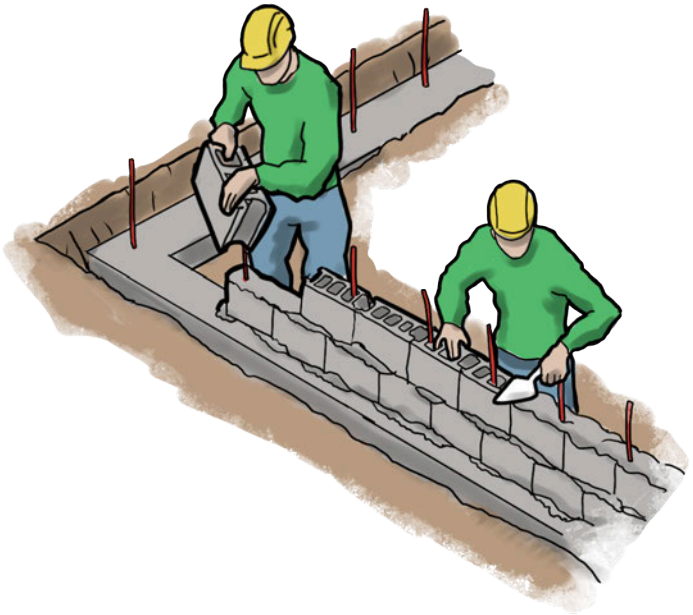


F. Concrete Pouring of Wall Footing

16. Check the wall footing rebars and the vertical rebar for the foundation wall to determine if these are properly installed.
17. On a mixing board, mix 1 part of cement with 2 parts of sand and 4 parts of gravel with water-cement ratio ranging from 0.45 to 0.55 all by mass (referred as 1:2:4 mix ratio herein and for the rest of the manual). Mix until the desired mixture is attained. Repeat the addition of these components until you have the volume of concrete needed.
18. Using a construction pail, pour mixed concrete into the prepared wall footing trench until the specified thickness is attained. Always check the elevation.
19. Provide proper curing by maintaining adequate moisture, temperature, and hydration for several days; this is necessary for the concrete to develop its desired properties. Concrete shall be cured and kept moist for a minimum of seven consecutive days immediately after pouring.

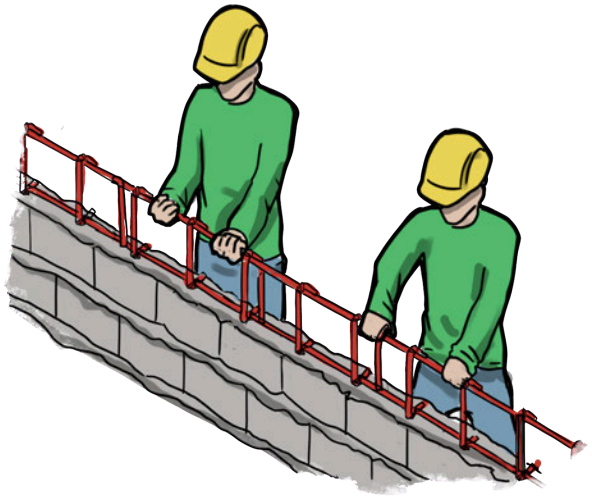
G. CHB Laying for Foundation Wall

20. Check vertical dowel rebar locations.
21. Clean the top surface of the wall footing to remove dirt.
22. Mark and install the CHB line guide (nylon thread).
23. On a mixing board, prepare a mortar mix using 1 part of cement to 3 parts of sand with water-cement ratio ranging from 0.6 to 0.8 all by mass (referred as 1:3 mortar mix ratio herein and for the rest of the manual). Mix until the desired consistency is achieved.
24. Place a layer of initial mortar bed (approximately 25 mm thick) along the marked lines on the footing.
25. Lay the first CHB, starting at one corner. Set the first layer of CHB on the mortar bed, pressing it down firmly and adjusting to ensure it is level and plumb. Use cement mortar as the filler in the CHB holes.
26. Lay a mortar bed on top of the first CHB layer, with thickness of 15 mm as the CHB setting for the second layer. Lay the next CHBs and use cement mortar as the filler in the CHB cells. Check alignments and elevations (level).
27. Splice vertical rebar into the cells of the CHBs, ensuring they extend to the height specified in the plan. Horizontal rebar should be placed in every third layer of CHBs or at a maximum spacing of 600 mm; ensure it is properly embedded in the mortar joints.
28. Repeat steps no. 26 and 27, if additional layers are necessary.
29. Provide a pipe sleeve on the CHB foundation wall for sanitary and water supply pipelines.
30. Keep the wall moist for a minimum of seven consecutive days to ensure proper curing of the mortar and grout. This helps in achieving maximum strength.



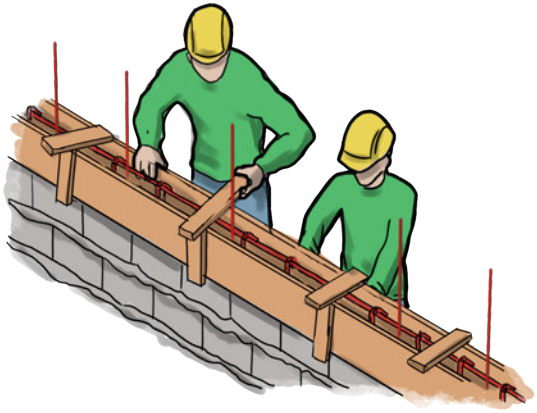
H. Fabrication and Installation of Rebar for Perimeter Plinth Beam

31. Use a minimum of 10 mm diameter for the longitudinal rebar and minimum stirrups of 8 mm with a maximum spacing of 200 mm.
32. Cut the longitudinal bars and stirrups bars, and then fabricate, considering the length and spacing of the rebar. (Note: Always consider the bar bending and hook of the stirrups.)
33. Install the fabricated plinth beam rebar on the top of the CHB foundation wall and check for alignment. Make sure that the longitudinal rebars and stirrups are properly tied with one another.



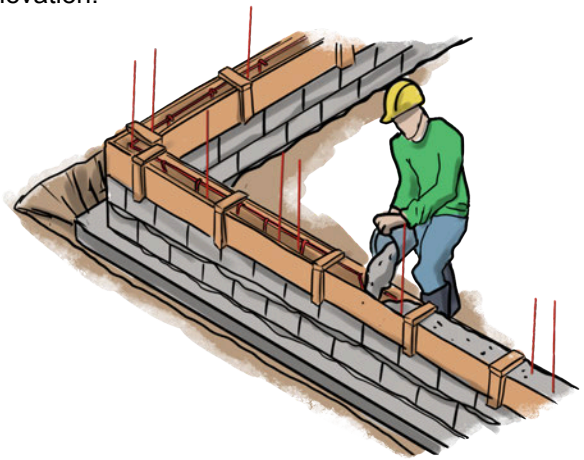
I. Fabrication and Installation of Forms (for Perimeter Plinth Beam) and Vertical Dowel for CBSW Panel

34. Use the minimum dimensions of 100 mm width and 200 mm depth for plinth beam. Use a minimum diameter of 10mm for vertical dowels for the CBSW panels.
35. Fabricate forms using 12-mm-thick plywood and 50 mm × 50 mm lumber.
    Mark the forms according to the dimensions of the plinth beam.
36. Install the fabricated forms according to the plinth dimensions. Provide sufficient braces or supports. Fabricate and install the vertical dowels for CBSW with a minimum diameter of 10 mm. Consider a minimum embedment of 600 mm to bamboo for length of dowels.



J. Concrete Pouring (Perimeter Plinth Beam)

37. Check the precision of the installed vertical bar dowels for the CBSW panels. They should coincide with the bamboo studs of prefabricated wall panels.
38. Check the elevation. Provide the guide using nylon thread.
39. On a mixing board, prepare the concrete using a 1:2:4 mix ratio. Add water and mix until the desired consistency is attained. Repeat the addition of these components until you have the required volume of concrete.
40. Using a construction pail, pour mixed concrete into the prepared side forms until the specified height is attained. Always check the level/elevation.



K. Backfilling and Compaction

41. Haul backfill materials and place them inside the specified areas.
42. Spread and level the backfill materials.
43. Compact the leveled materials in every 200 mm thick layer using a plate compactor until the desired compaction is attained.
44. Repeat steps (41-43) until the specified thickness is attained.
45. Always check the thickness.

L. Removal of Forms for Perimeter Plinth Beam

46. Check the poured concrete.
47. Remove forms, braces, and supports after 24 hours using a hammer and claw bar. Do it slowly to avoid breaking or damaging the concrete plinth beam and the forms.
48. Clean the forms. Remove extra nails.
49. Place forms and braces/supports in a safe, dry place.

M. Soil Treatment (Flooring)

50. In a container, mix the soil treatment solution with water. Verify the mixing ratio with the supplier.
51. Apply the mixed solution to the trenches using a sprayer or sprinkler, ensuring that all flooring areas are thoroughly covered.

N. Gravel Bedding (Flooring)

52. Haul gravel and pour it inside the specified areas.
53. Spread and level to achieve a minimum of 50-mm-thickness.
54. Always check the thickness and elevation (level).

O. Installation of Sanitary Pipelines

55. Check the sanitary pipeline plans.
56. For a toilet, use 100-mm-diameter sanitary pipes and fittings from the toilet bowl connected directly to the septic tank. Use 50-mm-diameter sanitary pipes and fittings from the lavatory connected directly to the main sewer/drainage.
57. For a CR Lavatory, use 50-mm-diameter sanitary pipes and fittings connected directly to the main sewer.

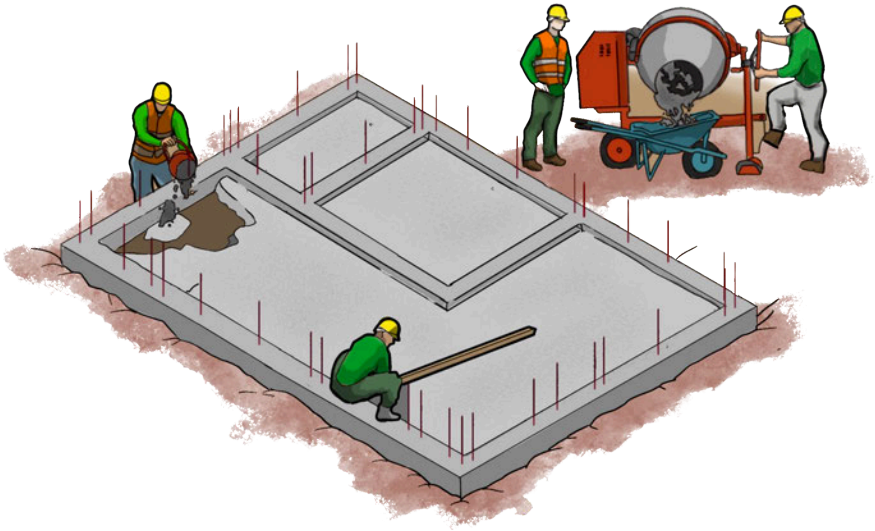
58. For a kitchen sink, use 50-mm-diameter sanitary pipes and fittings from the sink drain connected directly to the main sewer/drainage.
59. For a floor drain, use 50-mm-diameter sanitary pipes and fittings connected directly to the main sewer.
60. Apply PVC solvent cement to connect pipes and fittings.

P. Rebar Installation (Interior Wall Footing and Vertical Bar Dowels for CBSW Panels)

61. Use a minimum diameter of 10 mm for longitudinal bars and 8 mm for transverse bars of the interior wall footing. Use a minimum diameter of 10 mm for vertical dowels for the CBSW panels.
62. Install longitudinal and transverse bars with the minimum dimensions and maximum spacing. (Note: Always include at least 400 mm overlap or splicing.)
63. Anchor the vertical bar dowels to the longitudinal reinforcement of the plinth beam and fix them with tie wire.
64. Tie intersections and check for alignments. Make sure the two are properly tied with one another.
65. Provide concrete spacers between rebar and gravel bedding.
66. Ensure the minimum 600 mm embedment of the vertical bar dowels in the bamboo vertical studs.

Q. Concrete Pouring (Plain Concrete Slab and Interior Wall Footing)

67. Install electrical and plumbing rough-ins as shown in the plans.
68. Install flooring side forms using timber and/or plywood.
69. Check the elevation/level considering the minimum thickness of 75 mm. Provide a guide using nylon thread.
70. On a mixing board, prepare the concrete using a 1:2:4 mix ratio. Add water and mix until the desired consistency is attained. Repeat the addition of these components until you have the required volume of concrete.
71. Using a construction pail, pour mixed concrete into the prepared side forms until the specified height is attained. Always check the level/elevation.



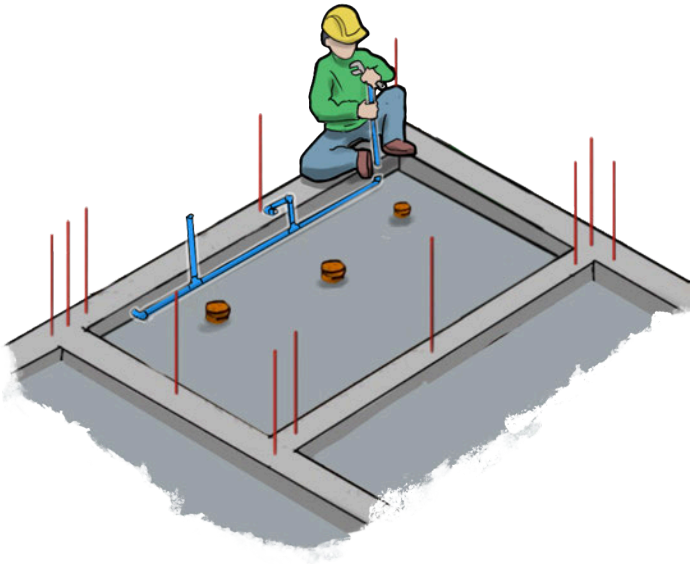
R. Concrete Pouring (Interior Plinth Beam)

72. Check the installed vertical bar dowels for the CBSW panels.
73. Install plinth beam side forms using timber and/or plywood.
74. Check the elevation/level considering the specified thickness. Provide a guide using nylon thread.
75. On a mixing board, prepare the concrete using a 1:2:4 mix ratio. Add water and mix until the desired consistency is attained. Repeat the addition of these components until you have the required volume of concrete.

76. Using a construction pail, pour mixed concrete into the prepared side forms until the specified height is attained. Always check the level/elevation.
77. Provide proper curing by maintaining adequate moisture, temperature, and hydration for a minimum of seven consecutive days; this is necessary for the concrete to develop its desired properties.

S. Installation of Water Supply Pipelines

78. Check the water supply pipeline plan.
79. Use 12-mm-diameter water supply pipelines or blue pipes and fittings to all connections.
80. Apply PVC solvent cement to connect pipes and fittings.

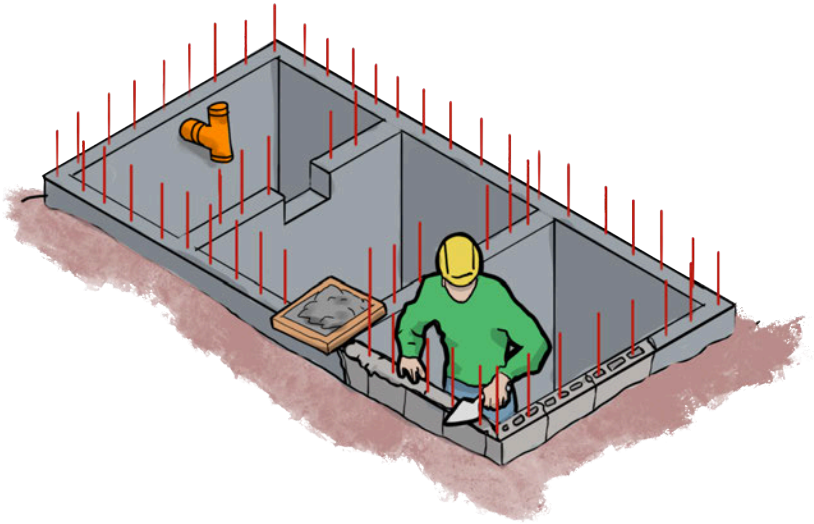


T. Plinth Waterproofing

81. Clean the concrete plinth surface.
82. In a mixing container, mix the waterproofing compound with the cement. Verify with the recommended mix proportions with the supplier. Slowly add cement to the compound while stirring.
83. Apply the recommended coat as per the supplier's material specifications.

U. Construction/Installation of Septic Tank

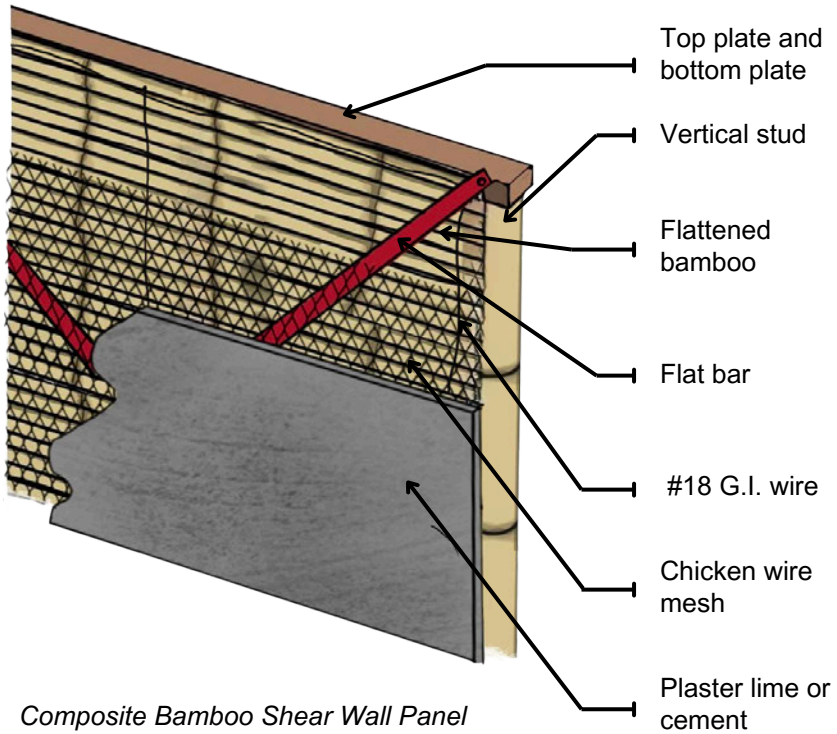
84. Check/interpret septic tank plan details.
85. Layout and stake dimensions.
86. Excavate.
87. Fabricate bottom slab rebars and install.
88. Pour concrete on the bottom slab.
89. Lay concrete hollow blocks. Use one part of cement and three parts of sand for the mortar mixture.
90. Apply 25-mm-thick wall plastering. Use 1:3 mortar mix ratio.
91. Install plumbing rough-ins.
92. Install forms for the top slab using lumber and ordinary plywood. Provide manholes.
93. Install top slab rebars.
94. Install concrete spacers between top slab rebars and forms.
95. Pour in a concrete mixture. Use one part of cement, two parts of sand, and four parts of gravel for the mixture.



Prefabrication of CBSW Panels

In the context of this manual, a composite bamboo shear wall (CBSW) is a structural system consisting of a bamboo or sawn timber frame, wrapped on one or both sides with a wall matrix made from flattened bamboo and chicken wire mesh or metal rib lath, and finished with a cement or lime mortar plaster.

The CBSW panels can be configured as either a single skin (with the wall matrix on one side only) or double skin (with the wall matrix on both sides). In a single-skin flattened bamboo setup, mortar render can be applied to one or both sides of the matrix. For a single-skin rib lath configuration, mortar render is applied to both sides of the matrix.



Composite Bamboo Shear Wall Panel

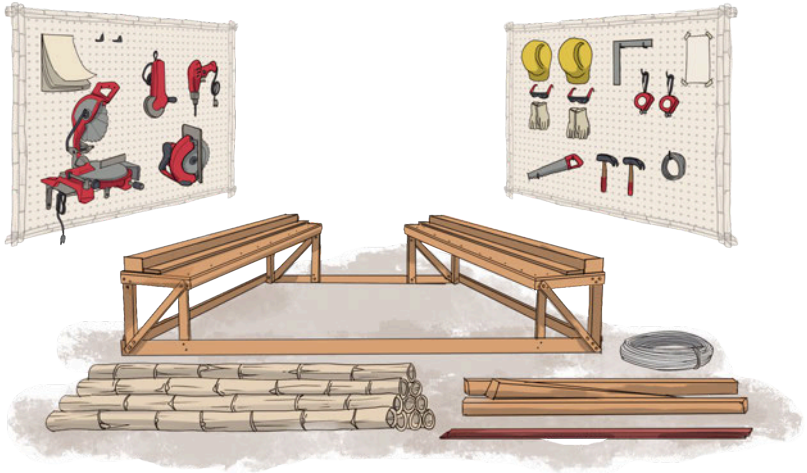
Materials and Tools

- Nuts and washers (ASTM A307)
- Threaded rods (ASTM A307)
- Nails (ASTM F1667)
- Bamboo (ISO 22156)
- #18 G.I. wire (ASTM A641)
- Flat bars (ASTM A36)
- Flattened bamboo (ISO 22156)
- Chicken wire mesh (ASTM A390)
- Kiln-dried timber wood (AWC NDS)

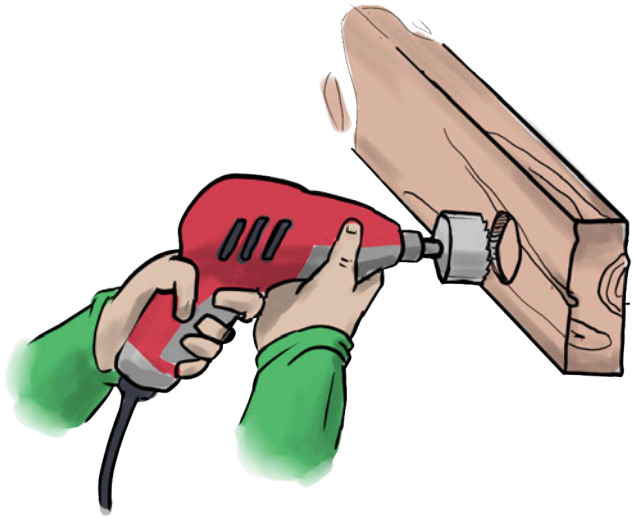
Step-by-Step Prefabrication Process

Prefabrication of a Solid Panel

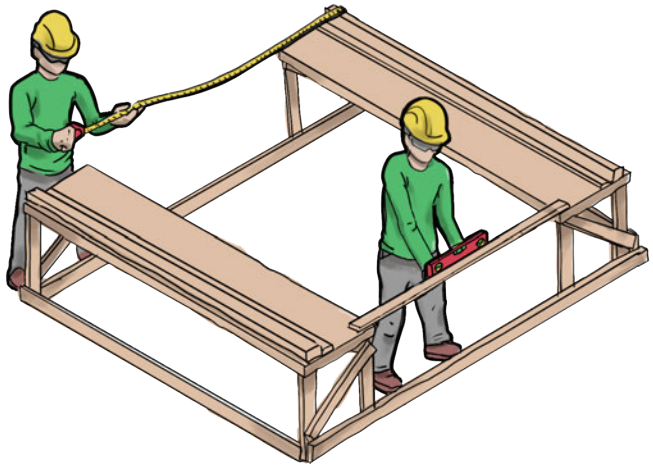
1. Prepare the fabrication table and materials needed for the fabrication. Pre-cut all the materials (bamboo poles, 50 mm × 100 mm kiln-dried treated timber, 3 mm × 25 mm flat bars, flattened bamboo, and 18–25 mm #20 chicken wire mesh) as per the measurements required.



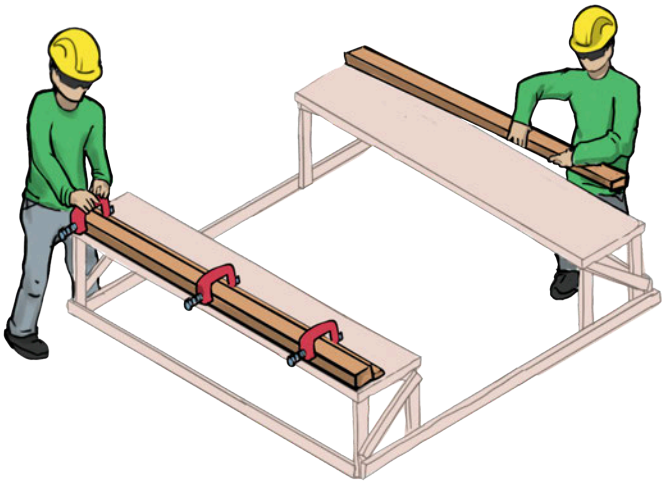
2. Pre-drill all holes as follows: use a 12-mm-diameter drill bit for the vertical bar and J-bolt locations, a 10-mm-diameter bit for securing the flat bar, and a 25-mm-diameter bit for the mortar holes. For nut indentations on the timber plates, use a hole saw or flat bit with a diameter of 35 mm and drill up to a depth of 15 mm.



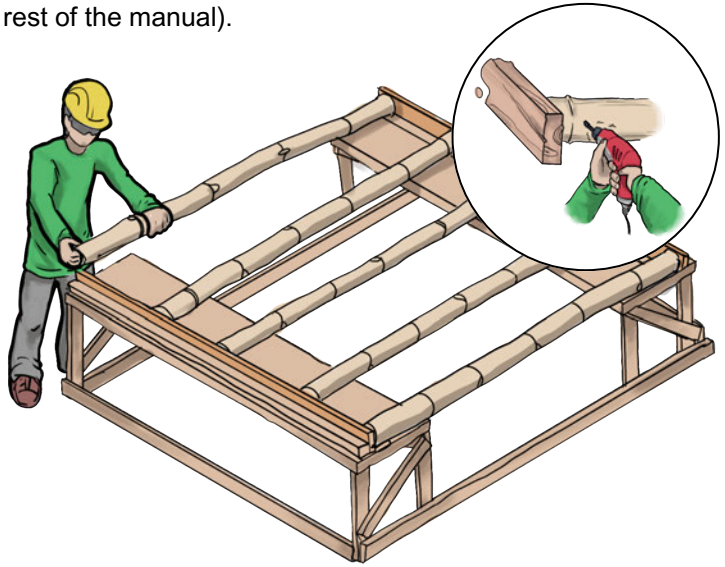
3. Verify the angle and alignment of the fabrication table. Adjust the working table according to the measurements of the wall panel.



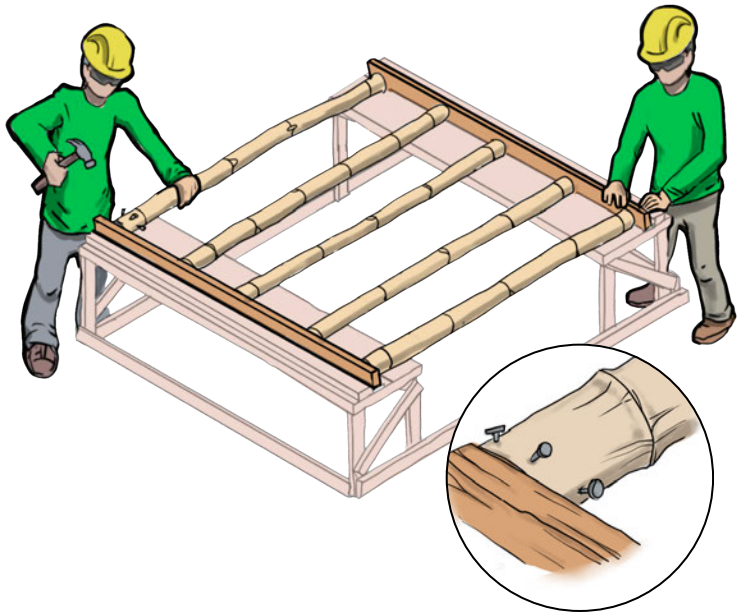
4. Place the 50 mm × 100 mm kiln-dried treated timber for the top and bottom plates on the metal/wood guide of the fabrication table. Fix with C-clamps to maintain its location.



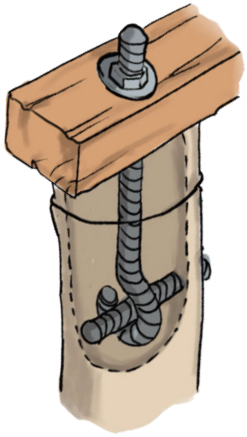
5. Determine the number of bamboo poles needed, then position them against the 50 mm × 100 mm kiln-dried treated timber. Pre-drill the top and bottom of the bamboo studs to make it easier to insert the 3-mm-diameter by 62-mm-long nails (referred to as 8d herein and the rest of the manual).



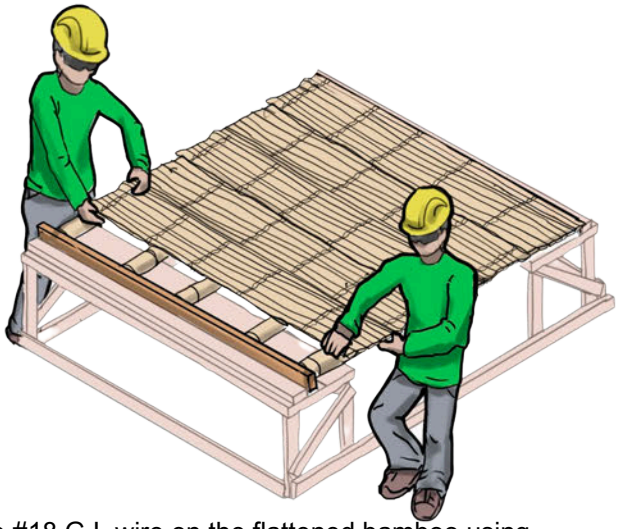
6. Place three pieces of 8d common wire nails at both the top and bottom of each bamboo stud to secure them to the top and bottom timber.



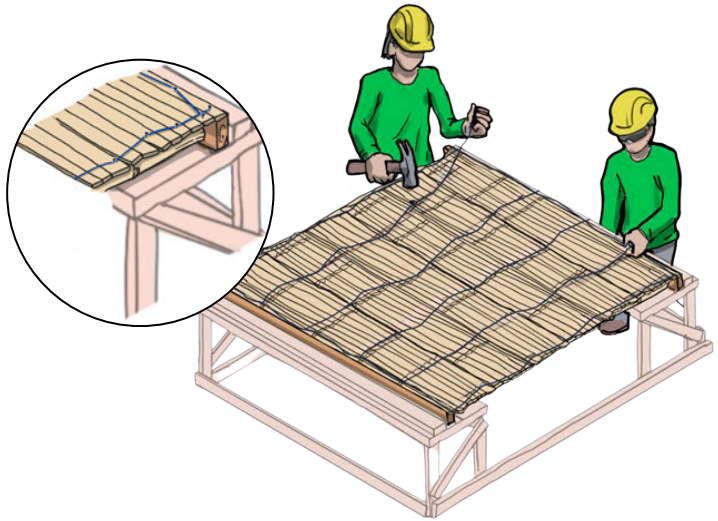
7. Place the 12-mm-diameter J-bolt on the top timber plates.



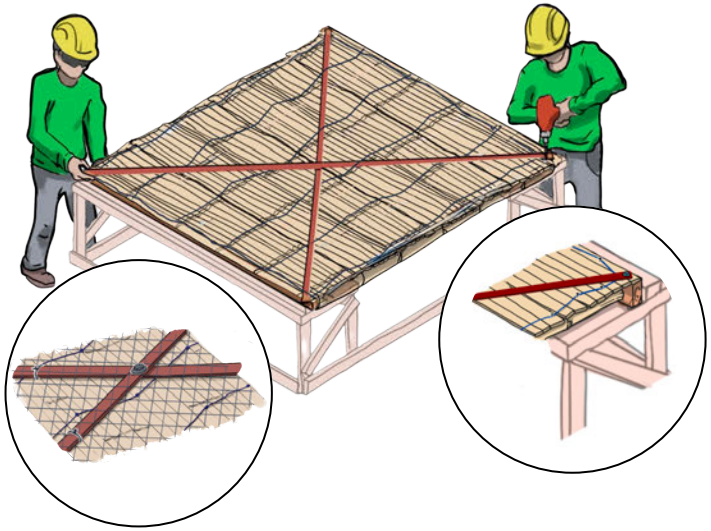
8. Place the flattened bamboo on the bamboo studs in a horizontal position, ensuring it is perpendicular to the studs. The flattened bamboo should cover the panel up to the timber plates.



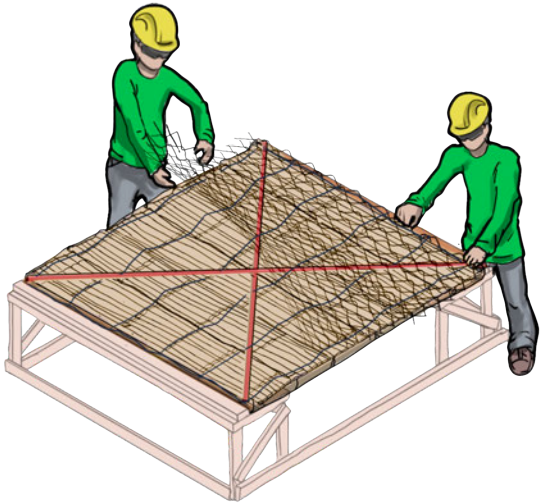
9. Place the #18 G.I. wire on the flattened bamboo using 2-mm-diameter by 35-mm-long common wire nails (referred to as 4d herein and the rest of the manual). The nails should be spaced at approximately 100 mm vertically (bamboo) and horizontally (timber plates) in zigzag/staggered positions.



10. Place the precut 3 mm × 25 mm flat bar on the frame and mark the intersections where it meets the bamboo studs and timber plates. Drill holes at the marked points using a 10-mm-diameter drill bit. Then, use threaded rods with pre-painted nuts and washers to secure the connection.

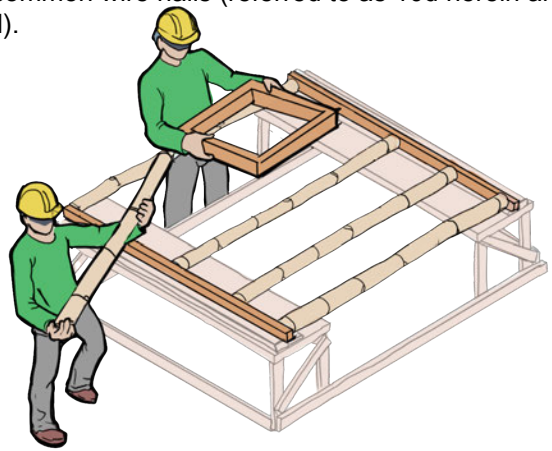


11. Place the 18 to 25-mm-hole #20 chicken wire mesh on top, fixing it at the edges and on the mid-portions using a #50 staple wire gun tacker with #18 tie wires attached to the flat bars.

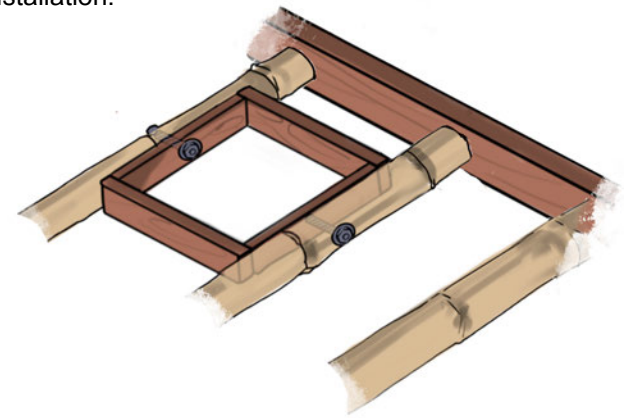


Prefabrication of a Window Panel

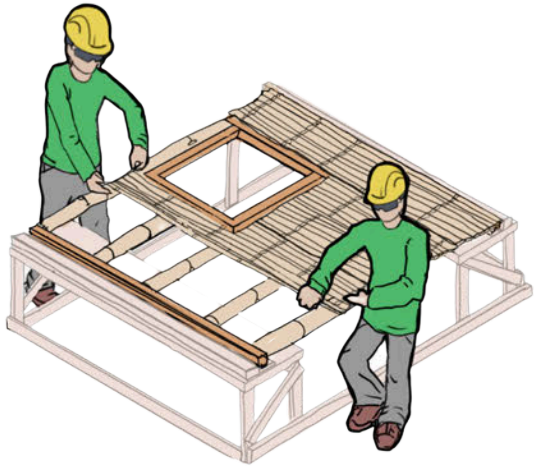
1. After putting the pre-cut and pre-drilled materials in place, make sure that the bamboo poles were nailed firmly to the timber plates and the J-bolts were attached to the top timber plate (See Solid Panel steps 1-7). Verify the window jamb dimensions in the plan before cutting the timber plates to size. Apply wood glue to the ends of the timber and join them using a butt joint secured with 3.25-mm-diameter by 75-mm-long common wire nails (referred to as 10d herein and the rest of the manual).



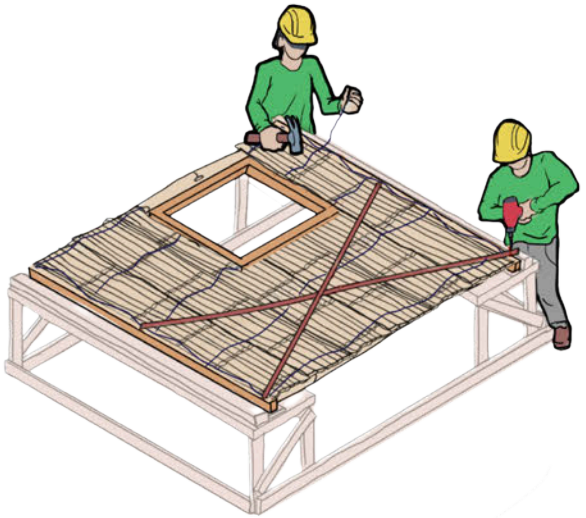
2. After assembling the jamb, position it on the bamboo studs. Fasten it in place using 10-mm-diameter bolts with nuts and washers, making sure the hardware is properly recessed into indentations for a secure and flush installation.



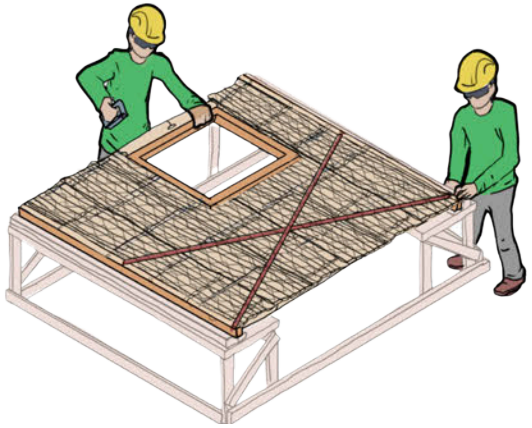
3. Place the flattened bamboo on bamboo studs in a horizontal position, and perpendicular to the bamboo studs.



4. Place the precut 3 mm × 25 mm flat bar on the frame and mark the intersections where it meets the bamboo studs and timber plates. Drill holes at the marked points using a 10-mm-diameter drill bit. Then, use threaded rods with pre-painted nuts and washers to secure the connection.

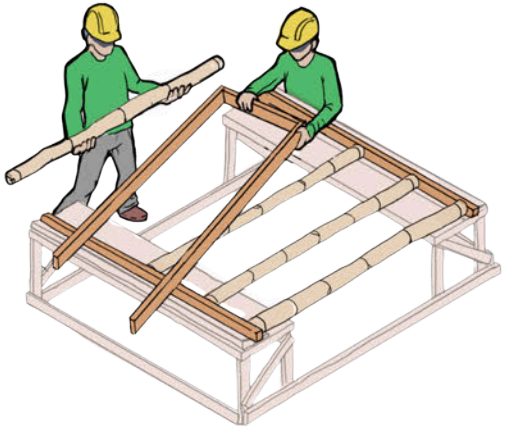


5. Place the 18 to 25-mm-hole #20 chicken wire mesh on top, fixing it at the edges and on the mid-portions through #50 staple wire gun tacker with #18 tie wires attached to the flat bars.

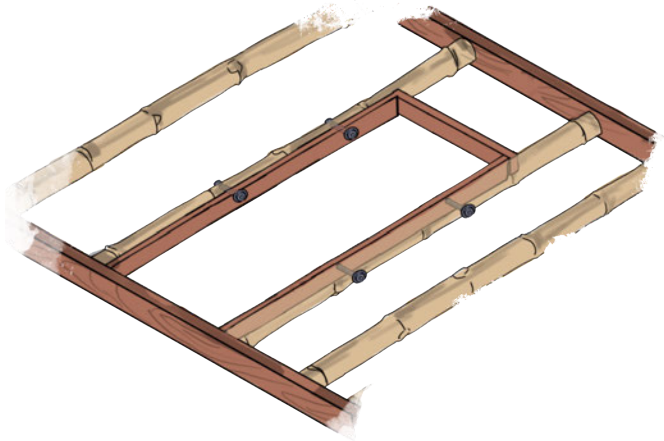


Prefabrication of a Door Panel

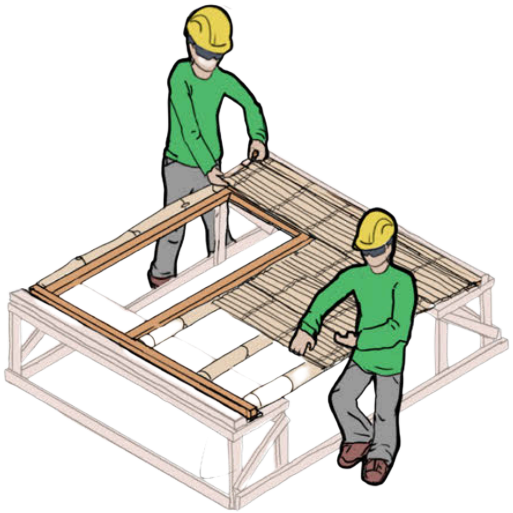
1. After putting the pre-cut and pre-drilled materials in place, make sure that the bamboo poles were nailed firmly to the timber plates and the J-bolts were attached to the top timber plate (See Solid Panel steps 1-7). Verify the door jamb dimensions in the plan before cutting the timber plates to size. Apply wood glue to the ends of the timber and join them using a butt joint secured with 10d common wire nails.



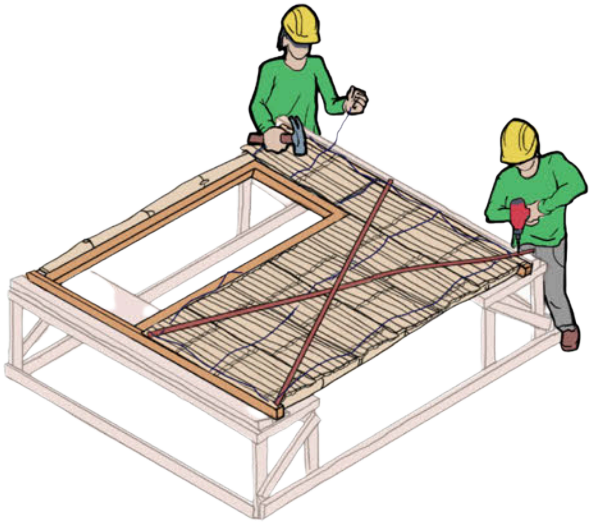
2. After assembling the jamb, position it on the bamboo studs. Fasten it in place using 10-mm-diameter bolts with nuts and washers, making sure the hardware is properly recessed into indentations for a secure and flush installation.



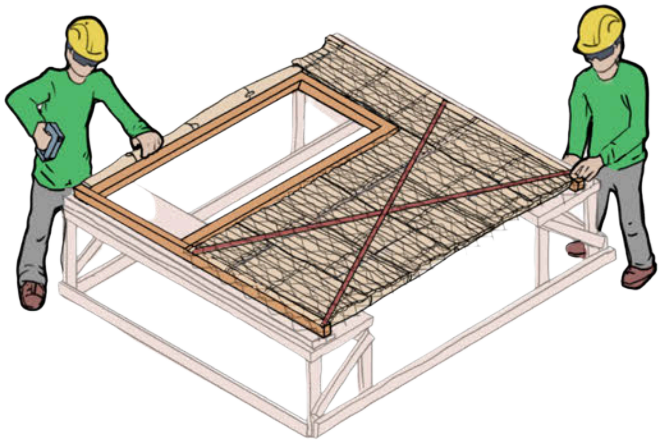
3. Place the flattened bamboo on the bamboo studs in a horizontal position, and perpendicular to the bamboo studs.



4. Place the precut 3 mm × 25 mm flat bar on the frame and mark the intersections where it meets the bamboo studs and timber plates. Drill holes at the marked points using a 10-mm-diameter drill bit. Then, use threaded rods with pre-painted nuts and washers to secure the connection.



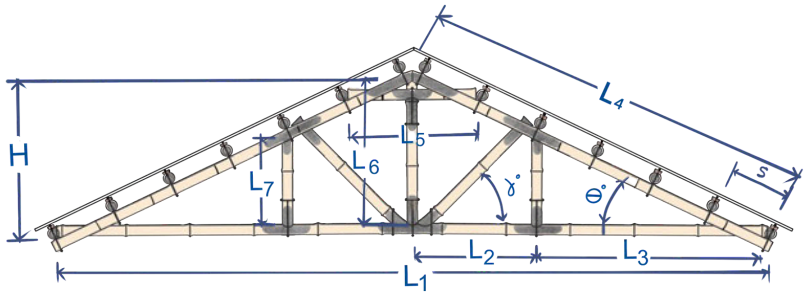
5. Place the 18 to 25 mm-hole #20 chicken wire mesh on top, fixing it at the edges and on the mid-portions through #50 staple wire gun tacker with #18 tie wires attached to the flat bars.



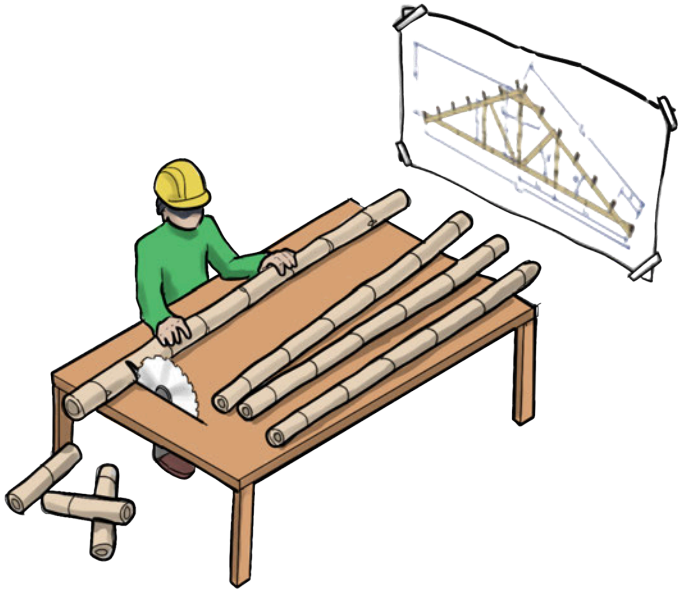
Prefabrication of a Roof Trusses

Step-by-Step Prefabrication Process

1. Select, measure, and cut bamboo poles according to its intended corresponding truss components.

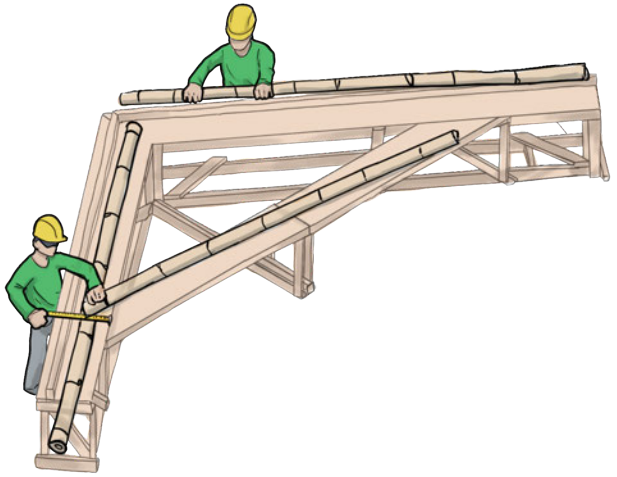


2. Ensure accurate angles and dimensions of the fabrication table for proper assembly.

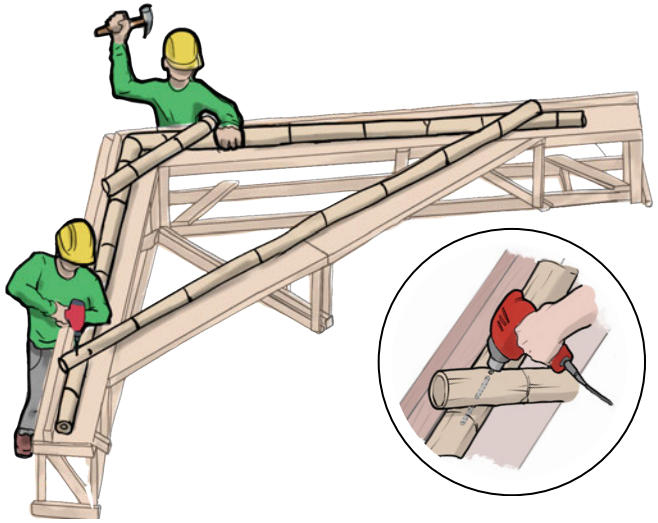


Prefabrication of a Mid Truss

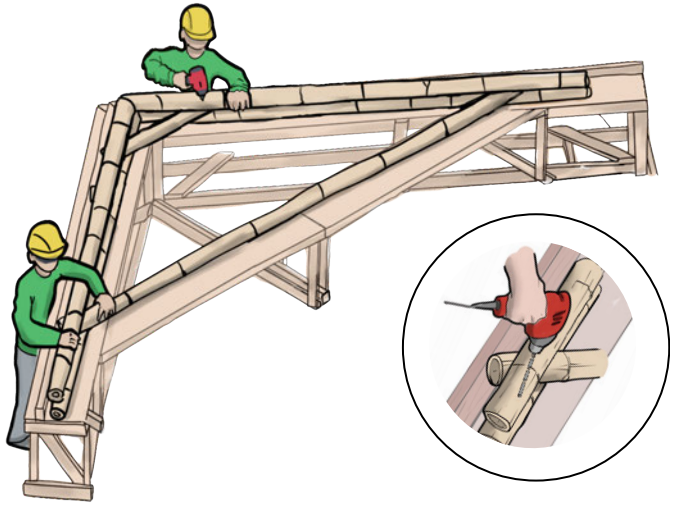
1. Position the bottom chord over the first set of top chords on the fabrication table, ensuring rightness and alignment for proper assembly.



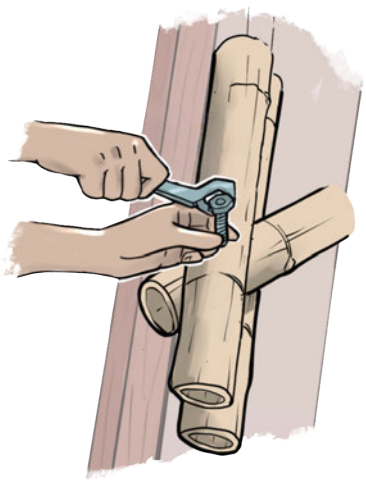
2. Drill a 14-mm-diameter hole at the specified connection points of the top and bottom chords.



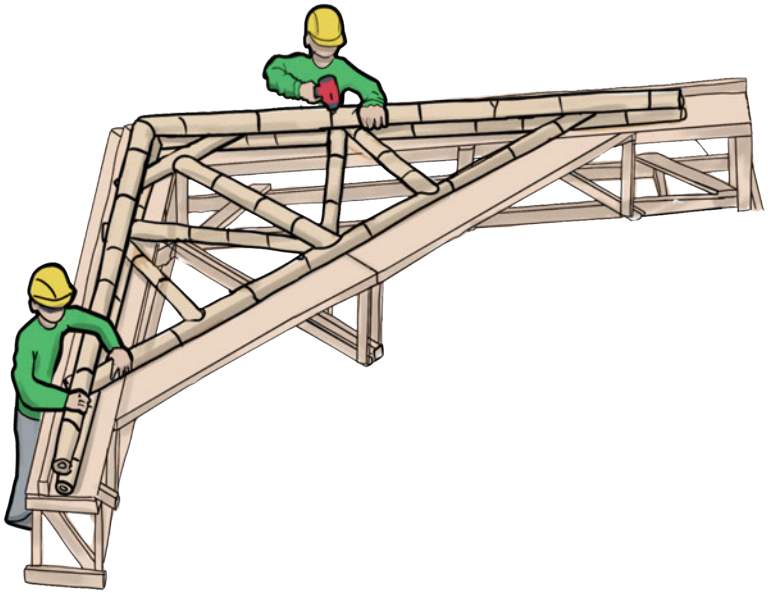
3. Position the second set of top chords over the bottom chord, ensuring rightness and alignment for the proper assembly. Drill a 14-diameter-hole at the same connection points for the 1st set of top chords and bottom chord.



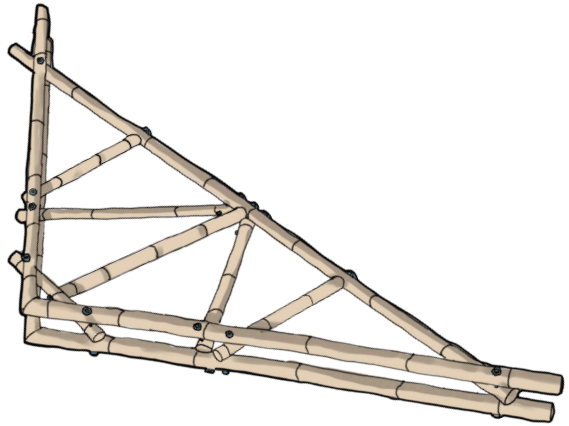
4. Connect the top chords to the bottom chord using a 12-mm-diameter threaded rod at the specified connection points. Secure connections with pre-painted nuts and washers, ensuring stability and structural integrity.



5. Connect the remaining web members to the top and bottom chords with either fishmouth or cross-joint bolted connections. For the fishmouth connections, refer to the diagram of steps no. 10-11 of prefabrication of end wall truss.

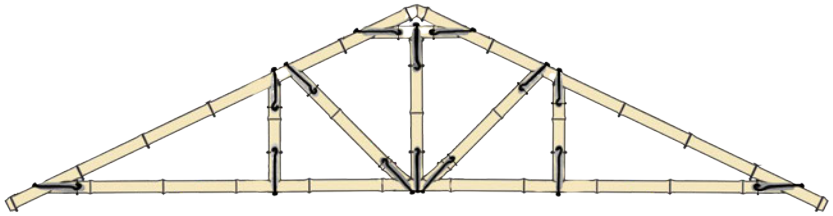


6. Remove the truss from the fabrication table and store it properly.

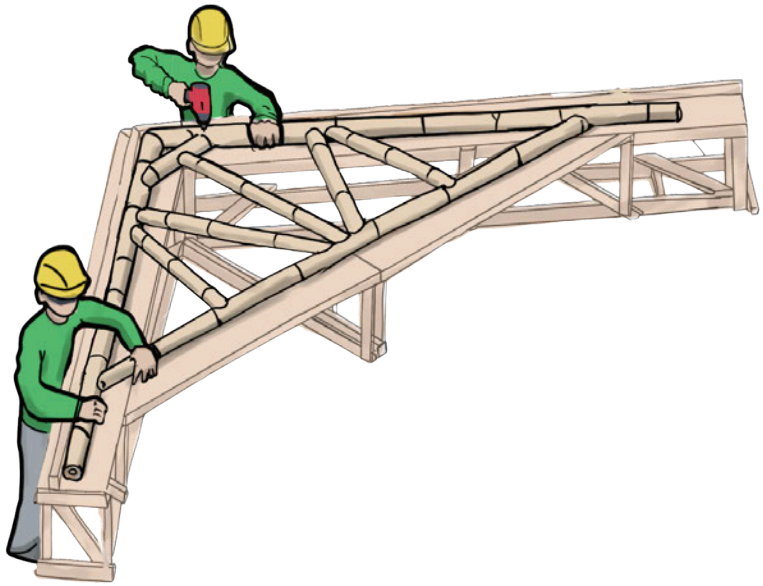


Prefabrication of an End Wall Truss

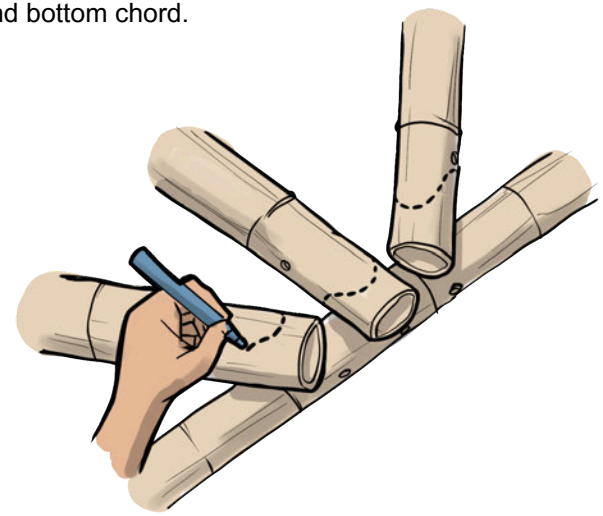
For the end wall trusses, it shall only be composed of single pair of top chords, a bottom chord, and web members connected to each other through fishmouth connections, locked with J-bolts.



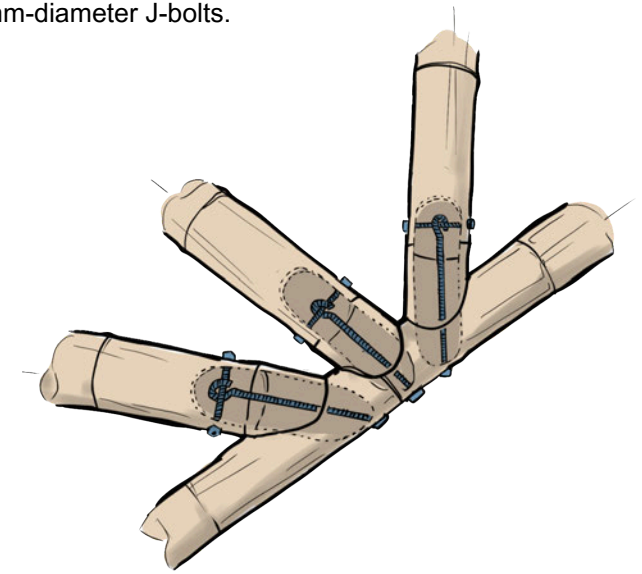
1. Position the bamboo poles on the prefabrication table following the truss plan. Ensure that the truss members are accurately positioned.



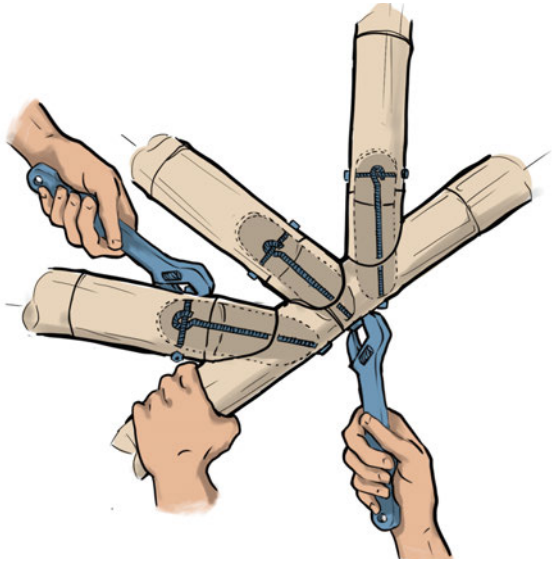
2. Connect web members to the top and bottom chords with fishmouth bolted connections. Mark the curvature of each web members before cutting with hole saw, ensuring a good fit to the top and bottom chord.



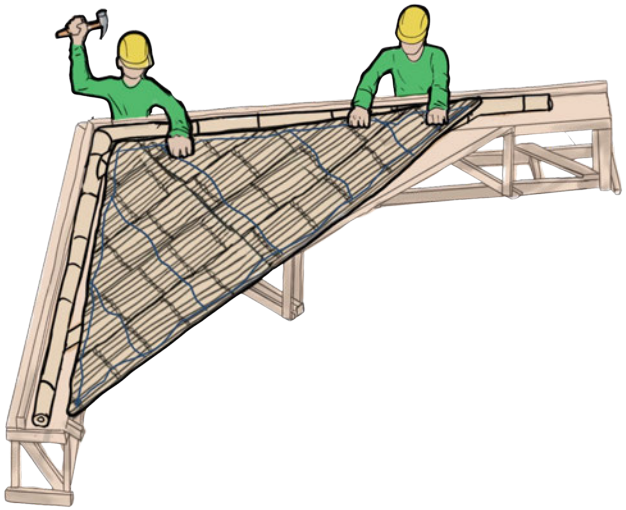
3. Drill 14-mm-diameter holes on the corresponding J-bolt connection points. Connect each web member to the top/bottom chord using 12-mm-diameter J-bolts.



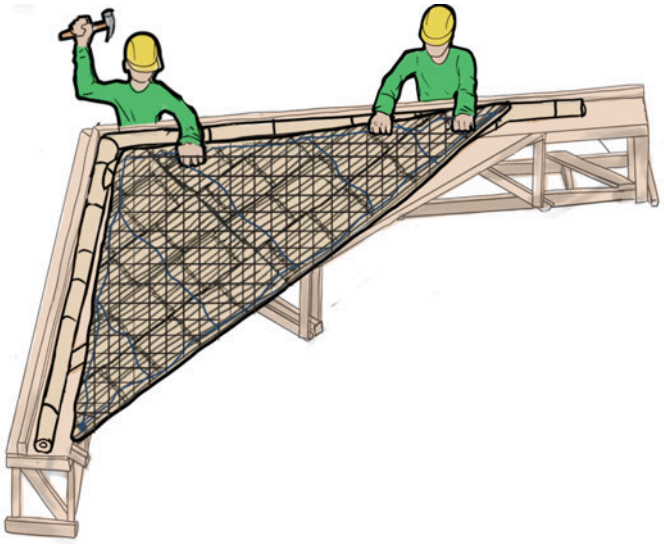
4. Secure the J-bolt with locking bolts, nuts and washers tightly using wrench.



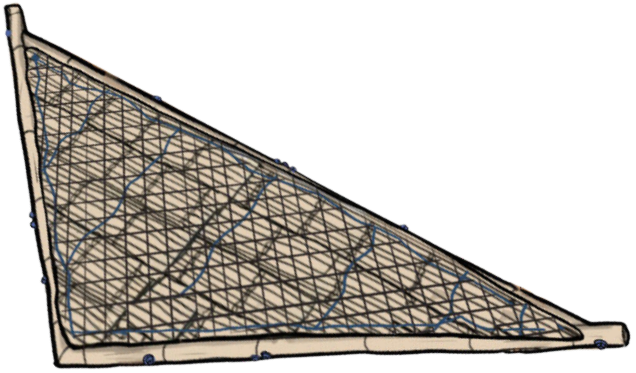
5. Place a flattened bamboo (trimmed in a triangular shape) on top of the bamboo truss frame in a horizontal position, following the same orientation of the wall panel flattened bamboo.



6. Secure 4d common wire nails with tie wire. The nails should be spaced at approximately 100 mm vertically in zigzag/staggered positions.
7. Place the 18 to 25-mm-hole #20 chicken wire mesh fixed on the edges and the mid-portions using a #50 staple wire gun tacker.



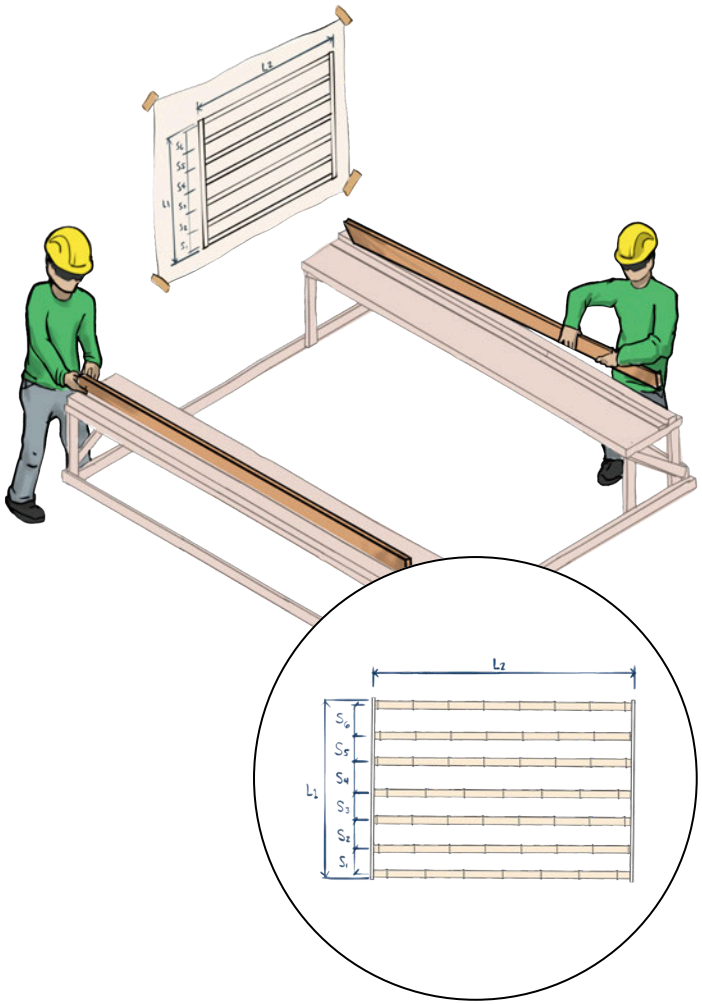
8. Remove the truss from the fabrication table and store it properly.



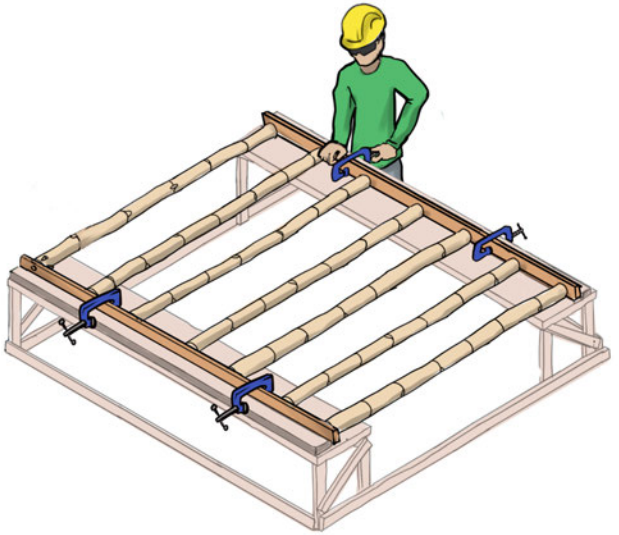
Prefabrication of Purlins

Step-by-Step Prefabrication Process

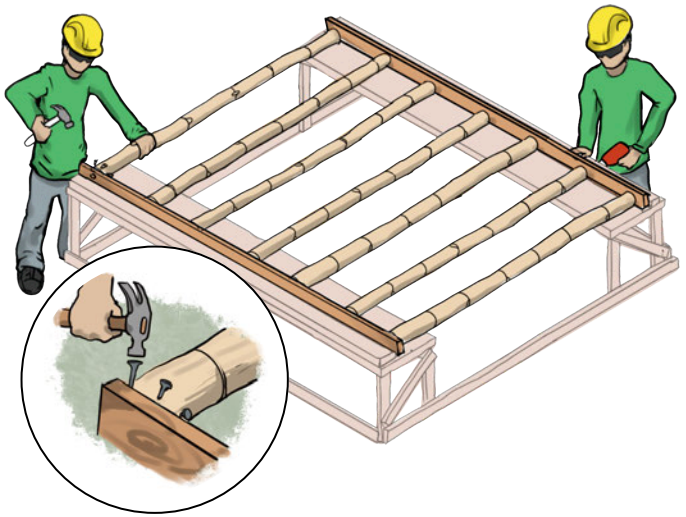
1. Prepare the fabrication table and materials needed for the fabrication. Pre-cut all the materials (bamboo poles and 25 mm × 100 mm and 25 mm × 50 mm kiln-dried treated timbers) as per the measurement required.



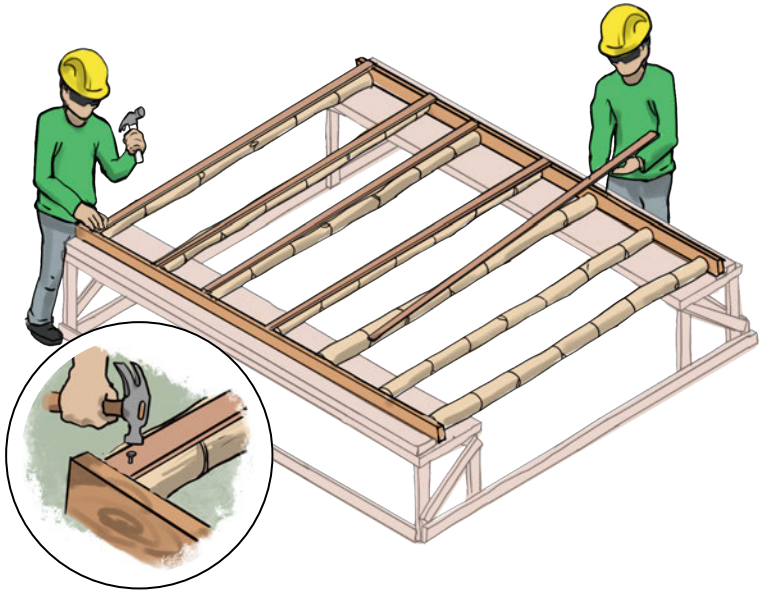
2. Verify the angle and alignment of the fabrication table. Adjust the working table according to the measurements of the purlins panel.
3. Place the 25 mm × 100 mm kiln-dried treated timber for the top and bottom plates on the metal/wood guide of the fabrication table. Fix with C-clamps to maintain its location.



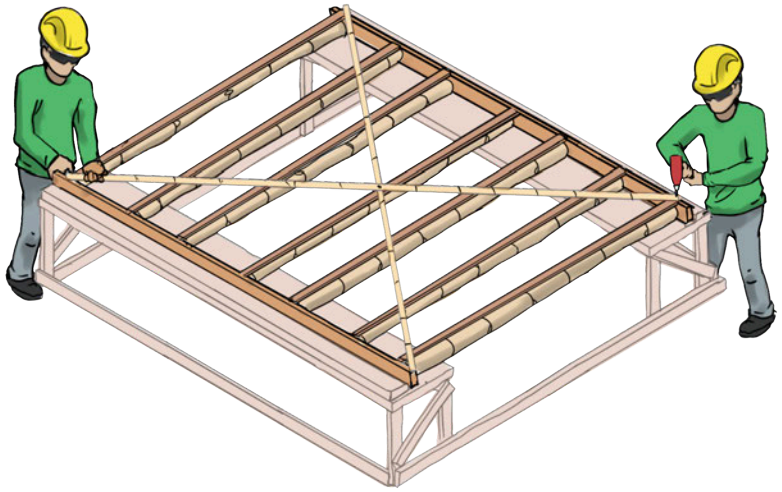
4. Install the number of bamboo poles needed based on the plan and fix them to the 25 mm × 100 mm kiln-dried treated timber using 2.5-mm-diameter by 50-mm-long common wire nails (referred to as 6d herein and the rest of the manual).



5. Install the 25 mm × 50 mm timber on top of the bamboo poles and secure using 6d common nails.



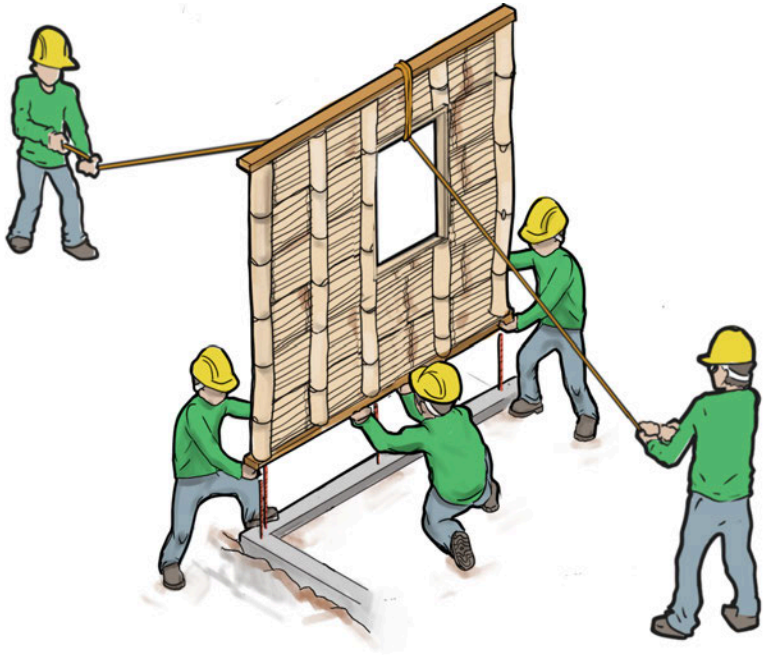
6. Place a temporary bamboo slat bracing on the frame using 6d common nails.



Installation of CBSW Panels

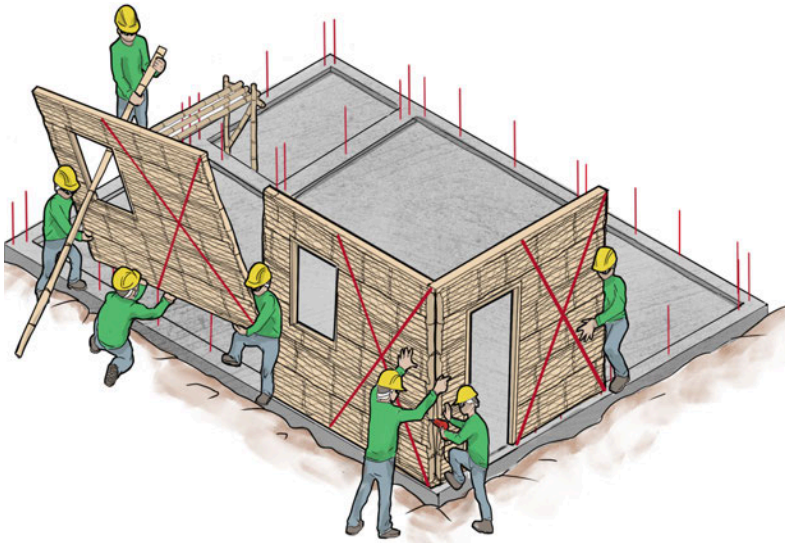
Step-by-Step Procedures

1. Confirm the panel tagging and locations of prefabricated panels based on the architectural/engineering plans.
2. Double-check the dowel alignment and orientation of each panel.
3. Make sure that the plinth beam surface is properly applied with waterproofing
4. Tie ropes on both ends and both sides to provide stability and balance during lifting and alignment.
5. Hold the panels on all sides. With the aid of ropes, carefully carry and place each panel in the designated location.

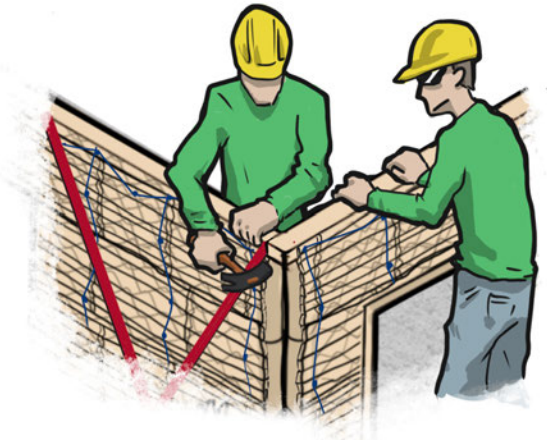


6. Ensure the bottom parts of the bamboo are aligned with the 10-mm-diameter rebar dowels above the plinth beam.

7. Repeat the lifting and placing process for the remaining panels.



8. Ensure that each panel is correctly positioned and aligned.

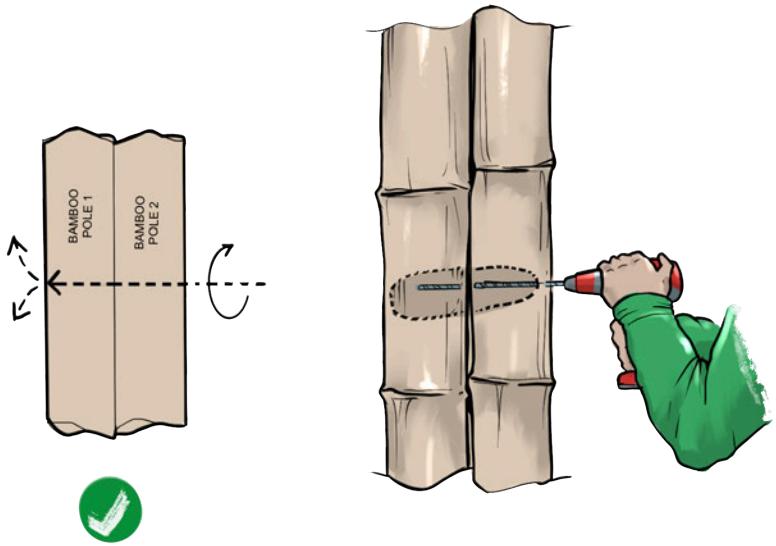


9. Align panels before bolting. Use a 10-mm-diameter rod with pre-painted nuts and washers to bolt each end panel stud at every 1/3 of the panel height. Do not tighten nuts excessively or you may crack the bamboo.

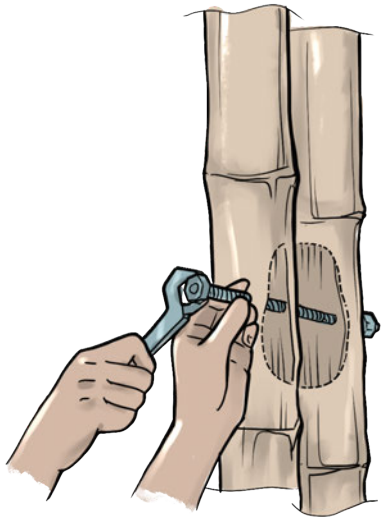
Bolting of Bamboo

Drill a hole in the bamboo studs using a 12-mm-diameter drill bit.

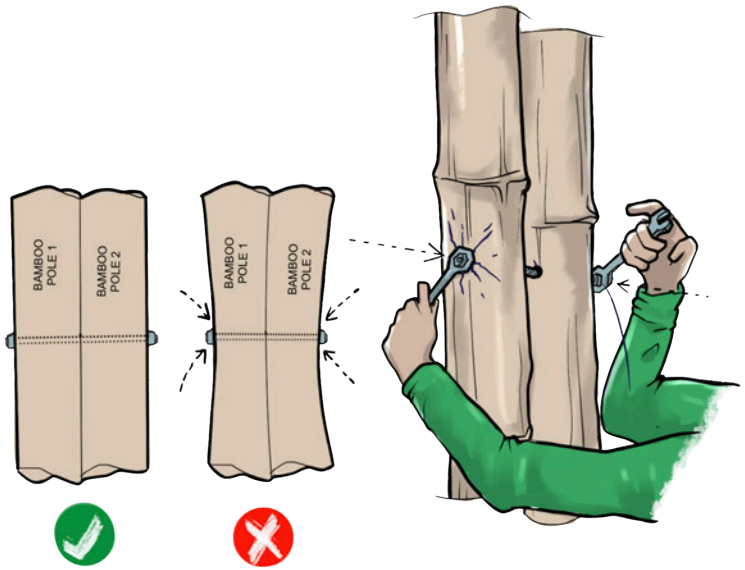
Proper Drilling of Holes



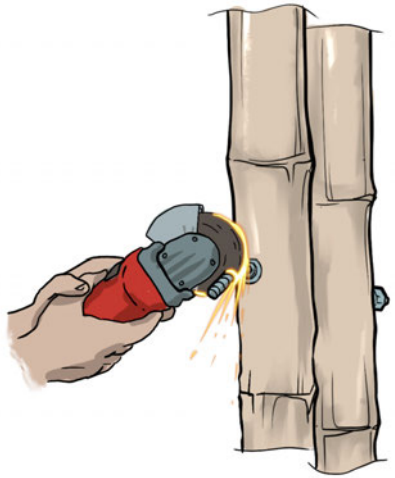
Place the 10-mm-diameter threaded rod with pre-painted nuts and washer to connect the two poles.



Proper and Improper Bolting

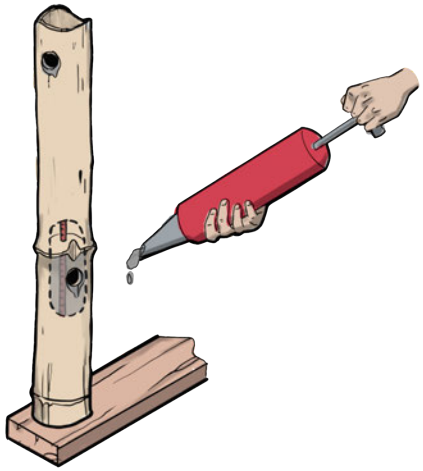


10. Cut excess threaded rod as needed.

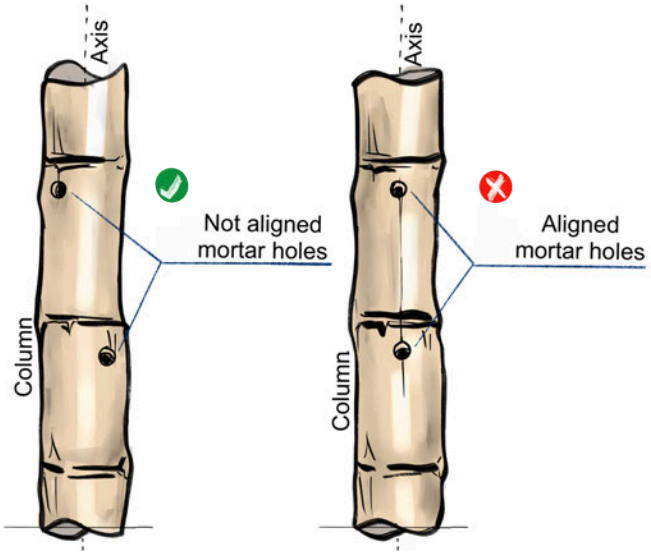


11. Mark and drill the locations of mortar holes. Use a 25-mm flat bit to make a mortar hole at 25 mm below the nodes.

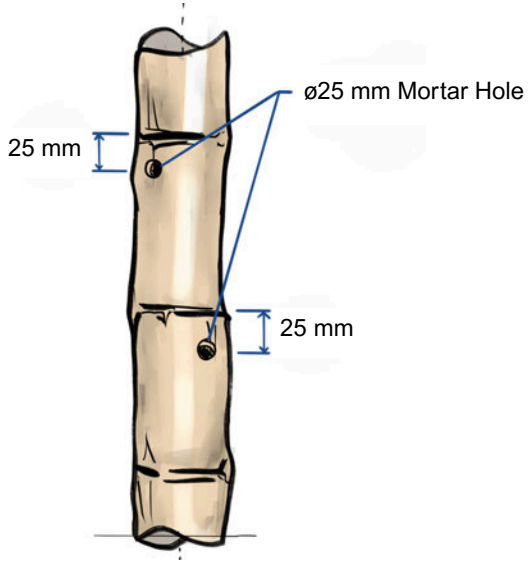
12. For the bamboo dowel connection, use a mortar pump to fill the two internodes of the bamboo stud. Use 1:3 mortar mix ratio. Add water and mix until the desired consistency is achieved. Gently tap the bamboo stud with a rubber mallet to ensure even distribution of the mortar.



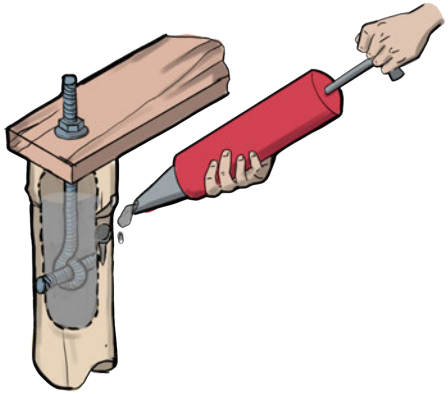
Drilling Mortar Holes



Location and Depth Specifications

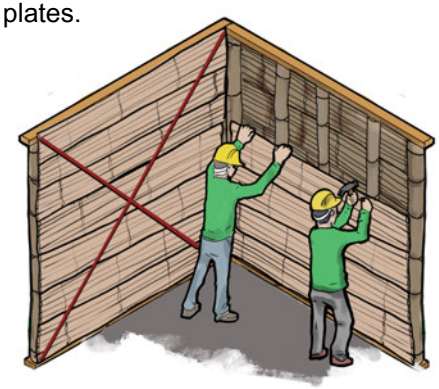


13. For the J-bolt connection, use a mortar pump to fill one internode of the bamboo stud with a 1:3 mortar mix. Gently tap the bamboo stud with a rubber mallet to ensure even distribution of the mortar.



Double Cladding

1. Place the flattened bamboo on the bamboo studs in a horizontal position, ensuring it is perpendicular to the studs. The flattened bamboo should cover the panel up to the timber plates.

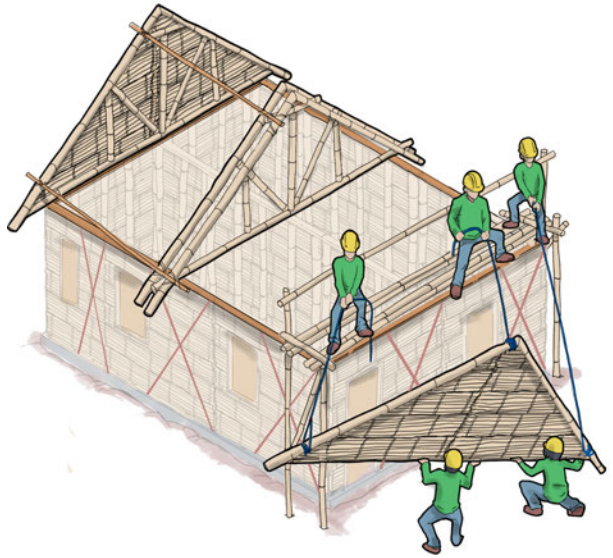


2. Place the #18 G.I. wire on the flattened bamboo using 4d common wire nails. The nails should be spaced at approximately 100 mm vertically (bamboo) and horizontally (timber plates) in zigzag/staggered positions.

Installation of Roof Trusses

Step-by-Step Procedures

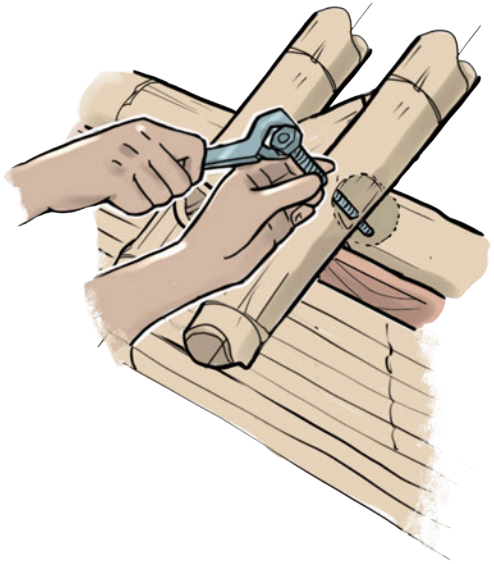
1. Lift each fabricated bamboo roof truss using ropes.



2. Ensure the top chords of both sides of the truss are placed properly on top of the bamboo ring beams.

3. Start the connection of the top chords to the ring beam through drilling a 14-mm-diameter hole on the corresponding connection point.

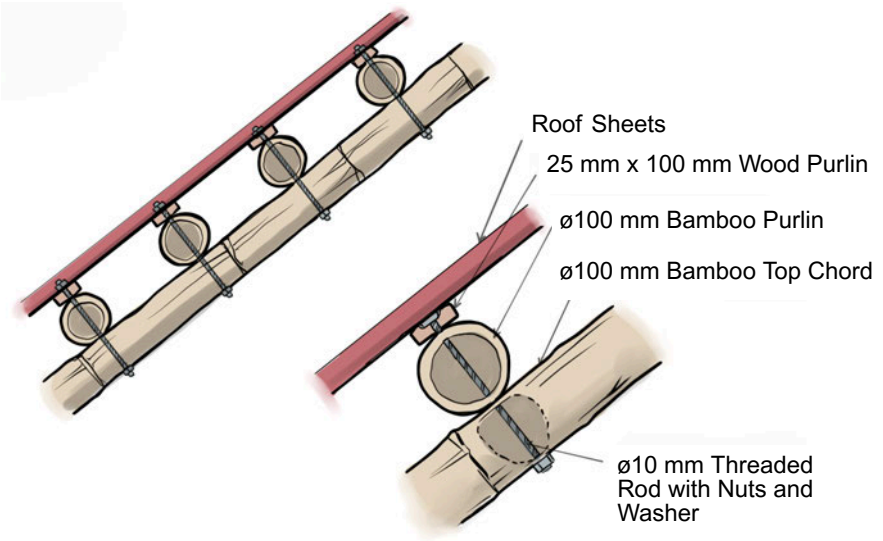
4. Secure the top chord-to-ring beam connection through inserting a 12-mm-diameter threaded rod on the hole, fixing them with nuts and washers.



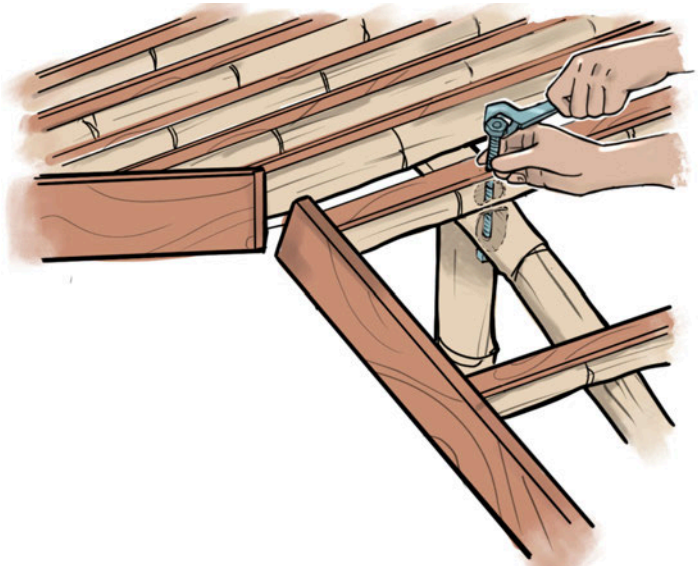
Installation of Purlins

Step-by-Step Procedures

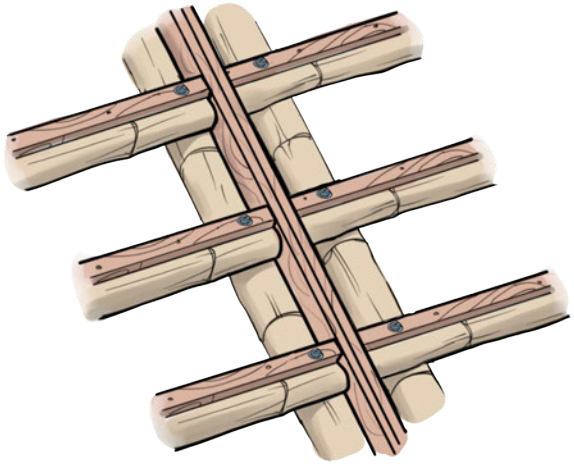
1. Start the connection of the bamboo purlins to the top chord through drilling a 12-mm-diameter hole on the corresponding connection



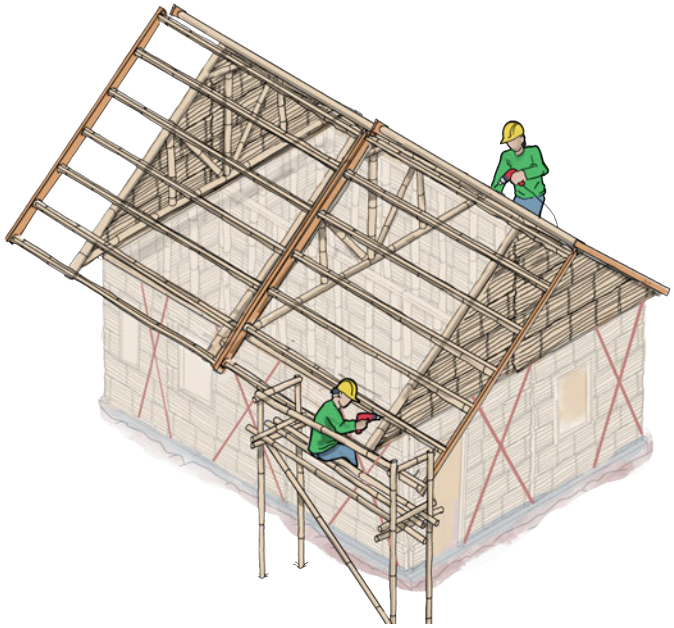
2. Secure the purlins-to-top chord connection through inserting a 10-mm-diameter threaded rod on the hole, fixing them with nuts and washers.



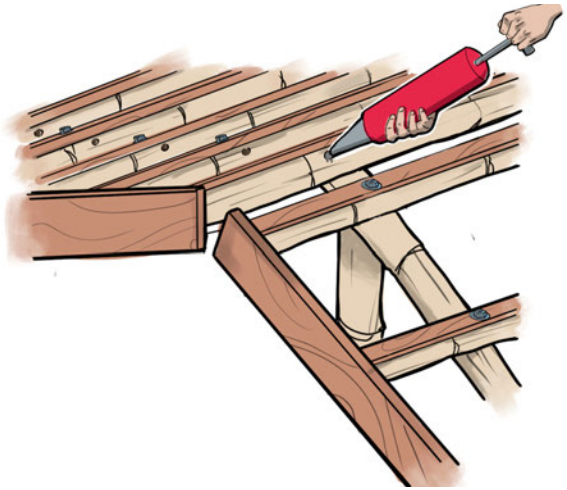
3. Ensure that the 25 mm × 100 mm timber frames of the purlins or placed along the center of the truss, in between the top chords.



4. Remove the temporary bracing of the purlins.
5. Check for levelness and alignment during the installation process. Repeat the process for all roof purlins.



6. Using 1:3 mortar mix, fill the internodes of purlins with connections.



Installation of Roof Sheets

Step-by-Step Procedures

1. Start installing roof sheets from the bottom, ensuring the appropriate overlapping to prevent water seepage.

2. Use a power drill to secure the roof sheets to the purlins with roofing screws.

3. Ensure that roof sheets are securely fastened and properly aligned.
4. Install the metal ridge caps on top of the roof sheets with tek screws, ensuring that the tek screws are also fixed to the purlins nearest to the apex.

5. Install the metal end flashing to the adjacent purlins panel frame with tek screws. Ensure that the connections are properly fastened and aligned.
6. Install the metal fascia cover to the adjacent end purlins with tek screws. Ensure that the connections are properly fastened and aligned.

Installation of Sanitary Fixtures

Toilet Bowl

1. Bind the toilet bowl to the concrete floor using mixed mortar. Use 1:3 mortar mix ratio.

Toilet and Bath Lavatory Set

1. Install/mount the lavatory set using steel wall brackets and screws.
2. Install the fittings and check if leaks are present.

Floor Drain

1. Bind the floor drain to the concrete floor using mixed mortar. Use 1:3 mortar mix ratio.

Installation of Water Supply Fixtures

Service Faucet

1. Install the service faucet using Teflon tape and Polyvinyl Chloride (PVC) solvent.
2. Ensure that leaks are not present.

CR Lavatory Faucet

1. Install the lavatory faucet using Teflon tape and PVC solvent.
2. Install faucet fittings and accessories.
3. Ensure that leaks are not present.

Kitchen Sink Faucet

1. Install the service faucet using Teflon tape and PVC solvent.
2. Ensure that leaks are not present.

Installation of Electrical Rough-ins

1. Install an 18-mm-diameter Unplasticized Polyvinyl Chloride (uPVC) electrical pipe and connect the entrance cap.
2. Install the panel board.
3. Install a 12-mm-diameter flexible electrical pipe, connecting to fixtures.
4. Install electrical wires from the entrance cap to the panel board. For splices, use approved electrical tape.
5. Install electrical wires from the panel board to the fixtures.
6. Install the circuit breakers.
7. Install the electrical fixtures.
8. Check and test if the electrical system is working.

Plastering

The plastering of the walls is performed right after the roofing works. The plastering provides protection to the exposed bamboo poles against direct sunlight and weather, to prolong the lifespan of the house. Ensuring the correct plastering method can provide additional resistance to the panels.

Note: For plastering in toilet and bath areas, as well as the kitchen, use a waterproofing admixture. Please refer to the supplier's technical data sheet for proper application guidelines.

Step-by-Step Procedures:

1. Prepare 1:3 mortar mix ratio. Add water and mix until the desired consistency is achieved.

2. Apply a rough coating on the exterior walls of the bamboo panels, ensuring an even coverage. Use nylon to set the limit of the required thickness of the plaster.
3. Use a trowel and plastering hawk to apply a final coat of cement plaster (maximum thickness of 30 mm), achieving a smooth finish.
4. Ensure consistency in texture across the entire plastered surface.
5. Provide proper curing by maintaining adequate moisture, temperature, and hydration for a minimum of seven consecutive days.

Construction/Installation of Kitchen Countertop

Step-by-Step Procedures

1. Check/interpret the kitchen countertop plan details.
2. Layout and stake dimensions.
3. Excavate soil for the foundation of the countertop.
4. Fabricate and install the wall footing rebars.
5. Pour concrete in the wall footing trench and lay the concrete hollow blocks. Use 1:3 mortar mix ratio.
6. Install forms for the slab using lumber and ordinary plywood. Provide a kitchen sink hole where it should be located.
7. Install the slab rebars as specified on the plan. Provide concrete spacers where required.
8. Pour the slab concrete mixture into the prepared forms. Use 1:2:4 mix ratio.
9. Remove forms after 1 day and install the kitchen sink.
10. Apply 20-mm-thick wall plastering. Use 1:3 mortar mix ratio.
11. Install kitchen plumbing conduits.

Finishing

Step-by-Step Procedures:

A. Application of wall paint primer

1. Clean the wall surface. Make sure to remove dust, oil, and other dirt.
2. In a container, mix powder skim coat with water until the desired semi-sticky mixture is attained. Pre-mixed paint can also be used as an alternative. Confirm with the supplier its instructions for the proper application of pre-mixed paint.
3. Using a trowel, apply a thin and even layer of mixed skim coat on the wall.
4. Check the surface and apply an additional coat if needed.
5. Using sandpaper, scrub the wall surface to make it even and smooth.

B. Application of semi-gloss wall paint (latex paint)

1. Check the wall surface and make sure it is clean and dry.
2. Open the paint container and mix until it becomes sticky.
3. Using a roller brush, apply a thin and even layer of paint as the first coat.
4. After an hour, apply another paint layer as a second coat. Make sure to cover the previous coat evenly.
5. Using a utility paint brush, apply 2 coats of the same paint for the areas not reachable with the roller brush, following same procedures.
6. Clean or remove excess paint from the walls and floors.

C. Installation of doors and windows

1. Position doors and windows in their designated locations, ensuring proper alignment.
2. Attach hinges to doors and windows using screws, securing them to the door and window jambs.
3. Use a leveling tool to ensure doors and windows are plumb and level.
4. Securely fasten doors and windows in place, adjusting as necessary for proper

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MATERIAL STANDARDS

Cement	American Society for Testing and Materials. (2024) ASTM C150/C150M-24: Standard Specification for Portland Cement.
Chicken Wire Mesh	American Society for Testing and Materials. (2006) ASTM A390-06(2021): Standard Specification for Zinc-Coated (Galvanized) Steel Poultry Fence Fabric (Hexagonal and Straight Line).
Flat Bar	American Society for Testing and Materials. (2019) ASTM A36/A36M-19: Standard Specification for Carbon Structural Steel.
Nail	American Society for Testing and Materials. (2021) ASTM F1667-21A: Standard Specification for Driven Fasteners: Nails, Spikes, and Staples.
Nut, Bolt, and Threaded Rod	American Society for Testing and Materials. (2021) ASTM A307-21: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.
Roofing Sheet	American Society for Testing and Materials. (2023) ASTM A653/A653M-23: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
Steel Rebar	American Society for Testing and Materials. (2024) ASTM A615/A615M-24: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
Tek Screw	American Society for Testing and Materials. (2024) ASTM C1513-24: Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections.
Tie Wire	American Society for Testing and Materials. (2025) ASTM A641/A641M-25: Standard Specification for Zinc–Coated (Galvanized) Carbon Steel Wire.

ANNEXES

Annex A: Grading Process

It is very important to control the quality of bamboo right after the delivery. The following section presents the steps (and criteria) for grading bamboo culms for use in CBSW houses.

STEP 1. Identify the condition of the bamboo culms through visual grading. Herein, bamboo culms are visually evaluated for insect infestation, fungal damage, and cracks. The presence of these defects greatly reduces the quality, strength, and durability of bamboo culms.

1.1 Insect Infestation

Bamboo poles may be infested by beetle larvae and termites. These insects feed on the bamboo culm wall, weakening it by reducing the area available to carry the load. Generally, the signs of insect attack are hard to detect on the outer surface of a bamboo culm until the final stages of the attack. For this reason, bamboo poles with insect damage are rejected, even if the damage appears minimal on the surface or isolated to a small area.

This cross-section of the bamboo culm shows the damage inside caused by the longhorn beetle.

Beetles. The larvae of longhorn beetles and powder beetles feed on the starch present in a bamboo culm. They tunnel through the inner tissues of the culm. However, the outer surface of the culm remains intact, giving a false impression of no damage under visual inspection. The adult beetles emerge by making tiny round or oval exit holes on the outer surface of the culm. Bamboo poles with visible exit holes are discarded (Kaminski et al., 2016).

Visible exit hole (between 1 and 6 mm diameter) due to longhorn beetle damage.

Visible exit holes (ranging from 1 to 2 mm diameter) caused by powder beetle.

This longitudinal cut section of the bamboo culm shows the longhorn beetle damage inside.

This longitudinal cut section of the bamboo culm shows the powder beetle damage inside.

Termites. These are tiny insects that resemble ants and live in colonies. They feed on the cellulose of bamboo and can also attack dry culms. Signs of termites are observed through galleries or tunnels on the bamboo culms. Since they live in large colonies, termites can cause significant and rapid damage (Kaminski et al., 2016).

This cross-section of the bamboo culm shows the visible holes and damage inside caused by the longhorn beetle.

Termites attacking bamboo, Costa Rica. The termites are just as visible as the translucent insects crawling on the inside of the bamboo (Photo from: Arup).

Severe termite damage to timber and cane in traditional bahareque.

Visible white spots on bamboo that are exposed to rain indicate fungal infection.

1.2 Fungal Attack

A fungus survives in a moist environment, and it also causes rot. Rain or ground moisture may cause bamboo to become wet or damp, thus attracting the fungus (Kaminski et al., 2016).

1.3 Sun Radiation

Bamboo that has prolonged exposure to the sun may undergo discoloration, structural weakness, drying, and cracking.

Visible dark spots on bamboo that are exposed to rain indicate fungal infection.

Healthy bamboo culms with a golden color, unlike the faded culms at the bottom.

1.4 Fissure and Longitudinal Indentation

Fissures and longitudinal indentations are cracks or splits that run along the length of a bamboo pole. They can occur due to various factors such as environmental conditions, age, and the specific species of bamboo.

Fissures. These are cracks that originate from the outer surface of the bamboo wall which run parallel to the fibers (Figure 23). These cracks can occur at the end of the culm or any internode along its length. These could be brought on by changes in temperature, mechanical stress, or moisture content.

Visible fissure in a bamboo culm due to the effect of environmental conditions.

Key:

1. Fissure
2. Node
3. Internode

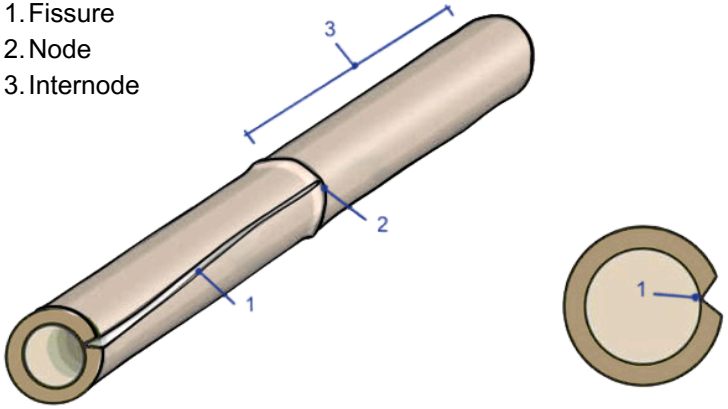


Figure 23. Fissure

Longitudinal indentations. Depressions or grooves parallel to the fibers of the bamboo (Figure 24). Such indentation may serve as an indicator of cracking in the inner surface of the bamboo culm. Depending on the bamboo species, these indentations may be inherent characteristics or the consequence of physical harm or environmental influences. The presence of indentations in bamboo may compromise its structural integrity and increase its susceptibility to breaking.

Visible longitudinal indentations on bamboo culms due to environmental conditions.

Key:

1. Longitudinal Indentation
2. Internal Fissure
3. Node
4. Internode

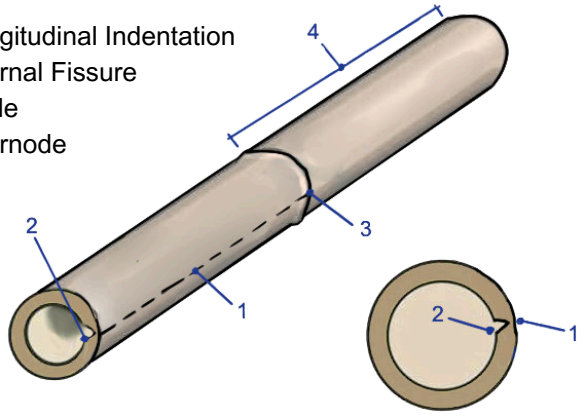


Figure 24. Longitudinal indentations

Figures 25-27 show the allowable and not allowable cracks in bamboo.

Allowable crack width:

- ≤1mm for fissure
- ≤2mm for longitudinal indentation

Figure 25. Allowable crack width

Not allowable:

Figure 26. Cracks extending to three adjacent internodes

Figure 27. The sum of the lengths of cracks ≥ 20% the length of the pole

STEP 2. Geometric Grading

The geometric properties vary along the culm. During grading, the geometry of pieces should be consistent with the intended geometry for their use. Herein, bamboo poles that pass the conditional property requirements are cut into the required lengths while ensuring compliance with the desired geometric properties (Figure 28).

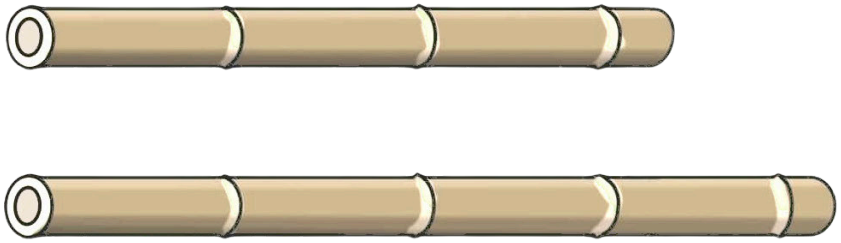


Figure 28. The poles are sectioned to the required lengths for treatment

2.1 Geometric properties refer to the directly measurable dimensions of a piece, including the diameter, wall thickness, internodal length, and culm length. Additionally, they encompass shape deviations such as bow, taper, and ovality.

Diameter – Significantly influences the structural capacity of a section. Any external diameters less than 70 mm are rejected.

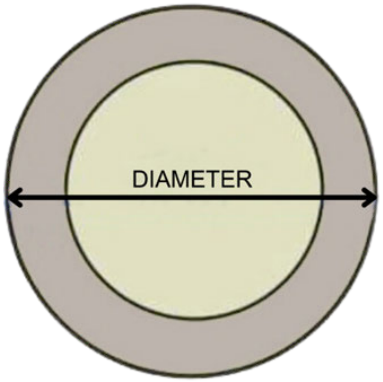


Figure 29. Diameter

The range of diameters (Figure 29) of bamboo culms for CBSW panels is limited to 70–120 mm (Table 4).

Table 4: Acceptable Pole End Diameters Used in Practice

Length (m)	Maximum Bottom Diameter (mm)	Minimum Top Diameter (mm)
2.4	110	80
3.0 or more	120	70

Wall Thickness – The thickness of bamboo walls (Figure 30) can be estimated if there are known species-specific relationships between diameter and thickness.

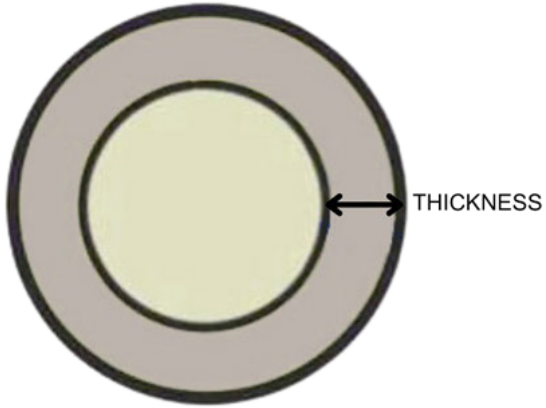


Figure 30. Wall thickness

The minimum thickness should be 8 mm.

Taper – The degree of change in the outer (external) or inner (internal) diameter along the length of the culm. This property can substantially reduce the bending and compression capacity of a culm. Taper can occur either externally or internally.

Figure 31. Taper

Generally limited to 0.5%, external taper (Figure 31) refers to the difference in diameter of the two ends divided by the length between them.

Bow – Refers to the out-of-straightness imperfection of a bamboo pole. It is the ratio of the greatest transverse deviation from the reference length of the culm.

$$Bow = \frac{B_{max}}{L}$$

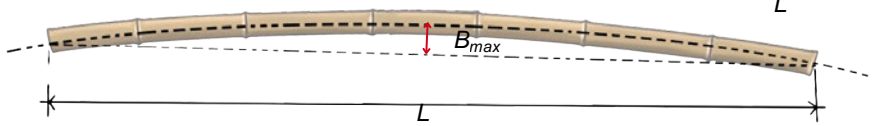


Figure 32. Bow

The bow or the curvature of the bamboo (Figure 32) used in the composite bamboo shear wall (CBSW) is less than 2%.

The following geometric properties are allowable for a bow:

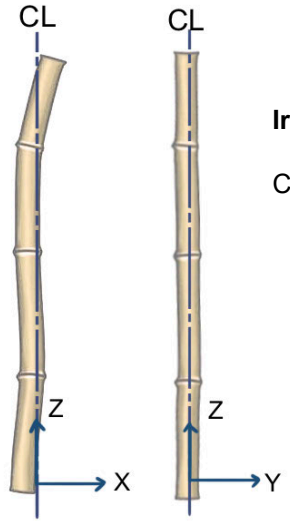


Figure 33. Irregular shape

Irregular Shape (Multiple Bow)

Conditions:

1. An irregular shape or similar (Figure 33) is permissible if one (1) plane is straight. Identify by rotating and observing the straightness.
2. No more than 2% of its length should be curved.

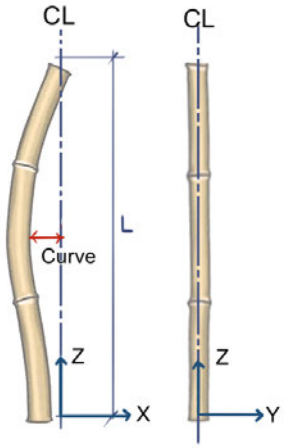


Figure 34. Mid curve

Regular Mid Curve (Single Bow)

The mid curve (Figure 34) is defined as the curve located/situated in the area from 1/3 to 2/3 of its length.

Conditions:

1. One plane straight is permissible. This is identified by rotating and observing.
2. No more than 2% of its length should be curved.

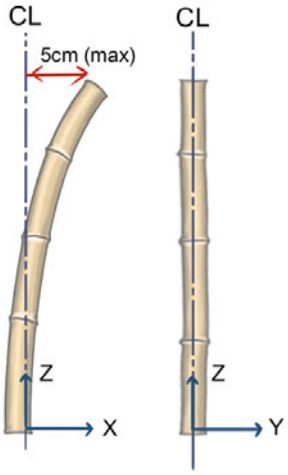


Figure 35. End curve

Regular End Curve (Single Bow)

The end curve (Figure 35) is defined as a curve located/situated either in the area before 1/3 or in that after 2/3 of its length.

Conditions:

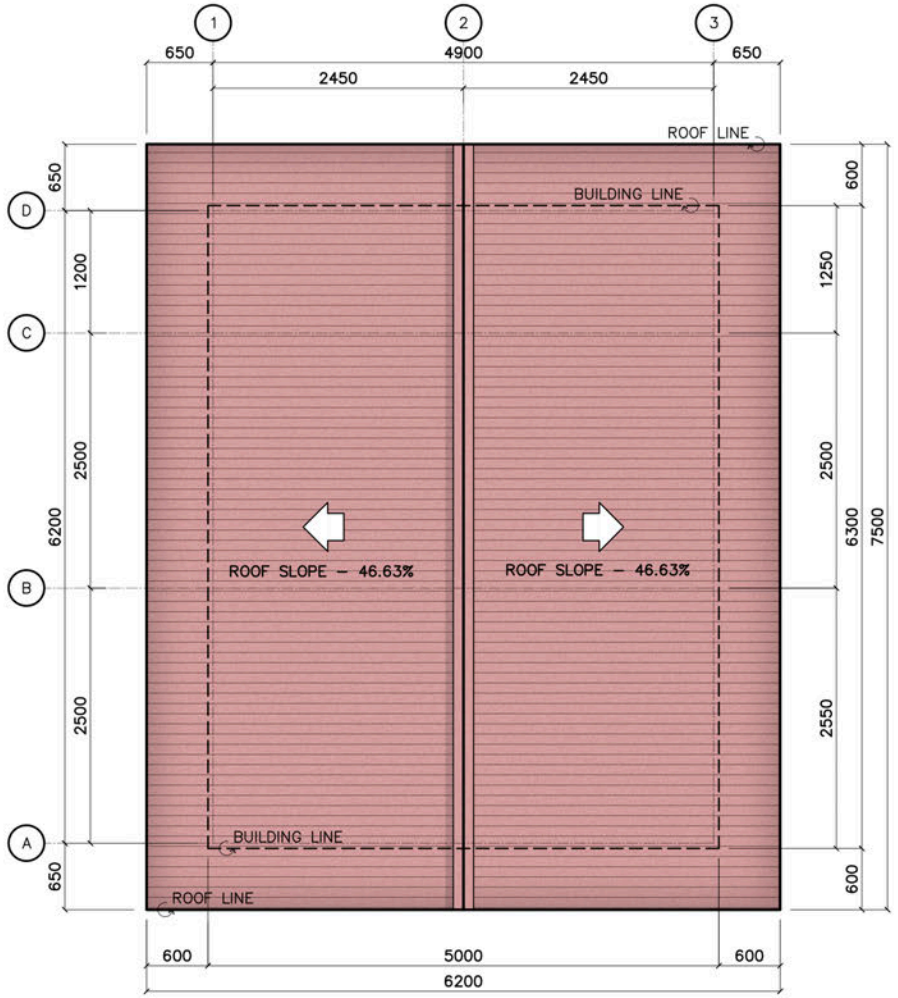
1. One plane straight is permissible. This is identified by rotating and observing the straightness.
2. The end curve should extend no more than 5 cm (for all cut poles).

Bamboo poles that meet these geometric requirements are then chemically treated to ensure their long-term protection against insect and fungal attacks.

Annex B: Sample Plans

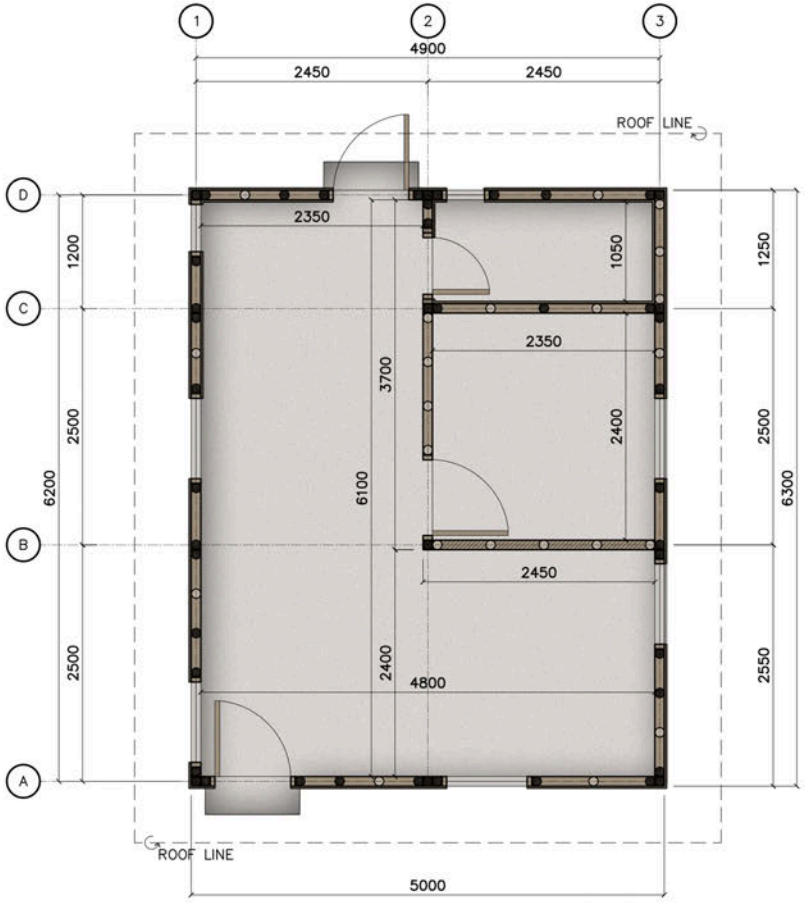
ARCHITECTURAL

FLOOR PLAN

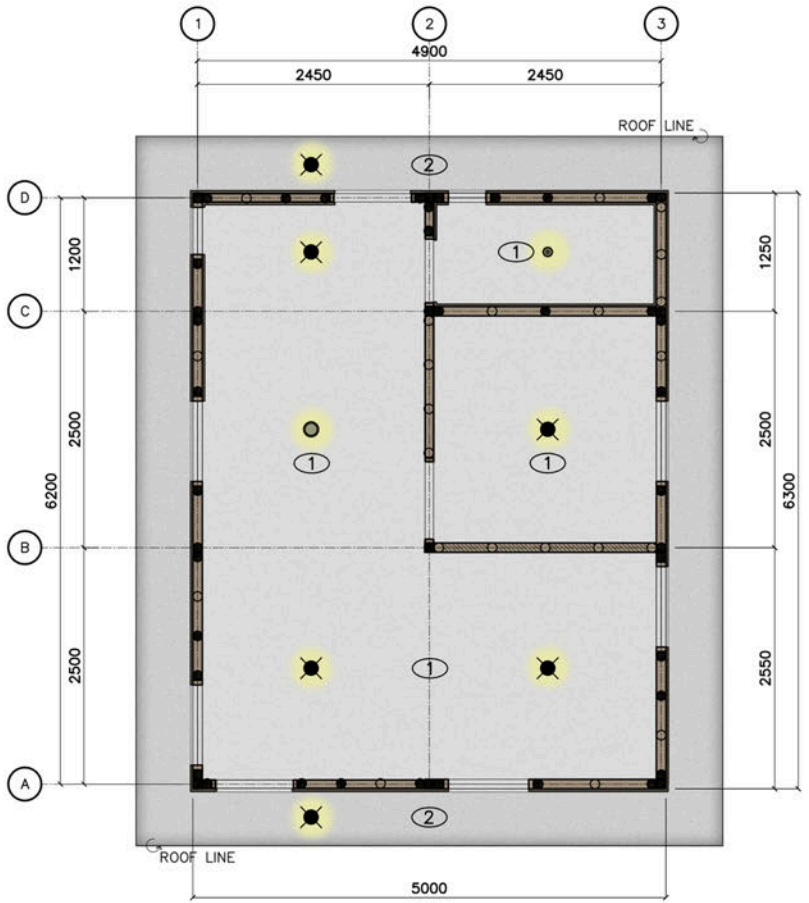


ROOF PLAN

Annex B: Sample Plans



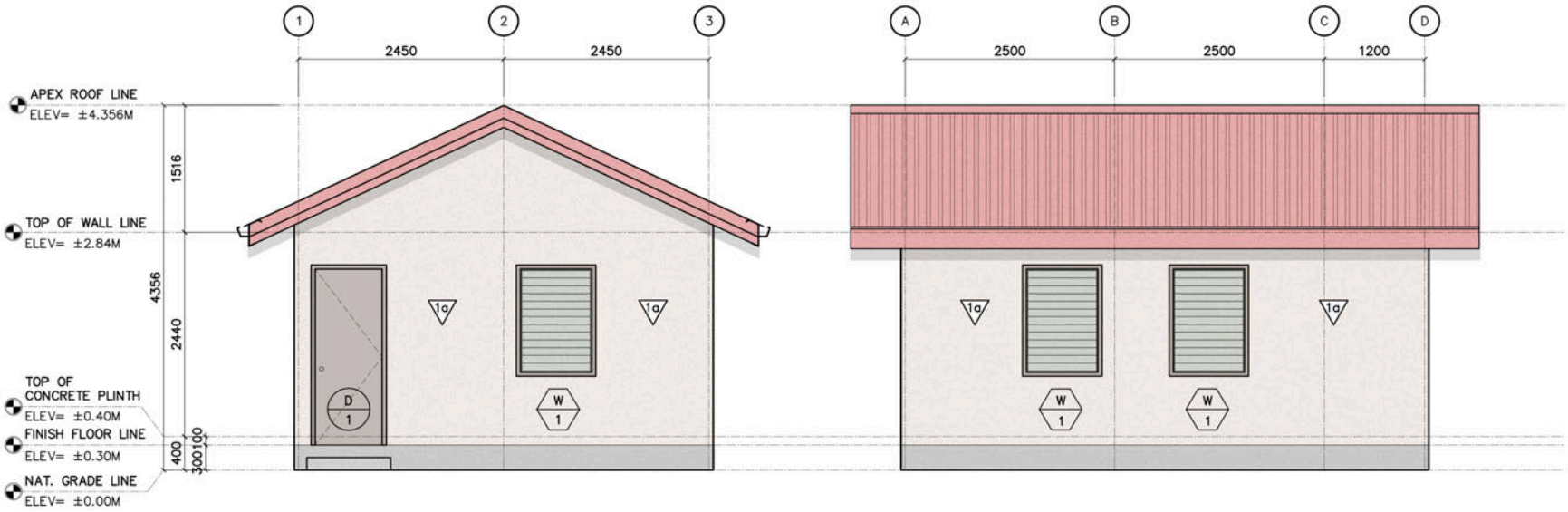
DIMENSIONS PLAN



REFLECTED CEILING PLAN

CEILING FINISH:			
1 2 3	CF–1 GYPSUM BOARD CEILING FINISH CF–2 INTERIOR EXPOSED CEILING FINISH CF–3 EXTERIOR EXPOSED CEILING FINISH	◎	**IL– 2 TROFFER LIGHTING 2: SURFACE MOUNTED LEDTUBE LAMP 2** SHALL BE 2X18WATTS T–8 COOL WHITE LED TUBE, WITH 302MM X 1218MM X 67MM HEIGHT, MIRRORIZED ALUMINUM REFLECTOR AND MULTI–LINED SATIN FINISH ALUMINUM LOUVERS IN POWDER–COATED PAINT FINISH, ZINC–PHOSPHATE STEEL SHEET HOUSING, SURFACE MOUNTED.
LIGHTING FIXTURES:			
○	**IL– 1 TROFFER LIGHTING 1: SURFACE MOUNTED LEDTUBE LAMP 1** SHALL BE 1X18WATTS T–8 COOL WHITE LED TUBE, WITH 177MM X 1218MM X 75MM HEIGHT, MIRRORIZED ALUMINUM REFLECTOR AND MULTI–LINED SATIN FINISH ALUMINUM LOUVERS IN POWDER–COATED PAINT FINISH, ZINC–PHOSPHATE STEEL SHEET HOUSING, SURFACE MOUNTED.	✱	**IL–4 DOWNLIGHT 1: SURFACE MOUNTED TYPE DOWNLIGHT 1 (LED BULB TYPE)** SHALL BE 1X12.5 WATTS COOL DAYLIGHT, LED BULB, LED BULB BY "G.E. SNOWCONE LED" OR APPROVED EQUAL, IN 167MM DIAMETER X 194MM HEIGHT, SURFACE MOUNTED DOWNLIGHT (WITHOUT GLASS COVER) WITH DOTTED REFLECTOR AND WHITE CASING WITH E27 SOCKET.
			NOTE: SUBJECT TO CHANGE. VERIFY FDA GUIDELINES.

Annex B: Sample Plans

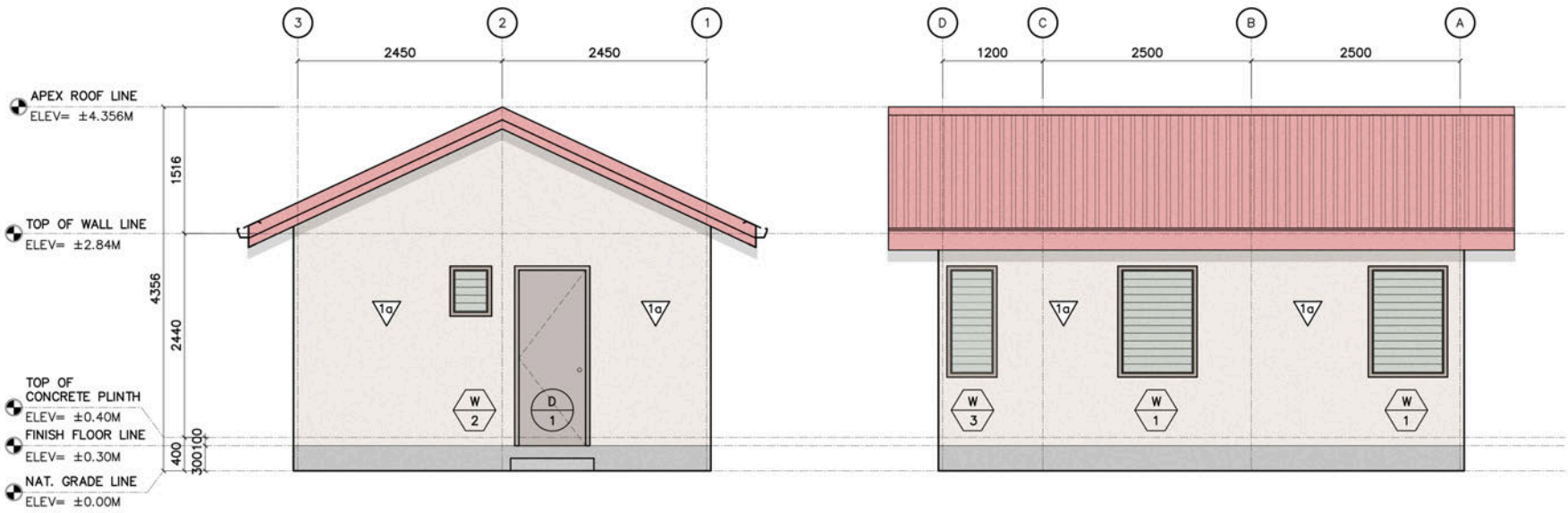


FRONT ELEVATION

RIGHT SIDE ELEVATION

SCHEDULE OF FINISHES				
FLOOR FINISHES		INTERIOR WALL		NOTE: ALL FINISHES ARE SUBJECT TO CHANGE. SUBMIT COLOR AND MATERIAL SWATCHES FOR ARCHITECT'S APPROVAL.
FF-1	PLAIN CEMENT FLOOR FINISH	1b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT	
FF-2	MATTE FINISH HOMOGENOUS PORCELAIN TILES			
WALL FINISHES		2b	AMAKAN	
EXTERIOR WALL				
1a	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH COLOR GREY PAINT FROM NGL TO WINDOW SILL AND WHITE ACRYLIC SEMI-GLOSS LATEX PAINT FROM WINDOW SILL TO TOP OF PANEL.	3b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT WITH 10MM THICK 300X300MM MATTE FINISH HOMOGENOUS TILES AT 300MM HEIGHT FROM FLOOR FINISH	

Annex B: Sample Plans

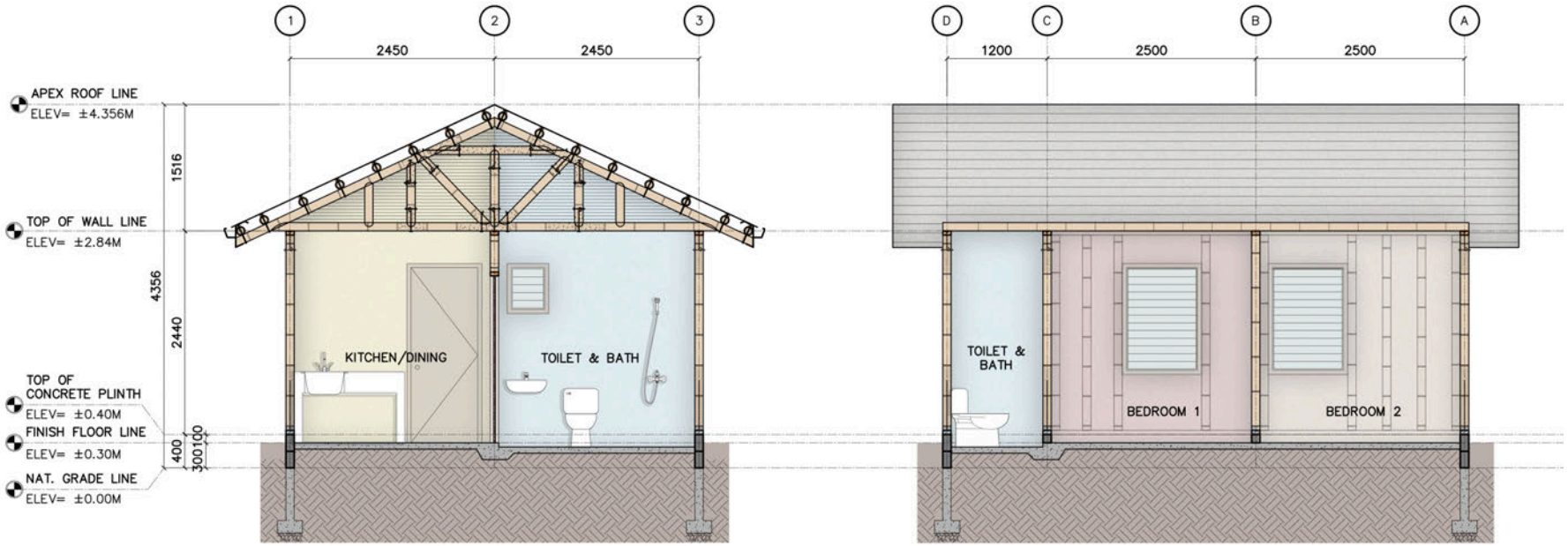


REAR ELEVATION

LEFT SIDE ELEVATION

SCHEDULE OF FINISHES				
FLOOR FINISHES		INTERIOR WALL		NOTE: ALL FINISHES ARE SUBJECT TO CHANGE. SUBMIT COLOR AND MATERIAL SWATCHES FOR ARCHITECT'S APPROVAL.
FF-1	PLAIN CEMENT FLOOR FINISH	1b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT	
FF-2	MATTE FINISH HOMOGENOUS PORCELAIN TILES			
WALL FINISHES		2b	AMAKAN	
EXTERIOR WALL				
1a	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH COLOR GREY PAINT FROM NGL TO WINDOW SILL AND WHITE ACRYLIC SEMI-GLOSS LATEX PAINT FROM WINDOW SILL TO TOP OF PANEL.	3b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT WITH 10MM THICK 300X300MM MATTE FINISH HOMOGENOUS TILES AT 300MM HEIGHT FROM FLOOR FINISH	

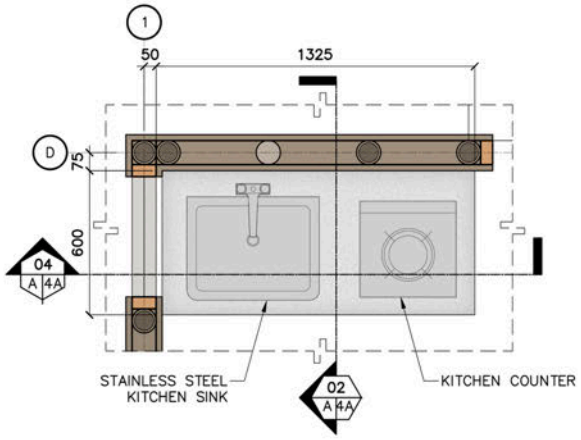
Annex B: Sample Plans



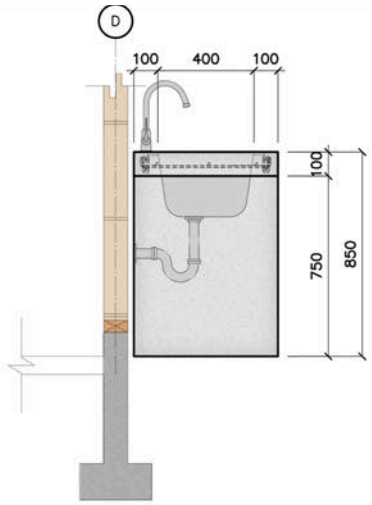
SECTION A

SECTION B

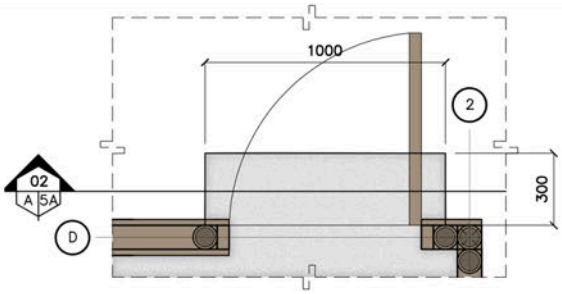
Annex B: Sample Plans



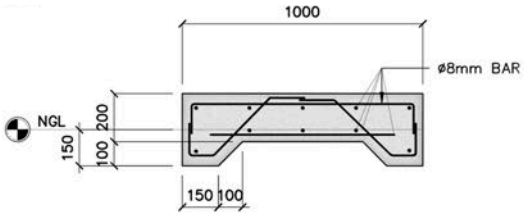
KITCHEN COUNTER
BLOW-UP PLAN



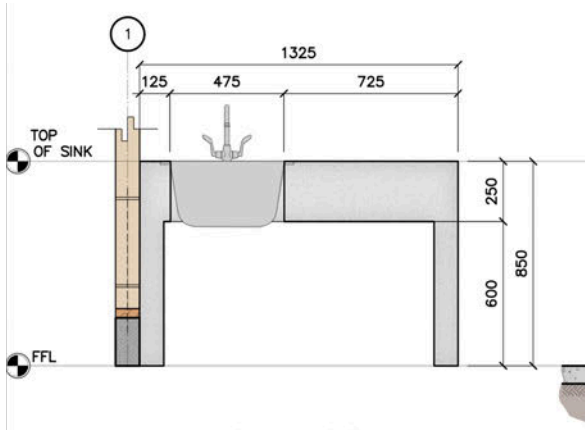
KITCHEN COUNTER
CROSS SECTION



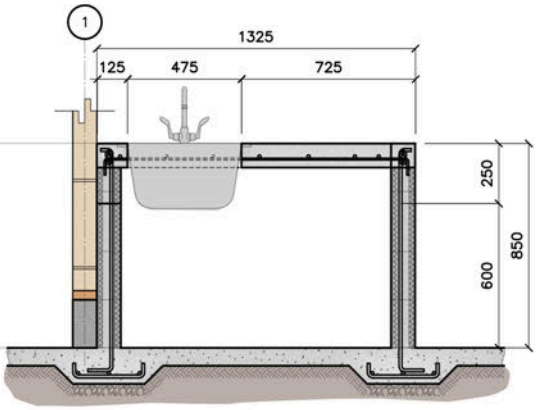
ENTRANCE STEP
BLOW-UP PLAN



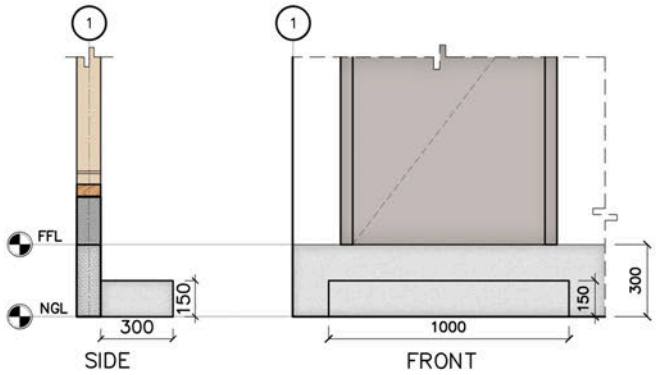
ENTRANCE STEP
LONGITUDINAL SECTION



KITCHEN COUNTER
FRONT ELEVATION

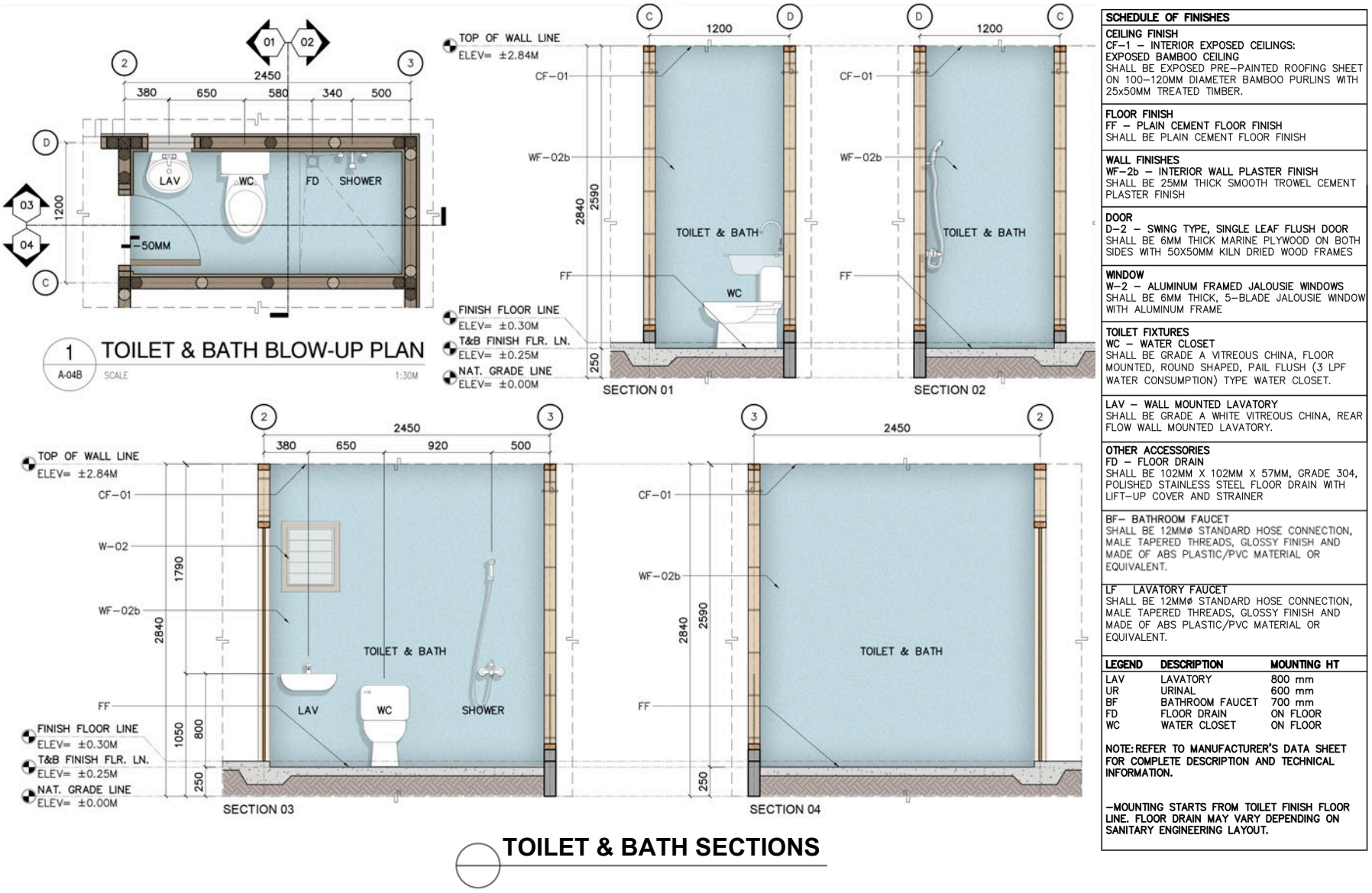


KITCHEN COUNTER
LONGITUDINAL SECTION



ENTRANCE STEP ELEVATION

Annex B: Sample Plans



TOILET & BATH SECTIONS

SCHEDULE OF FINISHES

CEILING FINISH
CF-1 – INTERIOR EXPOSED CEILINGS: EXPOSED BAMBOO CEILING
SHALL BE EXPOSED PRE-PAINTED ROOFING SHEET ON 100-120MM DIAMETER BAMBOO PURLINS WITH 25x50MM TREATED TIMBER.

FLOOR FINISH
FF – PLAIN CEMENT FLOOR FINISH
SHALL BE PLAIN CEMENT FLOOR FINISH

WALL FINISHES
WF-2b – INTERIOR WALL PLASTER FINISH
SHALL BE 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH

DOOR
D-2 – SWING TYPE, SINGLE LEAF FLUSH DOOR
SHALL BE 6MM THICK MARINE PLYWOOD ON BOTH SIDES WITH 50X50MM KILN DRIED WOOD FRAMES

WINDOW
W-2 – ALUMINUM FRAMED JALOUSIE WINDOWS
SHALL BE 6MM THICK, 5-BLADE JALOUSIE WINDOW WITH ALUMINUM FRAME

TOILET FIXTURES
WC – WATER CLOSET
SHALL BE GRADE A VITREOUS CHINA, FLOOR MOUNTED, ROUND SHAPED, PAIL FLUSH (3 LPF WATER CONSUMPTION) TYPE WATER CLOSET.

LAV – WALL MOUNTED LAVATORY
SHALL BE GRADE A WHITE VITREOUS CHINA, REAR FLOW WALL MOUNTED LAVATORY.

OTHER ACCESSORIES
FD – FLOOR DRAIN
SHALL BE 102MM X 102MM X 57MM, GRADE 304, POLISHED STAINLESS STEEL FLOOR DRAIN WITH LIFT-UP COVER AND STRAINER

BF- BATHROOM FAUCET
SHALL BE 12MMø STANDARD HOSE CONNECTION, MALE TAPERED THREADS, GLOSSY FINISH AND MADE OF ABS PLASTIC/PVC MATERIAL OR EQUIVALENT.

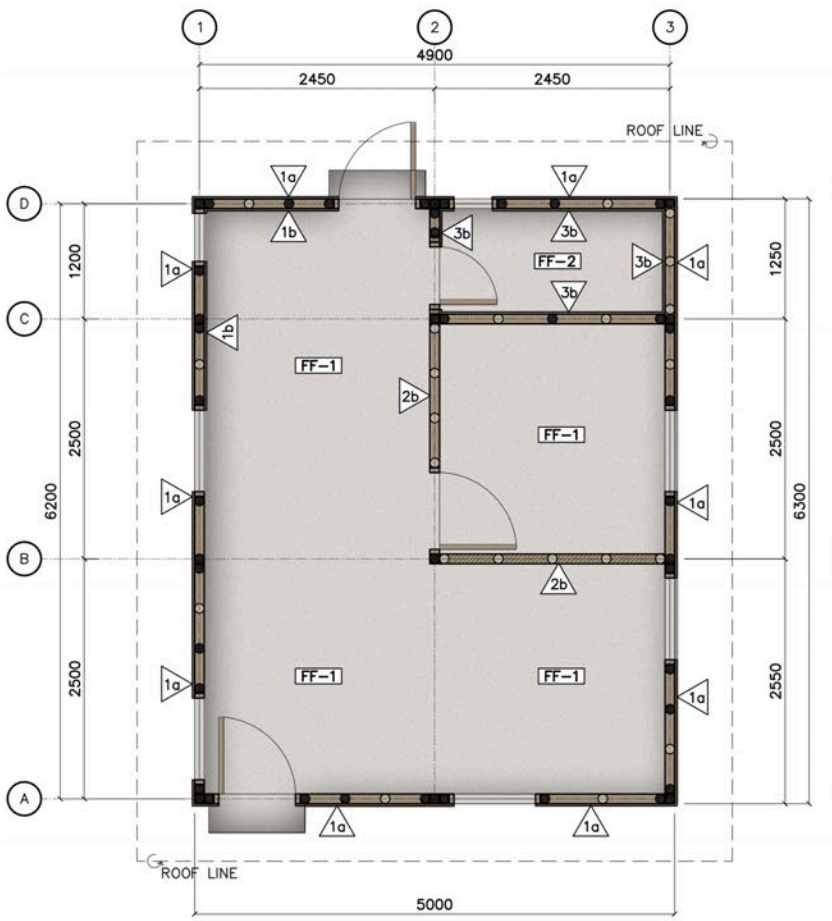
LF LAVATORY FAUCET
SHALL BE 12MMø STANDARD HOSE CONNECTION, MALE TAPERED THREADS, GLOSSY FINISH AND MADE OF ABS PLASTIC/PVC MATERIAL OR EQUIVALENT.

LEGEND	DESCRIPTION	MOUNTING HT
LAV	LAVATORY	800 mm
UR	URINAL	600 mm
BF	BATHROOM FAUCET	700 mm
FD	FLOOR DRAIN	ON FLOOR
WC	WATER CLOSET	ON FLOOR

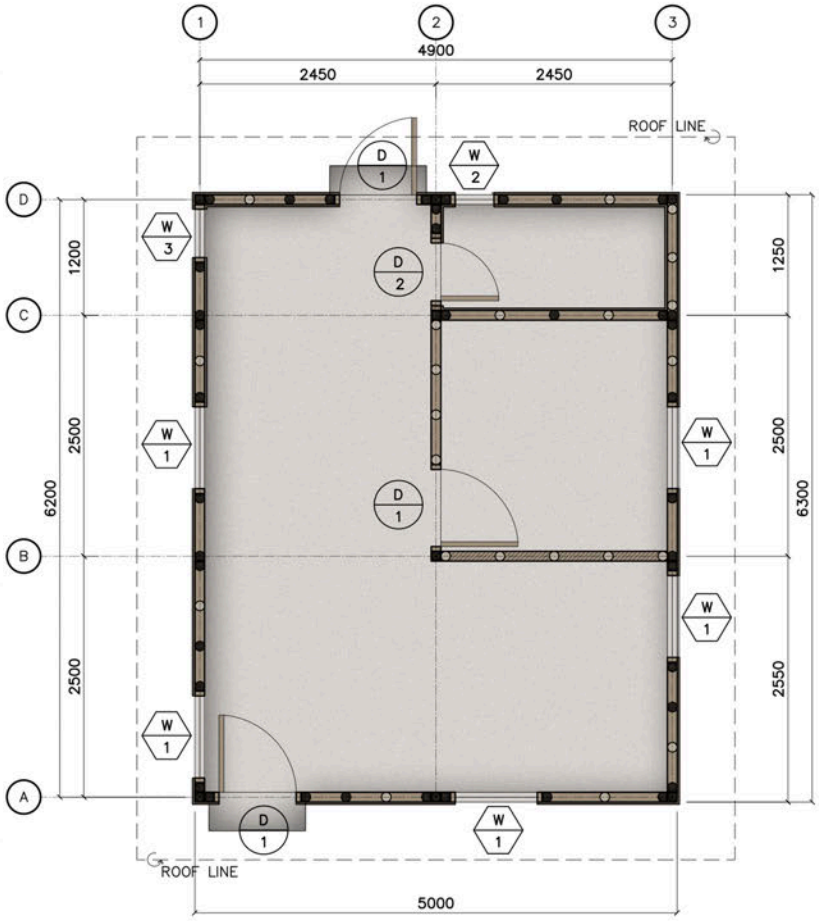
NOTE: REFER TO MANUFACTURER'S DATA SHEET FOR COMPLETE DESCRIPTION AND TECHNICAL INFORMATION.

–MOUNTING STARTS FROM TOILET FINISH FLOOR LINE. FLOOR DRAIN MAY VARY DEPENDING ON SANITARY ENGINEERING LAYOUT.

Annex B: Sample Plans



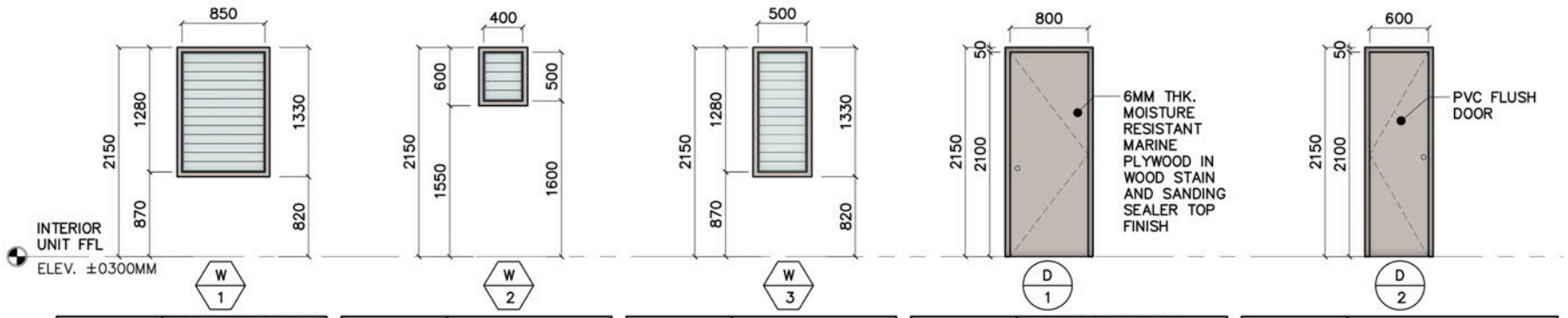
FINISH TAGGING PLAN



DOORS AND WINDOWS TAGGING PLAN

SCHEDULE OF FINISHES				
FLOOR FINISHES		INTERIOR WALL		NOTE: ALL FINISHES ARE SUBJECT TO CHANGE. SUBMIT COLOR AND MATERIAL SWATCHES FOR ARCHITECT'S APPROVAL.
FF-1	PLAIN CEMENT FLOOR FINISH	1b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT	
FF-2	MATTE FINISH HOMOGENOUS PORCELAIN TILES			
WALL FINISHES		2b	BAMBOO MATTING	
EXTERIOR WALL				
1a	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH COLOR GREY PAINT FROM NGL TO WINDOW SILL AND WHITE ACRYLIC SEMI-GLOSS LATEX PAINT FROM WINDOW SILL TO TOP OF PANEL.	3b	FLATTENED BAMBOO WALL WITH 25MM THICK SMOOTH TROWEL CEMENT PLASTER FINISH COATED WITH WHITE ACRYLIC SEMI-GLOSS LATEX PAINT WITH 10MM THICK 300X300MM MATTE FINISH HOMOGENOUS TILES AT 300MM HEIGHT FROM FLOOR FINISH	

Annex B: Sample Plans



LOCATION	LIVING, DINING AREA, KITCHEN, BEDROOM
QUANTITY	FIVE (5) SET/S
TYPE 1&2 MATERIAL	JALOUSIE WINDOW WITH GLASS
DESCRIPTION	VERIFY SUPPLIER FOR THE STANDARD DIMENSIONS OF BLADES
JAMB	WOOD
FINISH	
HARDWARE	
ACCESSORIES	
REMARKS	

LOCATION	TOILET & BATH
QUANTITY	ONE (1) SET
TYPE 1&2 MATERIAL	JALOUSIE WINDOW WITH GLASS
DESCRIPTION	VERIFY SUPPLIER FOR THE STANDARD DIMENSIONS OF BLADES
JAMB	WOOD
FINISH	
HARDWARE	
ACCESSORIES	
REMARKS	

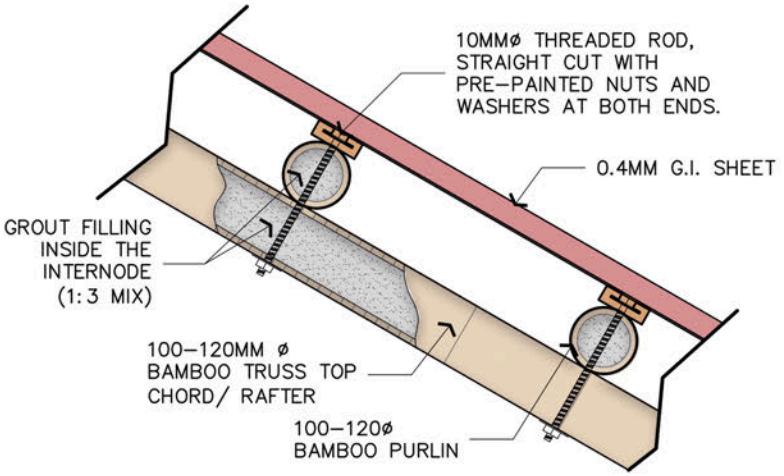
LOCATION	KITCHEN
QUANTITY	ONE (1) SET
TYPE 1&2 MATERIAL	JALOUSIE WINDOW WITH GLASS
DESCRIPTION	VERIFY SUPPLIER FOR THE STANDARD DIMENSIONS OF BLADES
JAMB	WOOD
FINISH	
HARDWARE	
ACCESSORIES	
REMARKS	

LOCATION	ENTRANCE, KITCHEN BEDROOM
QUANTITY	THREE (3) SET/S
TYPE 1&2 MATERIAL	SWING TYPE, SINGLE LEAF HOLLOW CORE WOOD DOOR
DESCRIPTION	FR. 50X150MM TREATED KD HARDWOOD STILES AND FR. 50x150 TREATED KD HARDWOOD BOTTOM RAIL WITH 6MM THK. MARINE PLYWOOD PANEL IN BARE FINISH
JAMB	FR. 50MMx100MM KD TREATED HARDWOOD
FINISH	VERIFY OWNER
HARDWARE	OWNER APPROVED KNOBS
ACCESSORIES	OWNER APPROVED HINGES
REMARKS	VERIFY SPECIFICATIONS

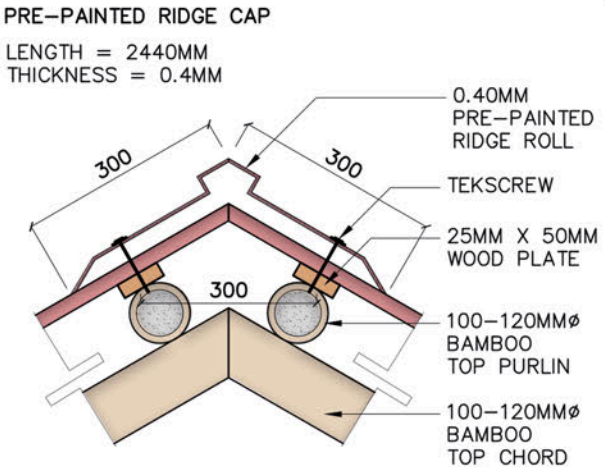
LOCATION	ENTRANCE
QUANTITY	ONE (1) SET/S
TYPE 1&2 MATERIAL	SWING TYPE, SINGLE LEAF PVC DOOR
DESCRIPTION	POLYVINYL CHLORIDE (PVC) FLUSH DOOR
JAMB	PVC JAMB (VERIFY SUPPLIER)
FINISH	VERIFY OWNER
HARDWARE	OWNER APPROVED KNOBS
ACCESSORIES	OWNER APPROVED HINGES
REMARKS	VERIFY SPECIFICATIONS

SCHEDULE OF DOORS AND WINDOWS

Annex B: Sample Plans



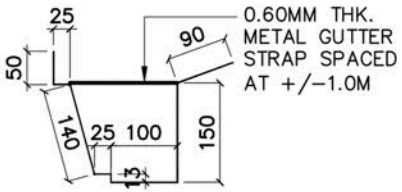
PURLIN TO TRUSS CONNECTION DETAIL



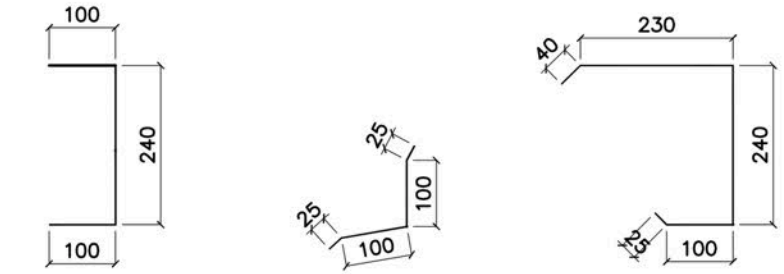
RIDGE CAP DETAIL

PREP–PAINTED FASCIA COVER	PREP–PAINTED WALL FLASHING	PREP–PAINTED END FLASHING
LENGTH = 2440MM THICKNESS = 0.4MM	LENGTH = 2440MM THICKNESS = 0.4MM	LENGTH = 2440MM THICKNESS = 0.4MM

NOTE: VERIFY DIMENSIONS IN ACTUAL



GUTTER DETAIL



FLASHING DETAILS

Annex B: Sample Plans

STRUCTURAL

Structural Notes

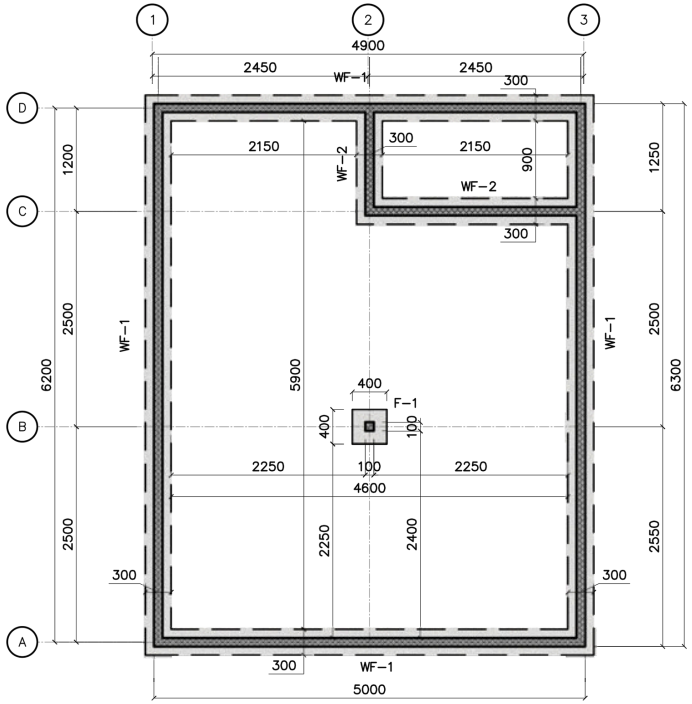
Bamboo

- Age before Harvest: Bamboo should be harvested between 3 to 6 years old, which is considered the ideal age for optimal structural strength.
- Moisture Content: Bamboo must be dried to a recommended moisture content of 12% but should not be greater than 19%.
- Treatment: All bamboo components must be treated with eco-friendly solutions prior to use in panel fabrication or installation.
- Dimensions:
  - Culm Diameter: 70 mm to 120 mm
  - Wall Thickness: 8 mm to 20 mm
- Culm Straightness: The natural curve or bow of the bamboo culm should not exceed 2% of its total length.
- Defects: Any bamboo showing signs of insect attack or fungal growth must be rejected.
- Piping Restriction: Water pipes and outlets must not be embedded within structural bamboo elements like walls or ceilings. They should instead be mounted on the surface to avoid water damage from potential leaks.
- Shear Wall Resistance for Cement-Bamboo Frame Technology (CBFT):
  - Double-sided cladding: 8.5 kN/m
  - Single-sided cladding: 4.3 kN/m
- Bamboo Connections: All joints must be completely filled with a concrete grout mix in a 1:3 ratio.
- Vertical Stud Node Positioning (Solid Wall Panels):
  - End studs: Maximum of 100 mm from node to top cut and 50 mm from node to bottom cut
  - Intermediate studs: Maximum of 200 mm from node to top cut and 50 mm from node to bottom cut
- Wall Panels with Large Openings (e.g., Doors/Windows):
  - If the opening exceeds one-third of the wall panel's height or length, apply the node-to-node spacing rule to end studs and those adjacent to the openings, with a maximum of 100 mm from node to top cut and 50 mm from node to bottom cut.

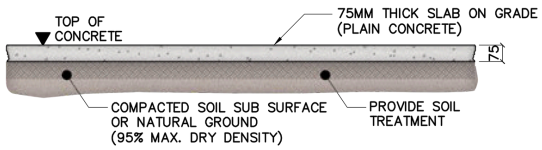
Timber

- Standard: AWC NDS
- Use Softwood Timber suitable for structural applications
- S4S (Surfaced Four Sides): Planed smooth on all faces and edges
- Kiln-dried to a maximum of 19% moisture content
- Nominal Size (Dimensional Lumber)
  - 50mmx100mm
- Treatment: All wood components must be treated with eco-friendly solutions prior to use in panel fabrication or installation.
- Cut ends of treated wood must be field-treated
- Defects: Any wood showing signs of insect attack or fungal growth must be rejected.
- Timber shall be visually or machine stress graded

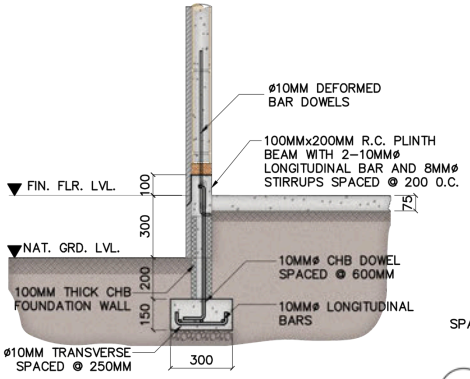
Annex B: Sample Plans



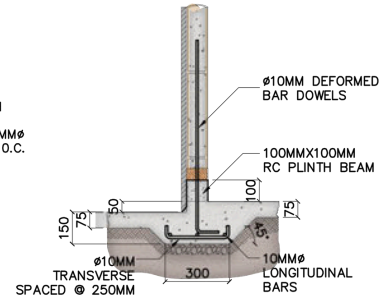
FOUNDATION PLAN



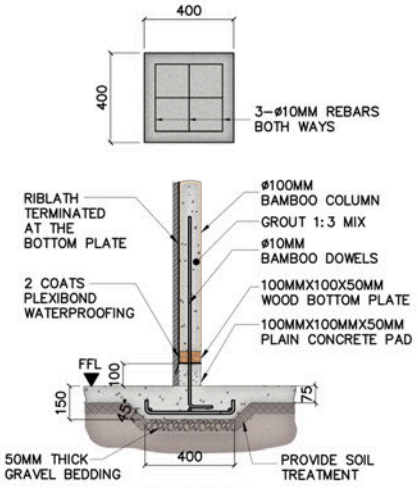
SLAB SECTION DETAIL



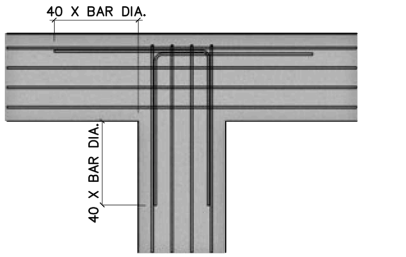
WF-01 SECTION DETAIL



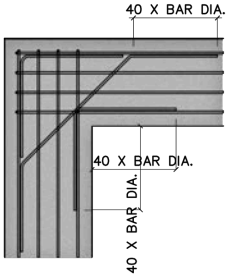
WF-02 SECTION DETAIL



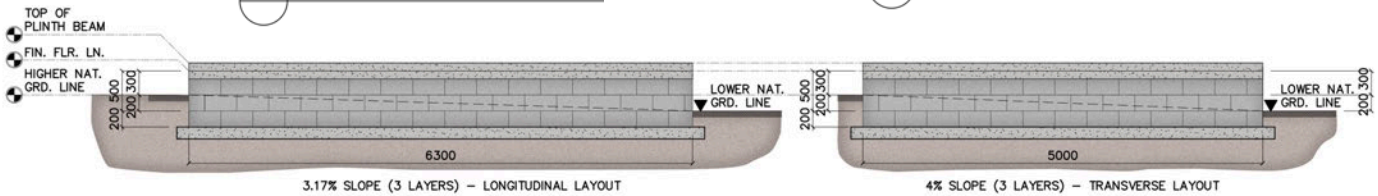
F-1 SECTION DETAIL



T-INTERSECTION REBAR DET.

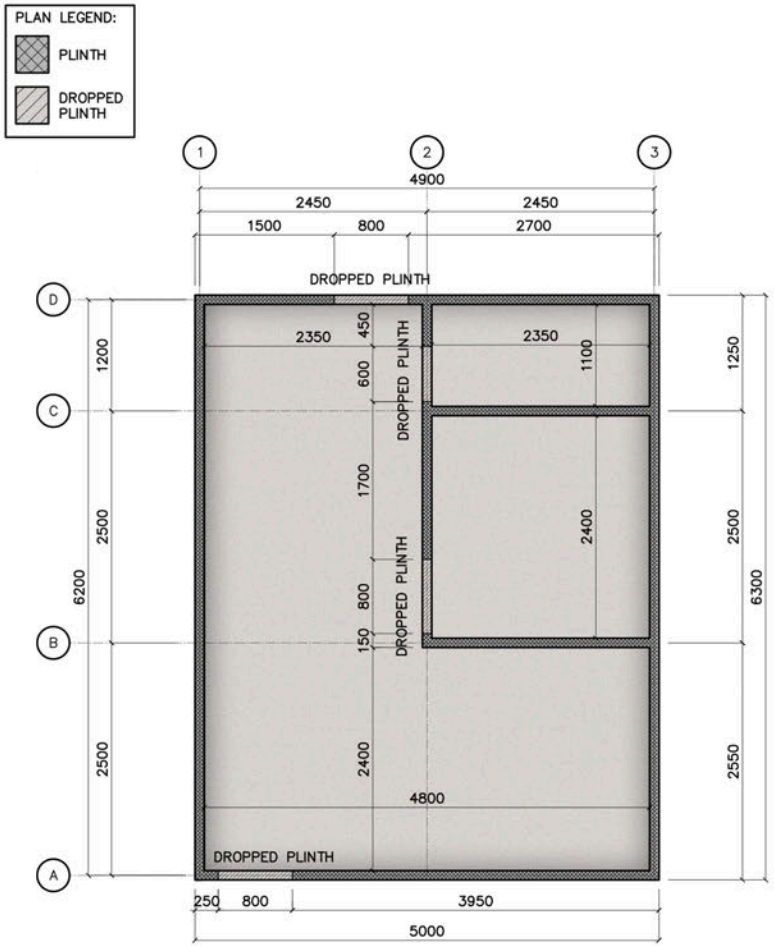


CORNER REBAR DET.

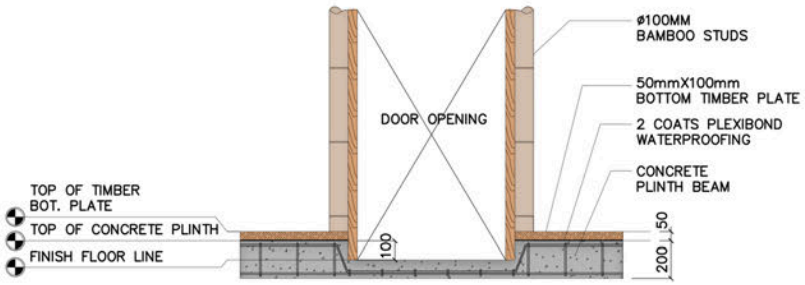


FOUNDATION DETAIL ON MINIMAL SLOPPED TERAIN

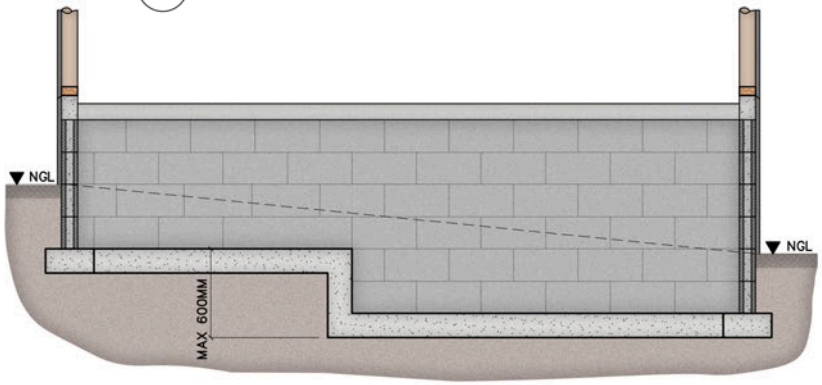
Annex B: Sample Plans



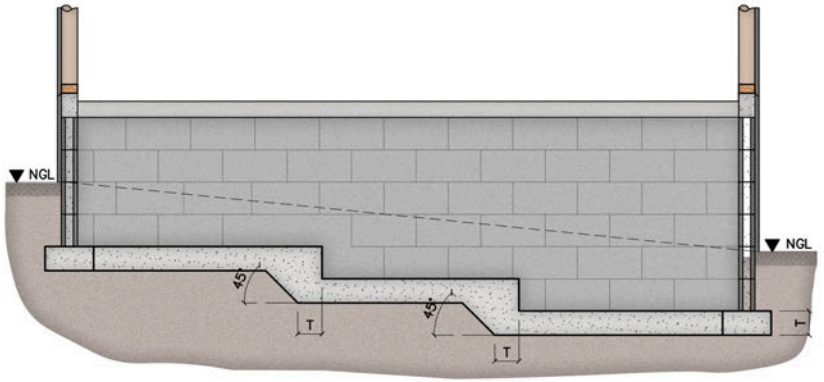
PLINTH LAYOUT PLAN



PLINTH DETAIL AT DOOR OPENING

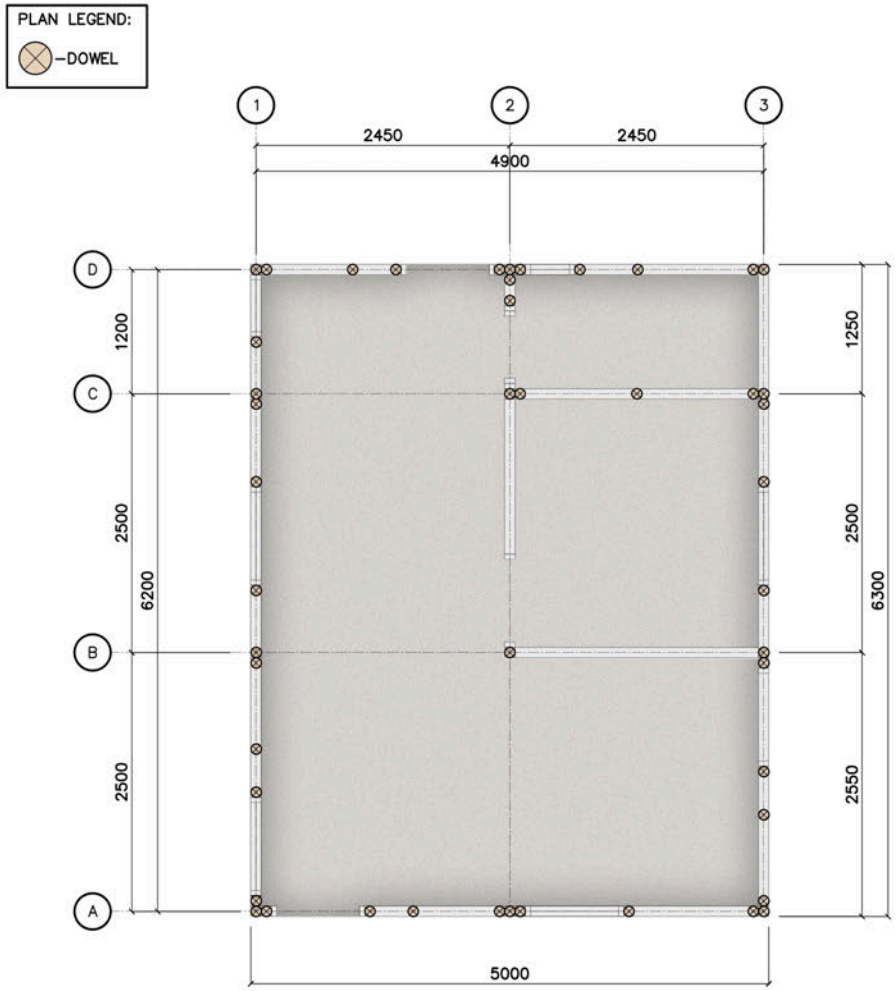


FOUNDATION ON A SLOPING TERRAIN (OPTION 1)

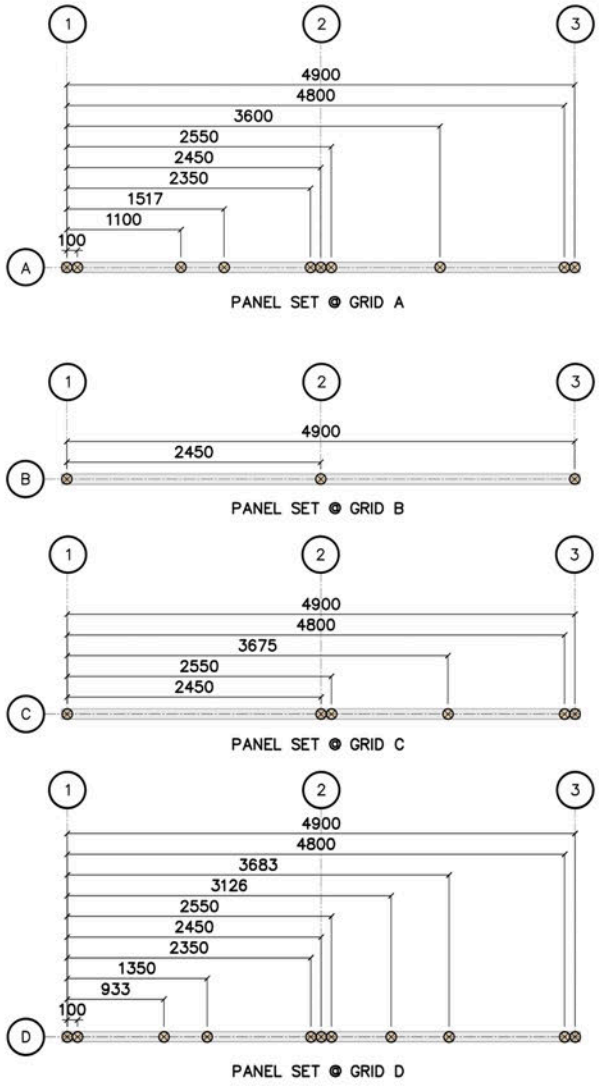


FOUNDATION ON A SLOPING TERRAIN (OPTION 2)

Annex B: Sample Plans

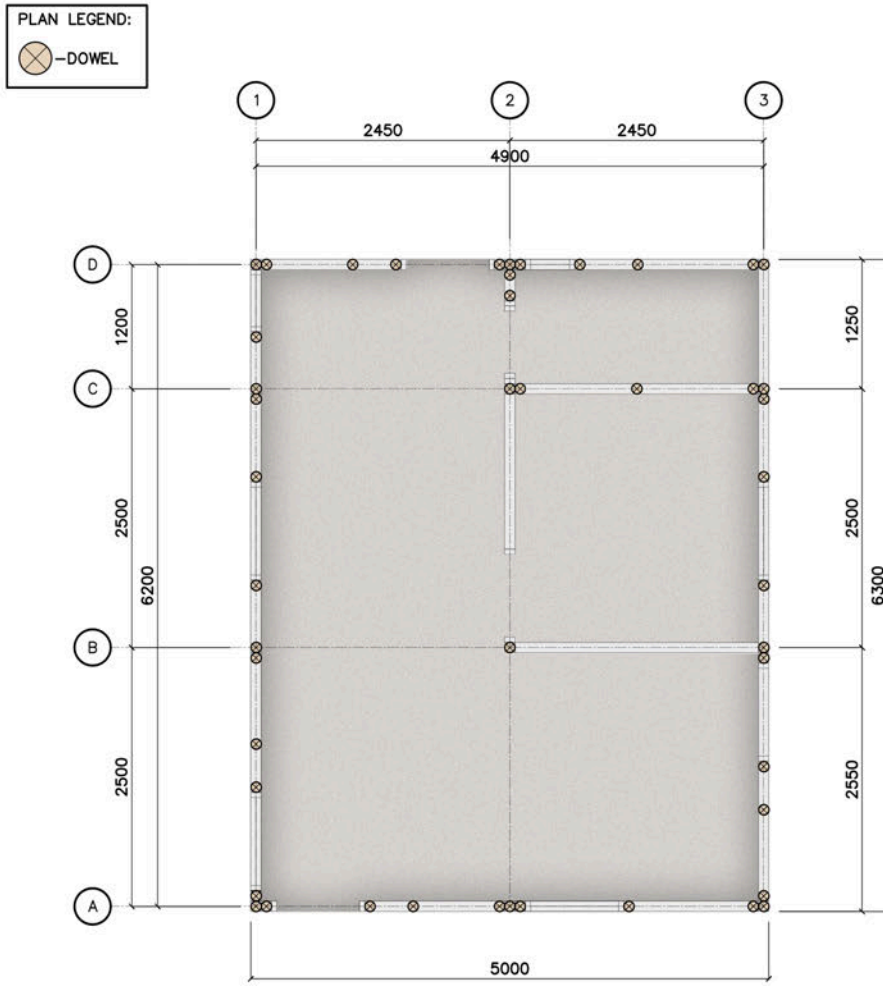


DOWEL LAYOUT PLAN

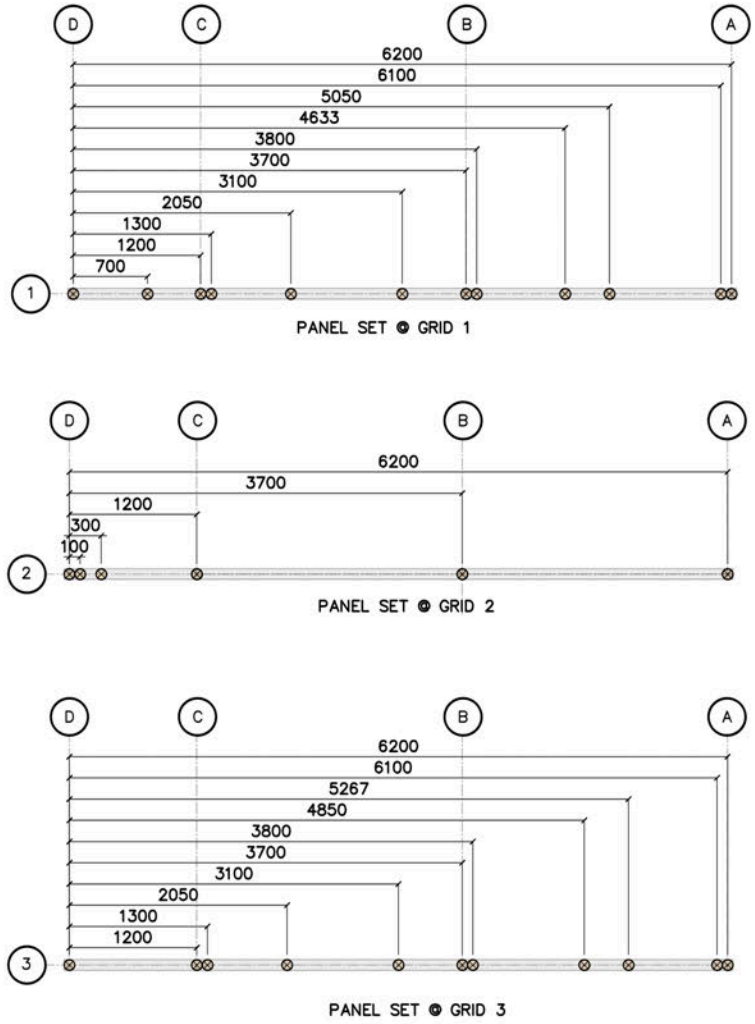


DOWEL LAYOUT PER AXIS

Annex B: Sample Plans

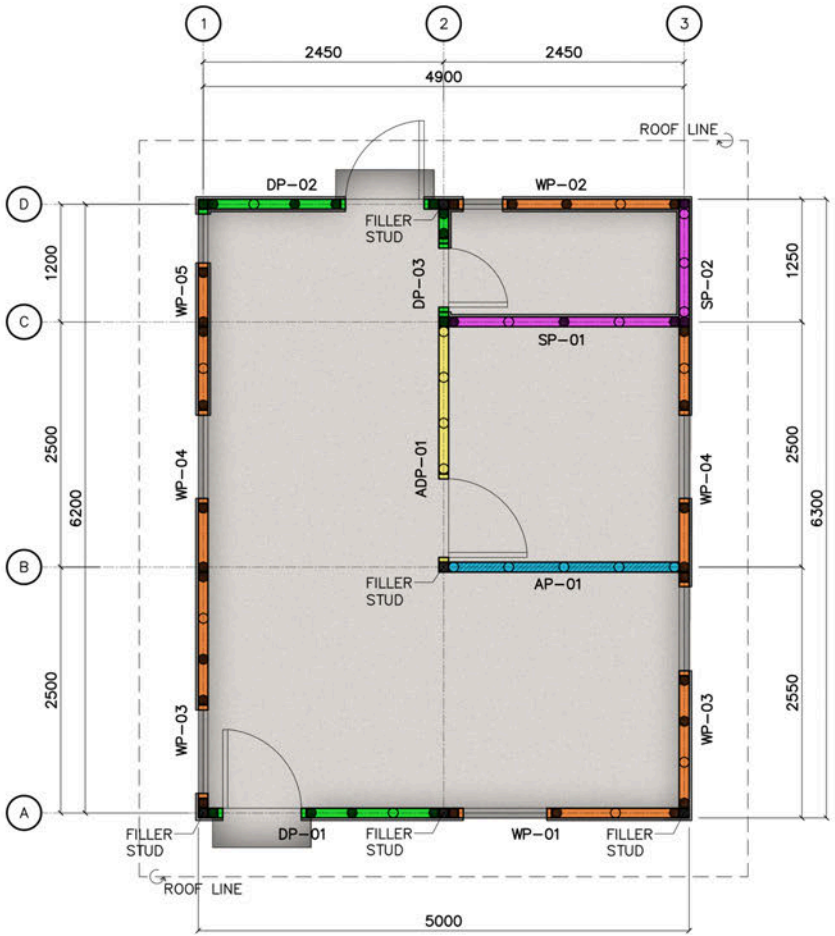


DOWEL LAYOUT PLAN

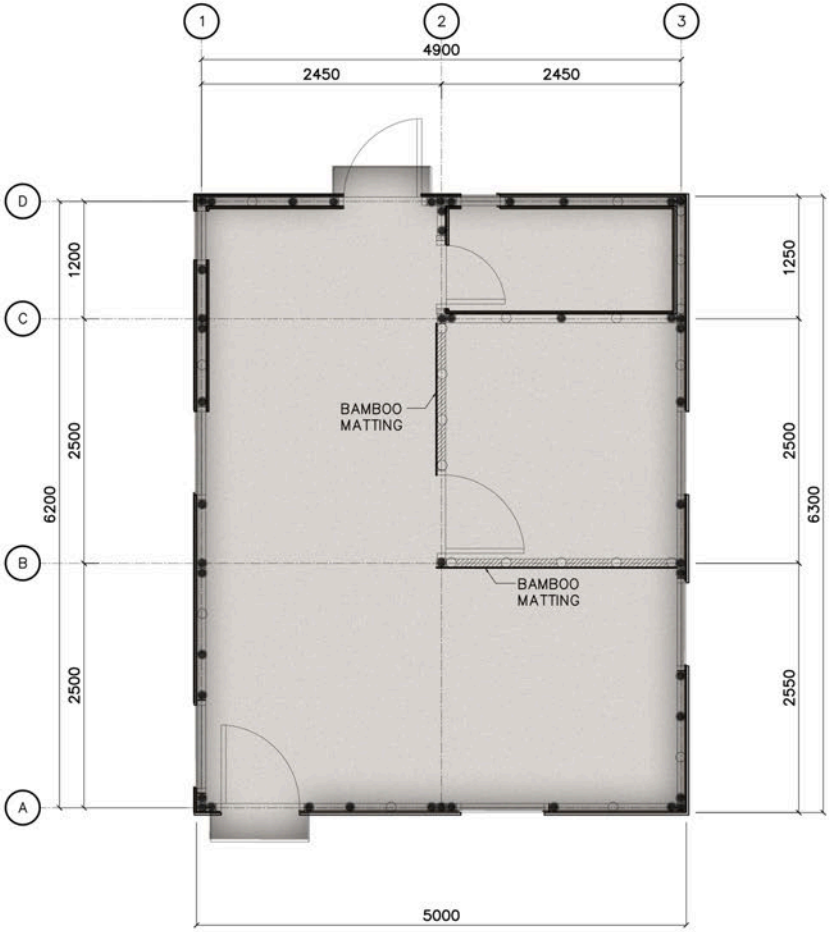


DOWEL LAYOUT PER AXIS

Annex B: Sample Plans

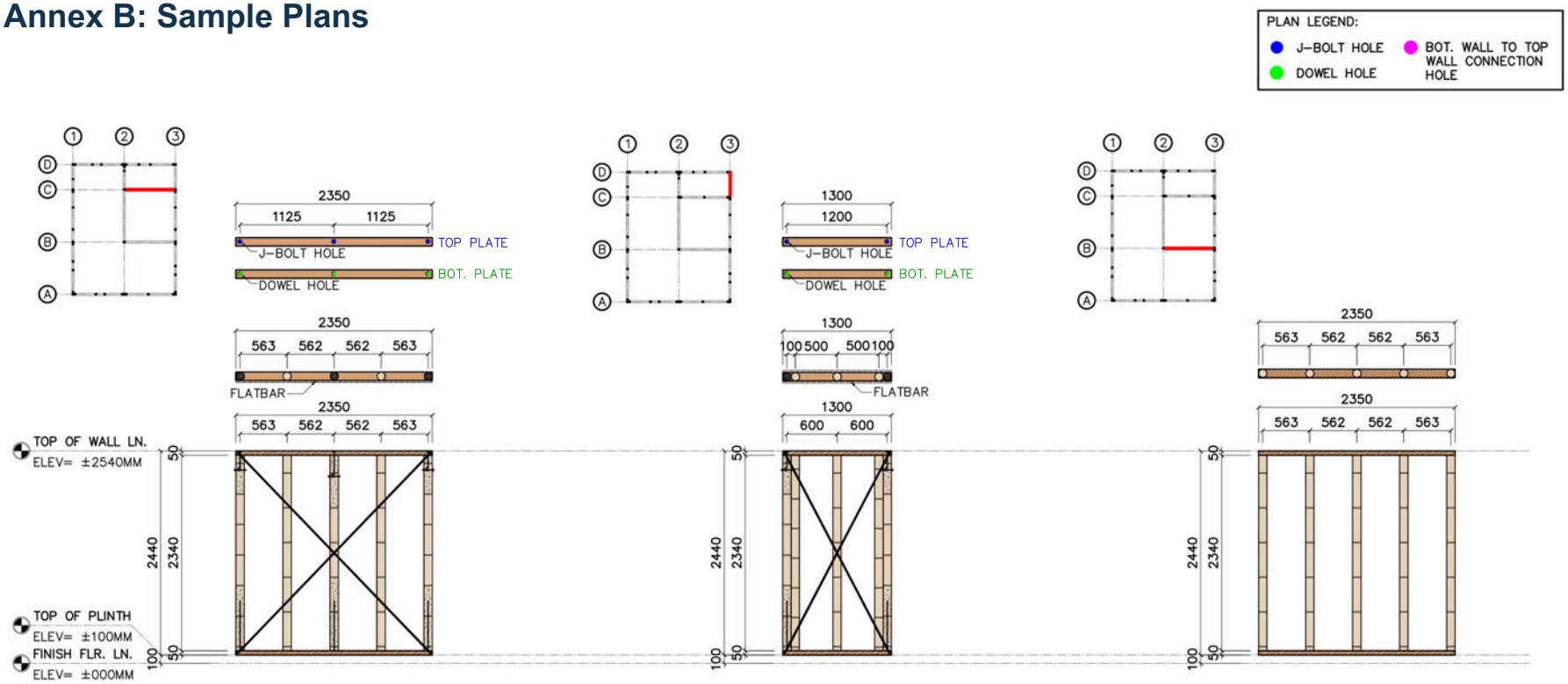


WALL PANEL LOCATION PLAN



MORTAR CLADDING PLAN

Annex B: Sample Plans



NAME	SP–01
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	2350 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	2 PC
T2 BAMBOO STUD	100MM ø	2340 MM	3 PC
FLAT BAR	25x3MM THK.	3345 MM	2 PC
THREADED ROD	10MM ø	150 MM	9 PC
NUTS	10MM ø	–	18 PC
WASHER	2.1MM THK. X 25MMø		18 PC
THREADED J–BOLT	12MM ø	300 MM	3 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	3 PC
NUTS	12MM ø	–	9 PC
WASHER	2.8MM THK. X 35MMø		9 PC
TADTAD	300x2350 MM		9 PC

NAME	SP–02
QTY	ONE (1) SET

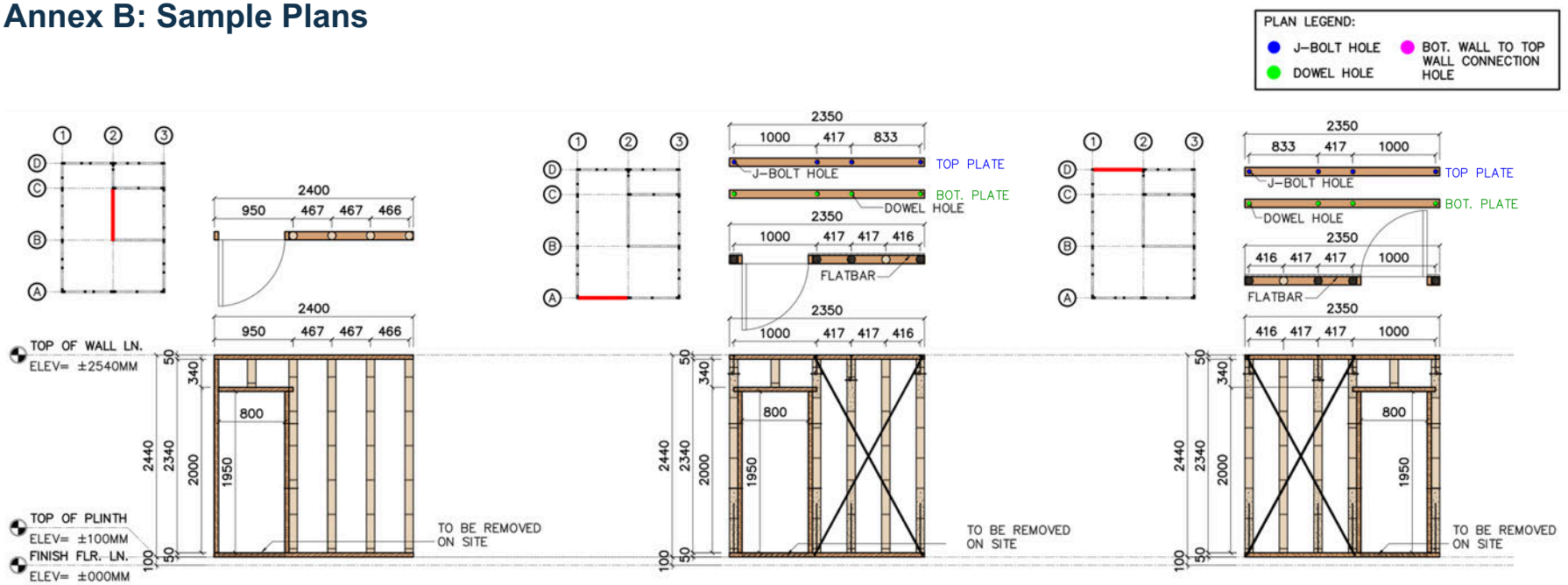
COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	1300 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	1300 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	2 PC
T2 BAMBOO STUD	100MM ø	2340 MM	3 PC
FLAT BAR	25x3MM THK.	2728 MM	2 PC
THREADED ROD	10MM ø	150 MM	5 PC
NUTS	10MM ø	–	10 PC
WASHER	2.1MM THK. X 25MMø		10 PC
THREADED J–BOLT	12MM ø	300 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	2 PC
NUTS	12MM ø	–	6 PC
WASHER	2.8MM THK. X 35MMø		6 PC
TADTAD	300x1300 MM		9 PC

NAME	AP–01
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	2350 MM	1 PC
T2 BAMBOO STUD	100MM ø	2340 MM	5 PC
AMACAN	2340X2350 MM		1 PC

SCHEDULE OF PANELS

Annex B: Sample Plans



NAME	ADP-01
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	2400 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	2400 MM	1 PC
T2 BAMBOO STUD	100MM ø	2340 MM	4 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
DOOR JAMB	50x100 MM	900 MM	1 PC
DOOR JAMB	50x100 MM	1850 MM	1 PC
DOOR JAMB	50x100 MM	2340 MM	1 PC
AMACAN	2340X2400 MM		1 PC

NAME	DP-01
QTY	ONE (1) SET

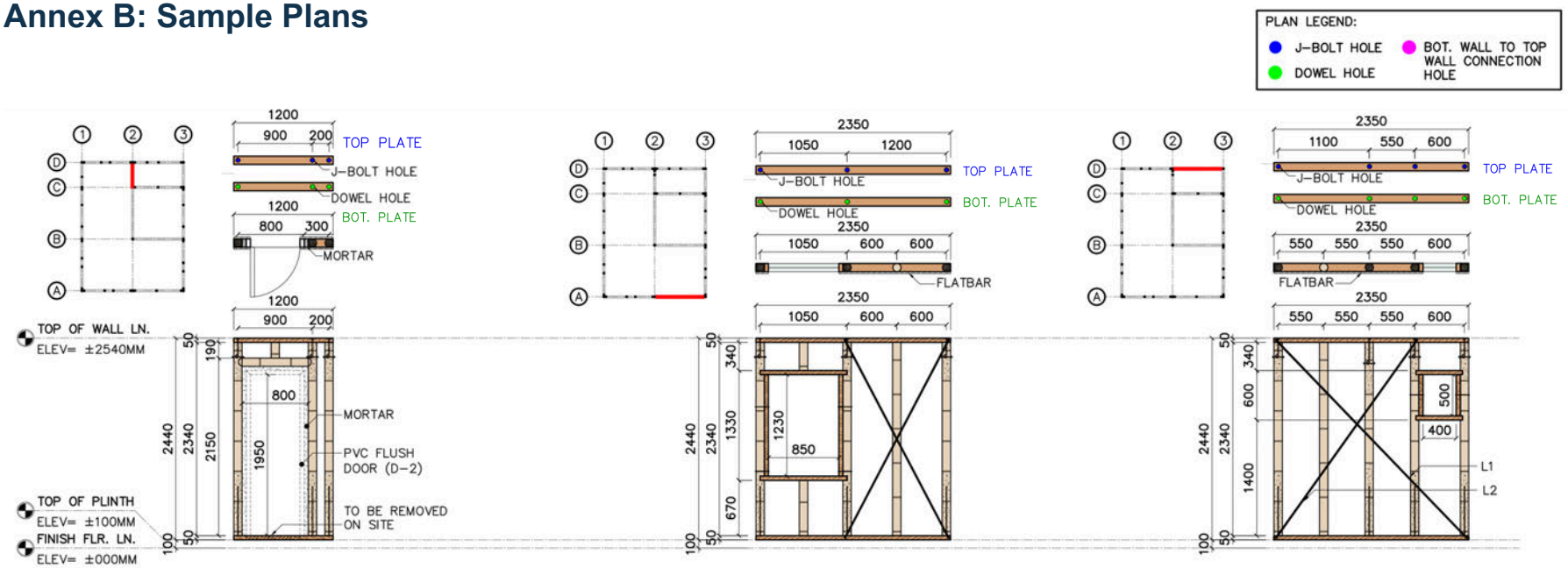
COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	2350 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
T2 BAMBOO STUD	100MM ø	2340 MM	2 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
DOOR JAMB	50x100 MM	1000 MM	1 PC
DOOR JAMB	50x100 MM	1850 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 25MMø		8 PC
FLAT BAR	25x3MM THK.	2751 MM	2 PC
THREADED ROD	10MM ø	150 MM	8 PC
NUTS	10MM ø	–	16 PC
WASHER	2.1MM THK. X 25MMø		16 PC
THREADED J-BOLT	12MM ø	300 MM	4 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	12 PC
WASHER	2.8MM THK. X 35MMø		12 PC
TADTAD	300x2350 MM		9 PC

NAME	DP-02
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50x100 MM	2350 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
T2 BAMBOO STUD	100MM ø	2340 MM	2 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
DOOR JAMB	50x100 MM	1000 MM	1 PC
DOOR JAMB	50x100 MM	1850 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 25MMø		8 PC
FLAT BAR	25x3MM THK.	2751 MM	2 PC
THREADED ROD	10MM ø	150 MM	8 PC
NUTS	10MM ø	–	16 PC
WASHER	2.1MM THK. X 25MMø		16 PC
THREADED J-BOLT	12MM ø	300 MM	4 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	12 PC
WASHER	2.8MM THK. X 35MMø		12 PC
TADTAD	300x2350 MM		9 PC

SCHEDULE OF PANELS

Annex B: Sample Plans



NAME	DP-03
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50x100MM	1200 MM	1 PC
BOT. TIMBER PLATE	50x100MM	1200 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
DOOR JAMB	50x100"	800 MM	1 PC
DOOR JAMB	50x100"	1850 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 35MMø		8 PC
THREADED J-BOLT	12MM ø	300 MM	3 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	3 PC
NUTS	12MM ø	–	9 PC
WASHER	2.8MM THK. X 35MMø		9 PC
TADTAD	300x1200 MM		9 PC
RIB LATH	600x1200 MM		6 PC

NAME	WP-01
QTY	ONE (1) SET

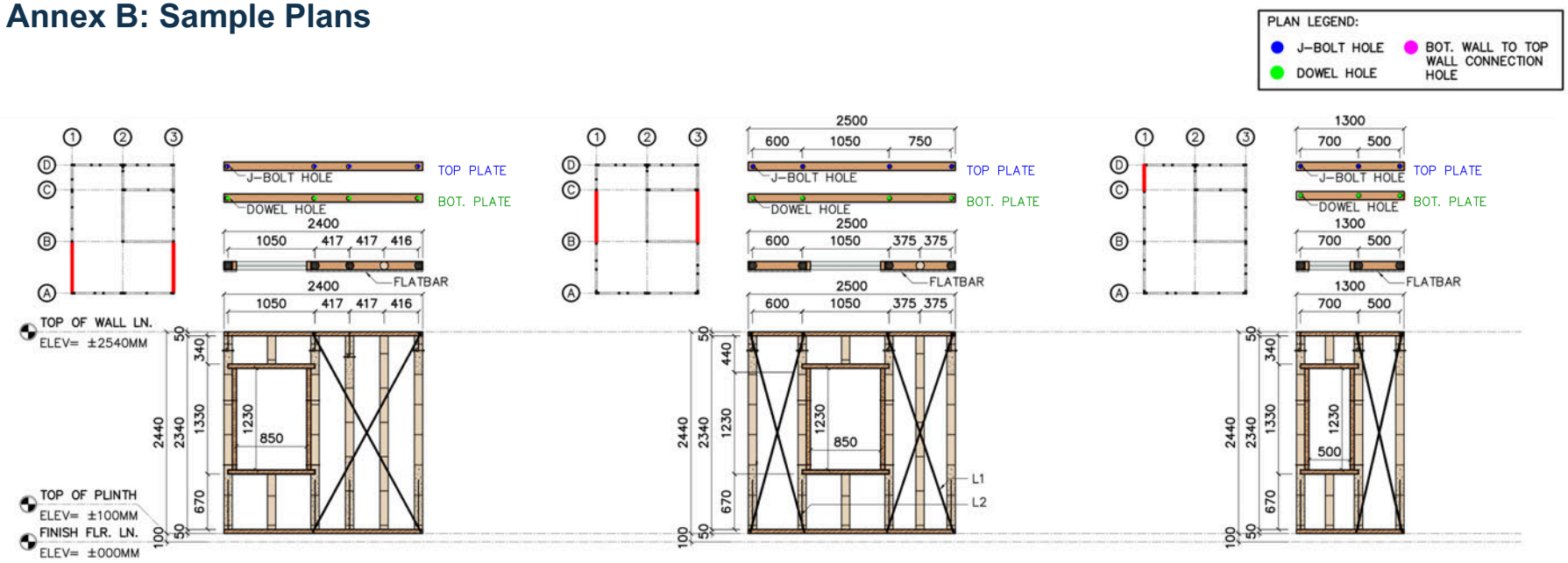
COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50X100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50X100 MM	2350 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
T2 BAMBOO STUD	100MM ø	2340 MM	1 PC
BAMBOO STUD	100MM ø	670 MM	1 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
TIMBER WOOD JAMB	50X100 MM	1050 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	1230 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 35MMø		8 PC
FLAT BAR	25x3MM THK.	2723 MM	2 PC
THREADED ROD	10MM ø	150 MM	5 PC
NUTS	10MM ø	–	10 PC
WASHER	2.1MM THK. X 25MMø		10 PC
THREADED J-BOLT	12MM ø	300 MM	3 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	3 PC
NUTS	12MM ø	–	9 PC
WASHER	2.8MM THK. X 35MMø		9 PC
TADTAD	300x2350 MM		9 PC

NAME	WP-02
QTY	ONE (1) SET

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50X100 MM	2350 MM	1 PC
BOT. TIMBER PLATE	50X100 MM	2350 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
T2 BAMBOO STUD	100MM ø	2340 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	500 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	600 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	2 PC
NUTS	12MM ø	–	4 PC
WASHER	2.1MM THK. X 35MMø		4 PC
FLAT BAR (L1)	25x3MM THK.	3347 MM	2 PC
FLAT BAR (L2)	25x3MM THK.	2963 MM	2 PC
THREADED ROD	10MM ø	150 MM	9 PC
NUTS	10MM ø	–	18 PC
WASHER	2.1MM THK. X 25MMø		18 PC
THREADED J-BOLT	12MM ø	300 MM	4 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	12 PC
WASHER	2.8MM THK. X 35MMø		12 PC
TADTAD	300x2350 MM		9 PC

SCHEDULE OF PANELS

Annex B: Sample Plans



NAME	WP-03
QTY	TWO (2) SETS

COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50X100 MM	2400 MM	1 PC
BOT. TIMBER PLATE	50X100 MM	2400 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
T2 BAMBOO STUD	100MM ø	2340 MM	2 PC
BAMBOO STUD	100MM ø	670 MM	1 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
TIMBER WOOD JAMB	50X100 MM	1050 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	1230 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 35MMø		8 PC
FLAT BAR	25x3MM THK.	2751 MM	2 PC
THREADED ROD	10MM ø	150 MM	8 PC
NUTS	10MM ø	–	16 PC
WASHER	2.1MM THK. X 25MMø		16 PC
THREADED J-BOLT	12MM ø	300 MM	4 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	12 PC
WASHER	2.8MM THK. X 35MMø		12 PC
TADTAD	300x2400 MM		9 PC

NAME	WP-04
QTY	TWO (2) SETS

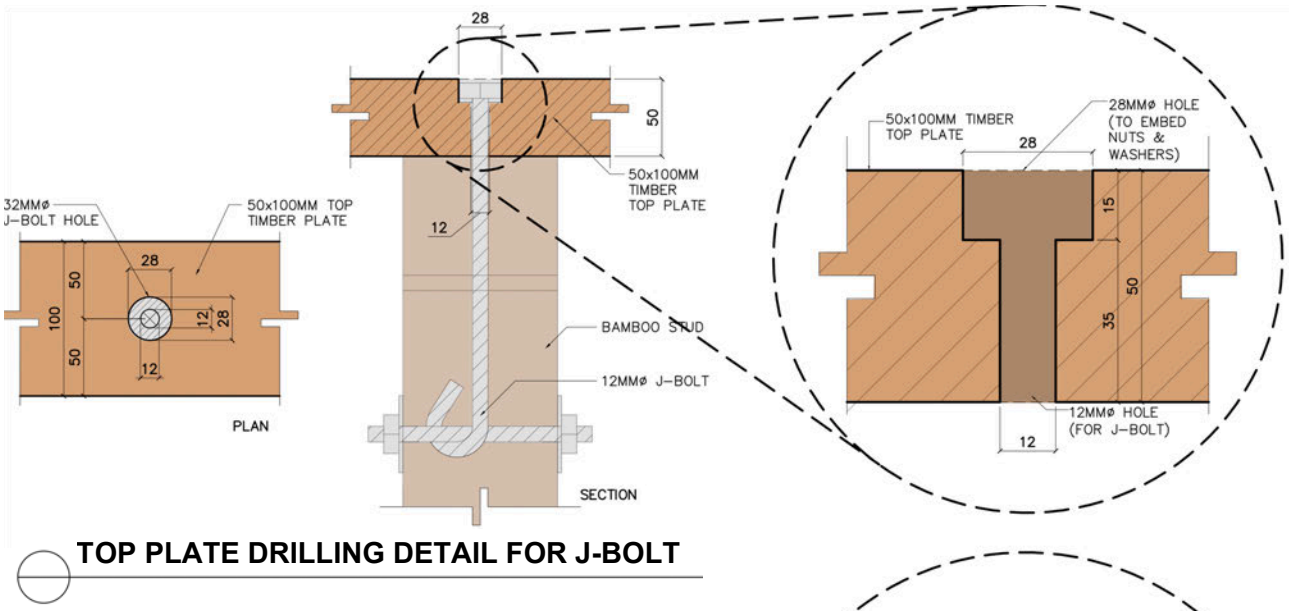
COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50X100 MM	2500 MM	1 PC
BOT. TIMBER PLATE	50X100 MM	2500 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	4 PC
T2 BAMBOO STUD	100MM ø	2340 MM	1 PC
BAMBOO STUD	100MM ø	670 MM	1 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
TIMBER WOOD JAMB	50X100 MM	1050 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	1230 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 35MMø		8 PC
FLAT BAR (L1)	25x3MM THK.	2551 MM	2 PC
FLAT BAR (L2)	25x3MM THK.	2507 MM	2 PC
THREADED ROD	10MM ø	150 MM	9 PC
NUTS	10MM ø	–	18 PC
WASHER	2.1MM THK. X 25MMø		18 PC
THREADED J-BOLT	12MM ø	300 MM	4 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	12 PC
WASHER	2.8MM THK. X 35MMø		12 PC
TADTAD	300x2500 MM		9 PC

NAME	WP-05
QTY	ONE (1) SET

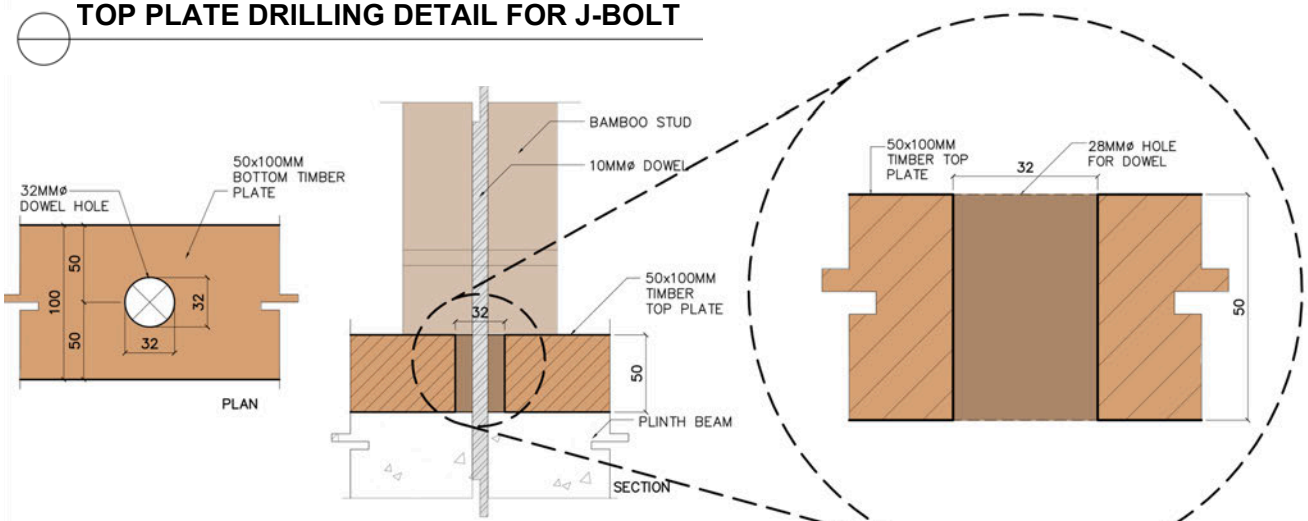
COMPONENT	SIZE	LENGTH	QTY
TOP TIMBER PLATE	50X100 MM	1300 MM	1 PC
BOT. TIMBER PLATE	50X100 MM	1300 MM	1 PC
T1 BAMBOO STUD	100MM ø	2340 MM	3 PC
BAMBOO STUD	100MM ø	670 MM	1 PC
BAMBOO STUD	100MM ø	340 MM	1 PC
TIMBER WOOD JAMB	50X100 MM	700 MM	2 PC
TIMBER WOOD JAMB	50X100 MM	1230 MM	2 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	4 PC
NUTS	12MM ø	–	8 PC
WASHER	2.1MM THK. X 35MMø		8 PC
FLAT BAR	25x3MM THK.	2438 MM	2 PC
THREADED ROD	10MM ø	150 MM	4 PC
NUTS	10MM ø	–	8 PC
WASHER	2.1MM THK. X 25MMø		8 PC
THREADED J-BOLT	12MM ø	300 MM	3 PC
STRAIGHT THREADED ROD	12MM ø	150 MM	3 PC
NUTS	12MM ø	–	9 PC
WASHER	2.8MM THK. X 35MMø		9 PC
TADTAD	300x1300 MM		9 PC

SCHEDULE OF PANELS

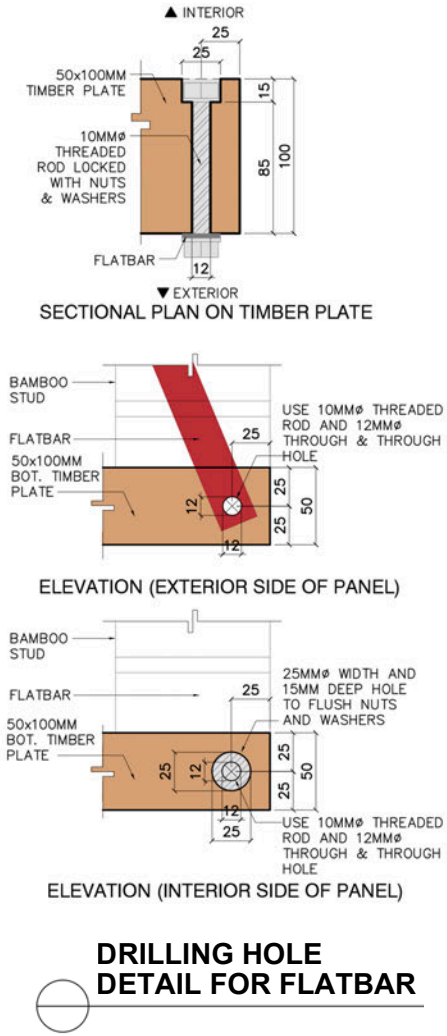
Annex B: Sample Plans



TOP PLATE DRILLING DETAIL FOR J-BOLT

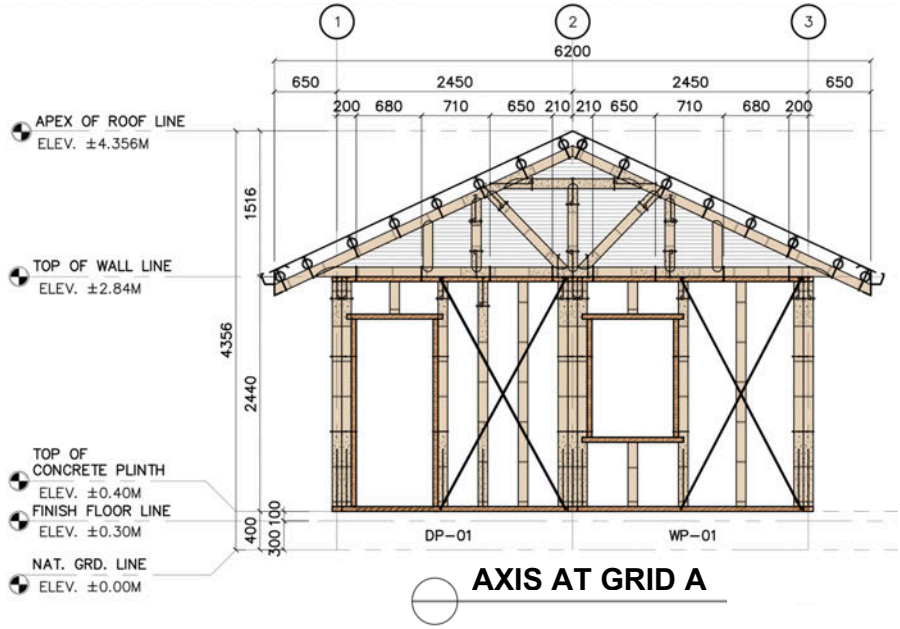


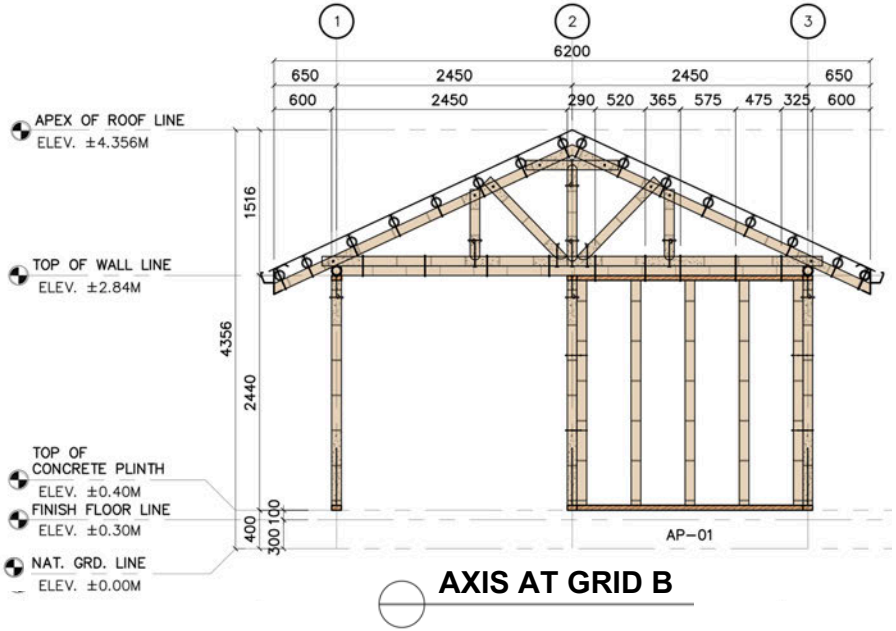
BOTTOM PLATE DRILLING DETAIL FOR DOWEL

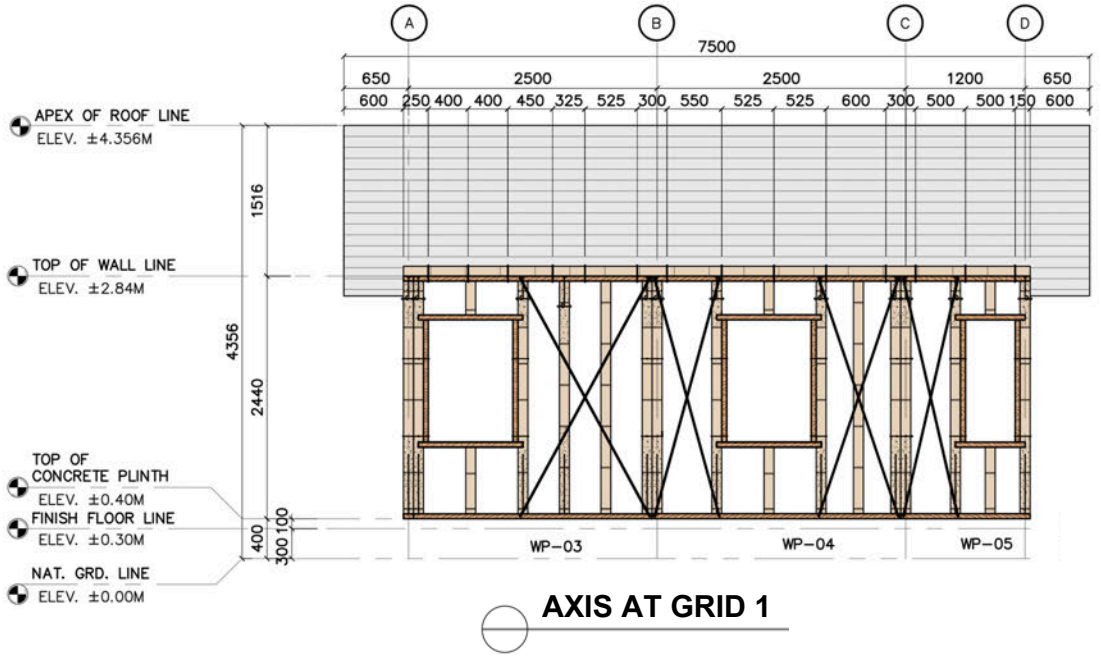


DRILLING HOLE DETAIL FOR FLATBAR

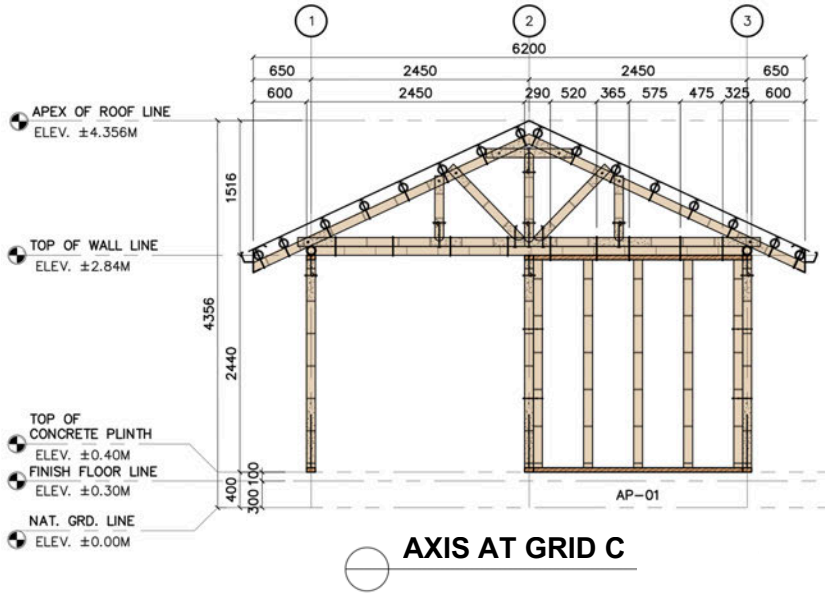
Annex B: Sample Plans



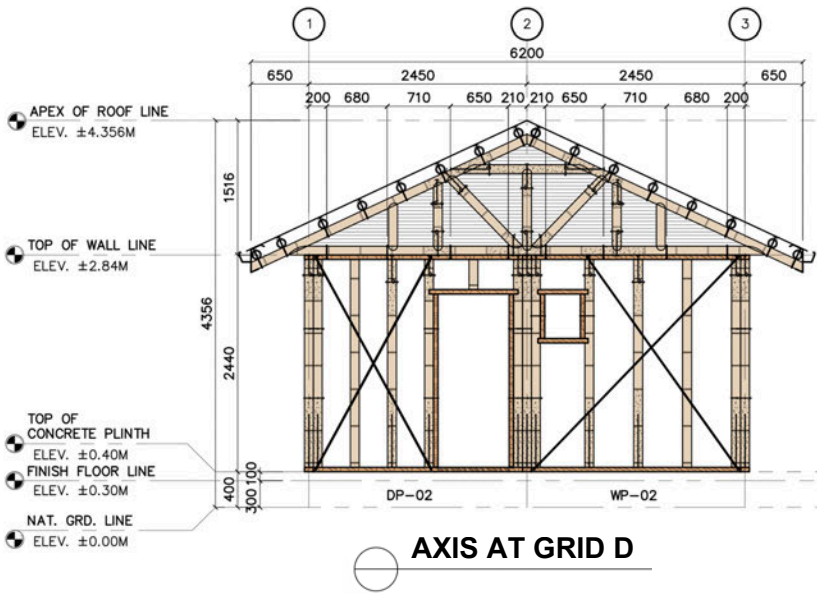




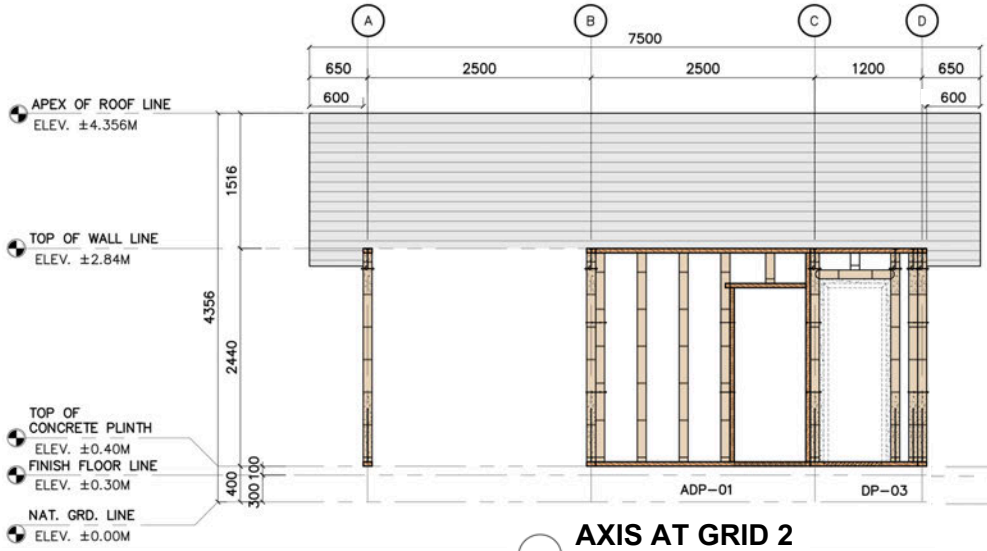
Annex B: Sample Plans



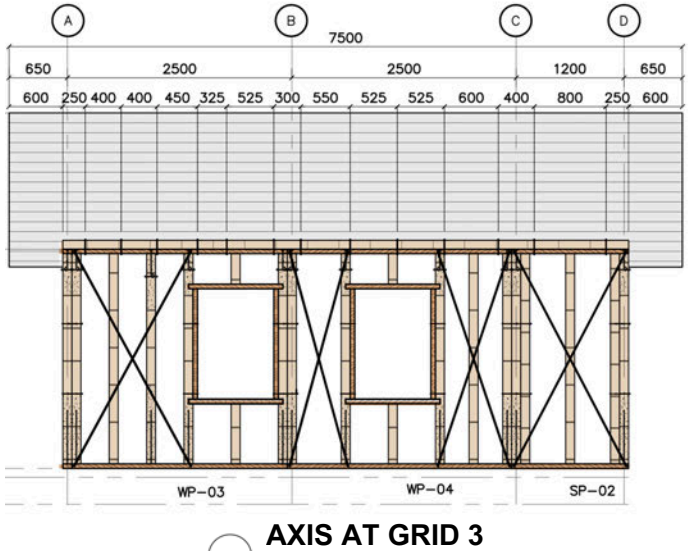
AXIS AT GRID C



AXIS AT GRID D

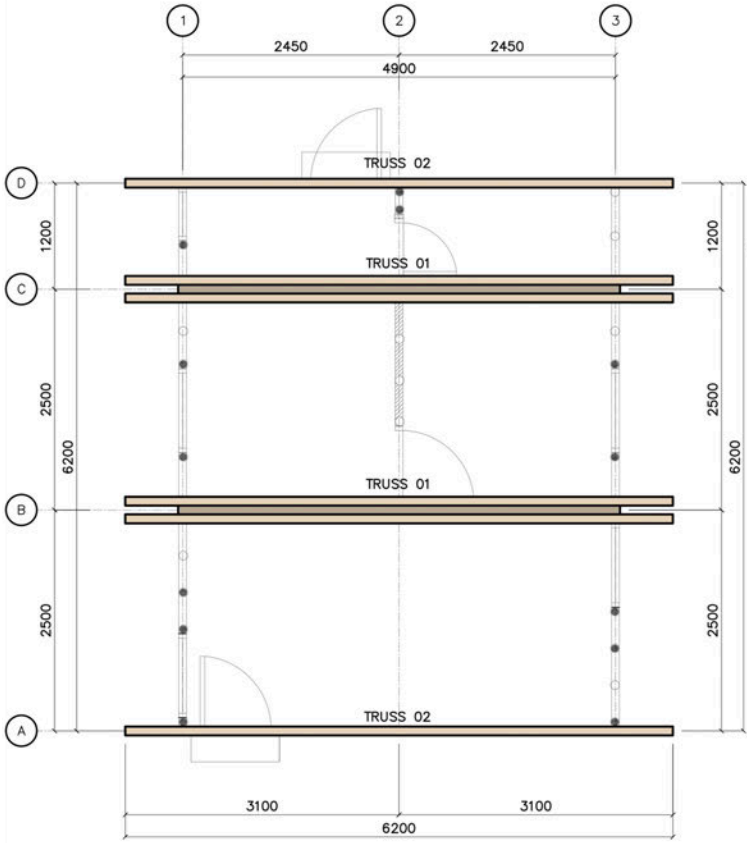


AXIS AT GRID 2

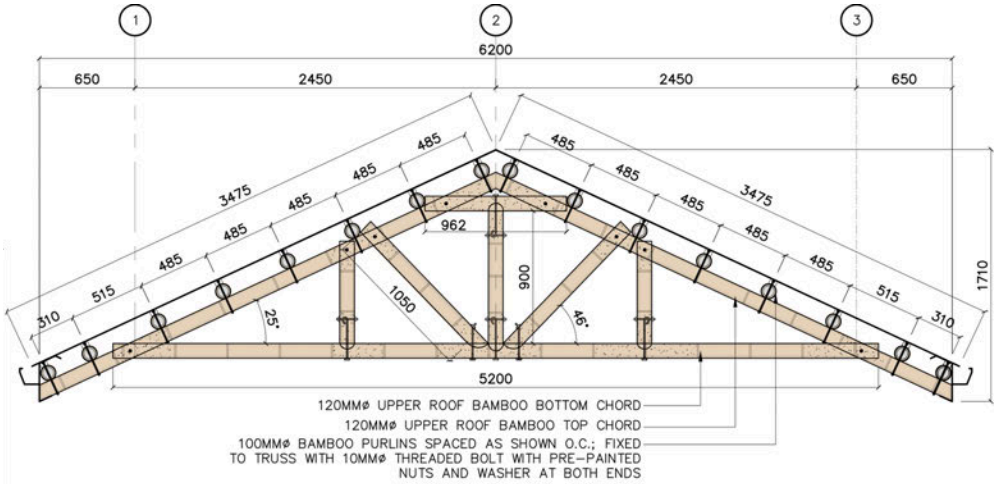


AXIS AT GRID 3

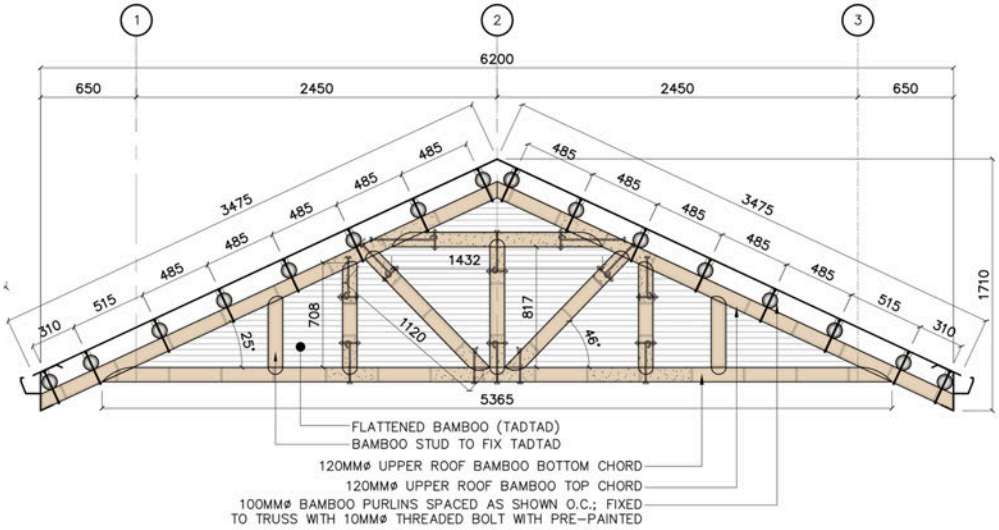
Annex B: Sample Plans



TRUSS PLAN

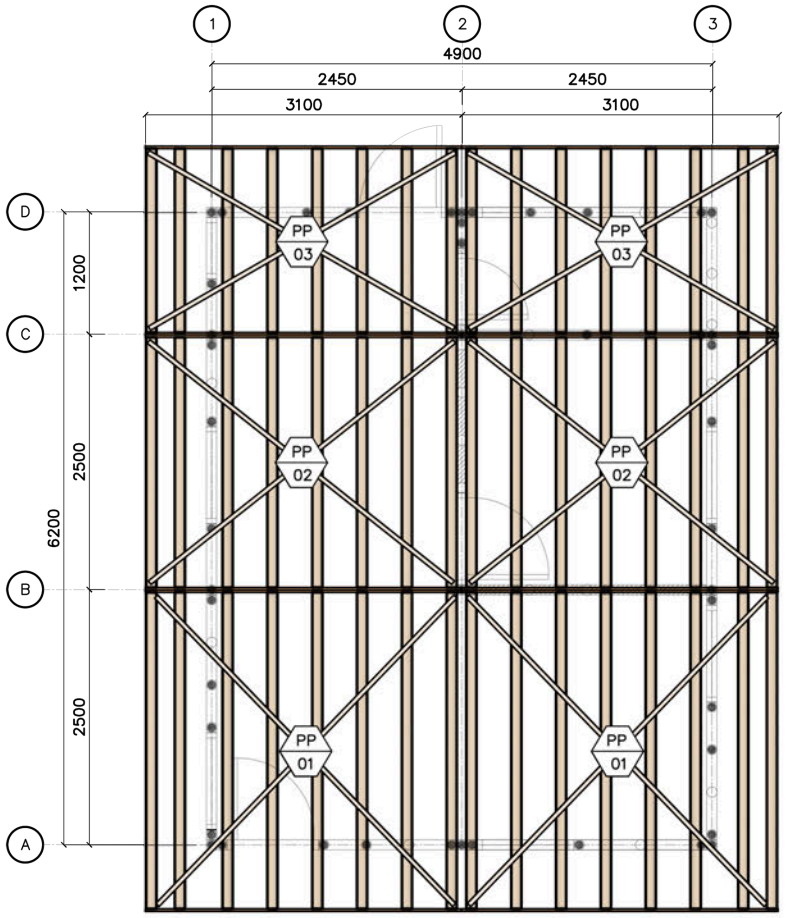


TRUSS 01 DETAIL

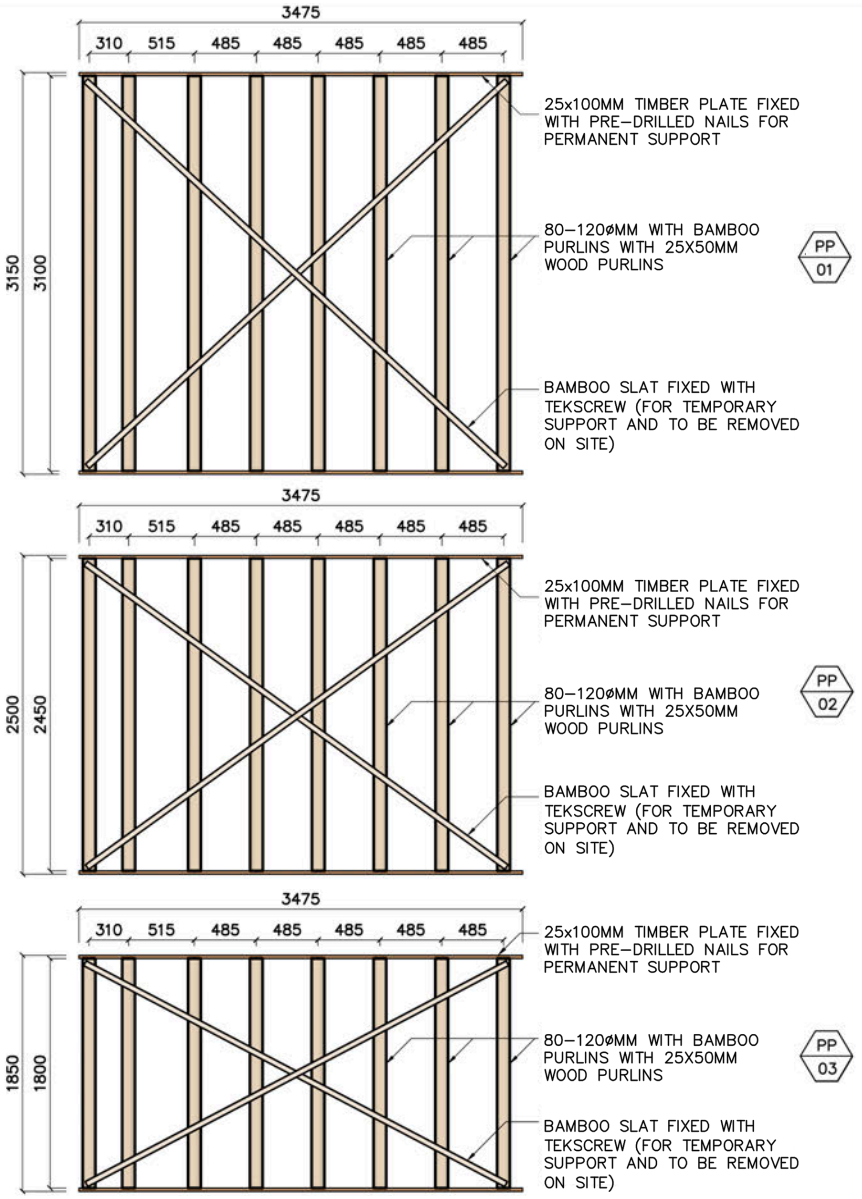


TRUSS 02 DETAIL

Annex B: Sample Plans

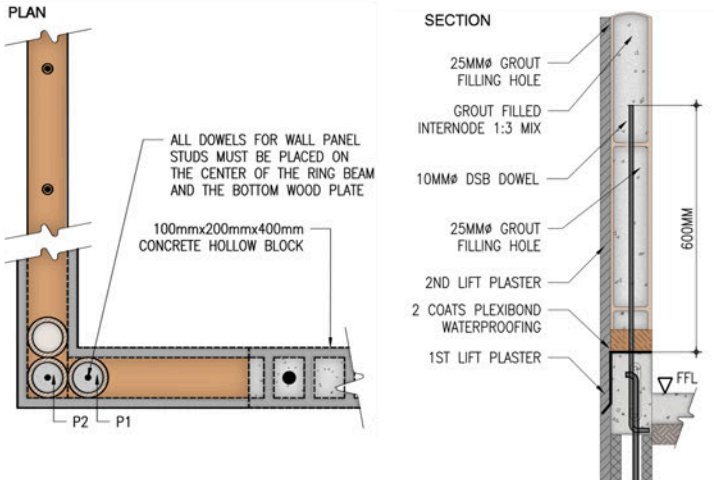


PURLINS PLAN

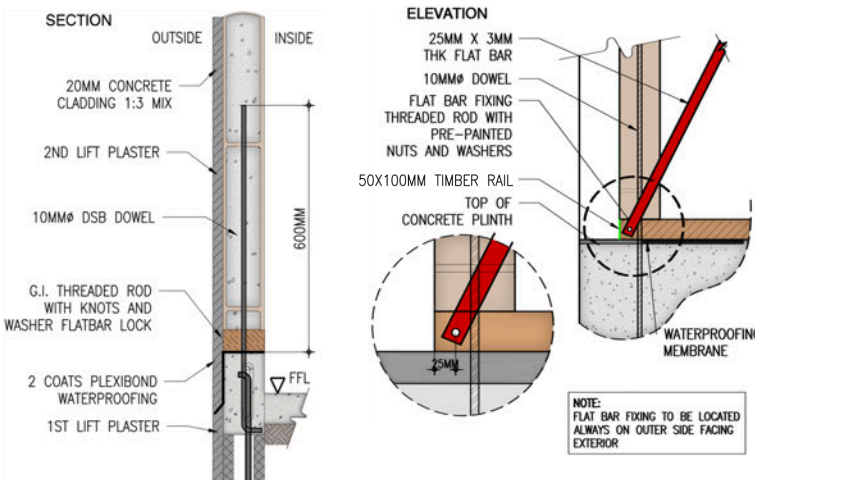


PURLIN DETAILS

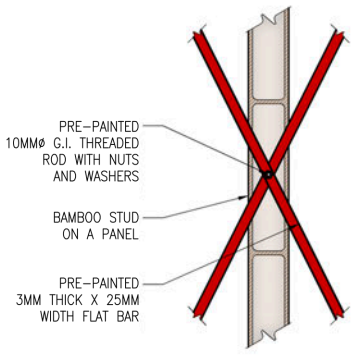
Annex B: Sample Plans



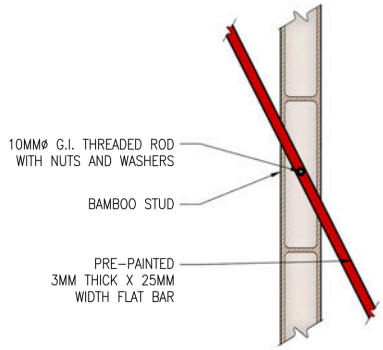
BAMBOO WALL STUDS AND DOWEL CONNECTION DETAIL



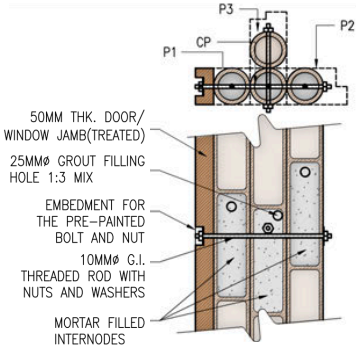
FLATBAR AND BOTTOM WOOD PLATE CONNECTION DETAIL



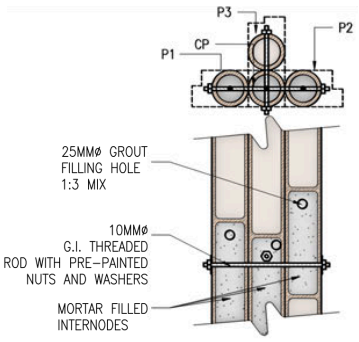
TWO FLATBAR CONNECTION DETAIL



SINGLE FLATBAR CONNECTION DETAIL

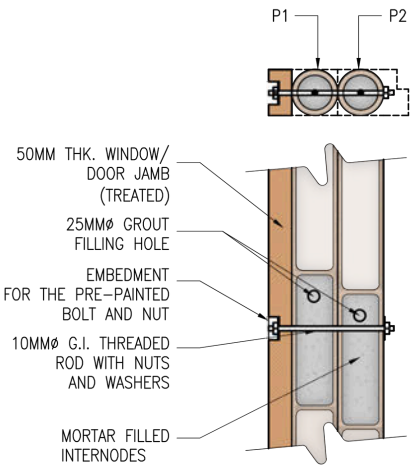


END TO END STUD AT INTERSECTION WITH CENTER POLE AND WOODEN JAMB CONNECION DETAIL

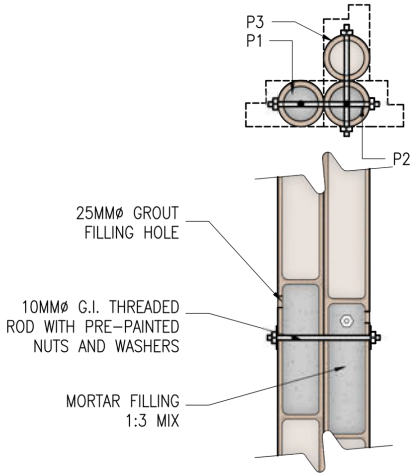


END TO END STUD AT INTERSECTION WITH CENTER POLE CONNECION DETAIL

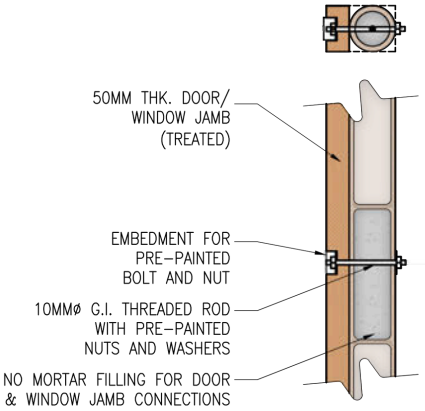
Annex B: Sample Plans



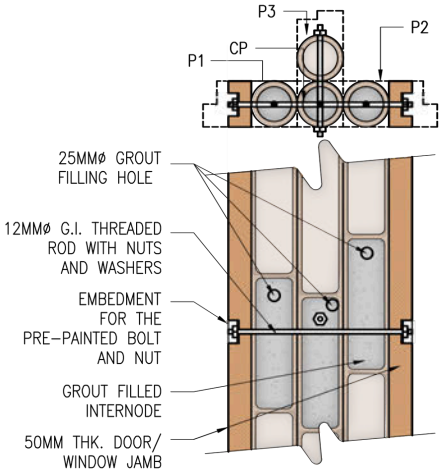
TYPICAL END TO END STUD WITH WOODEN JAMB CONN. DETAIL



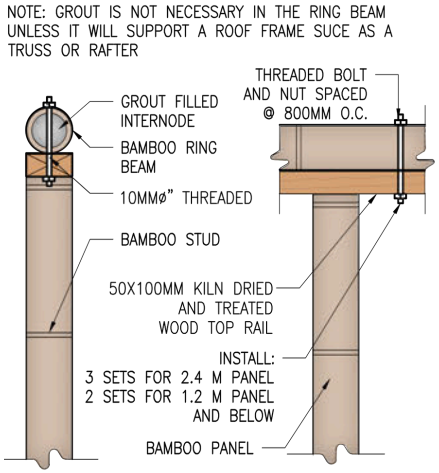
END TO END STUD AT CORNER CONN. DETAIL



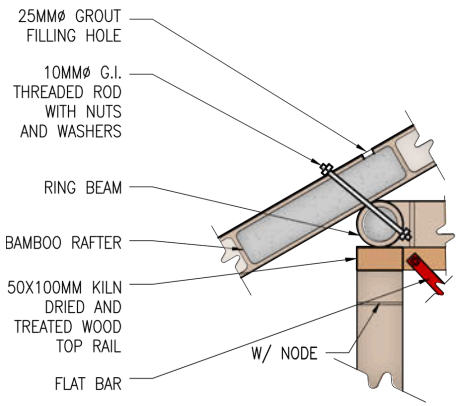
BAMBOO STUD AND JAMB CONNECTION DETAIL



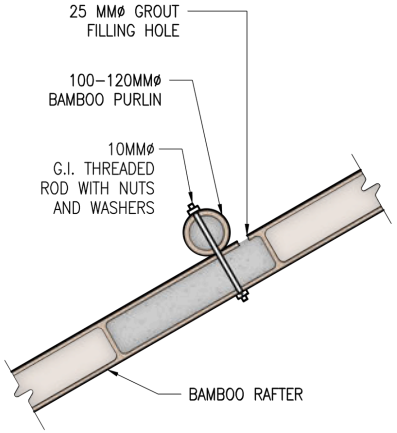
3 POLE CONNECTION WITH JAMB DETAIL



RING BEAM-TOP RAIL CONNECTION DETAIL

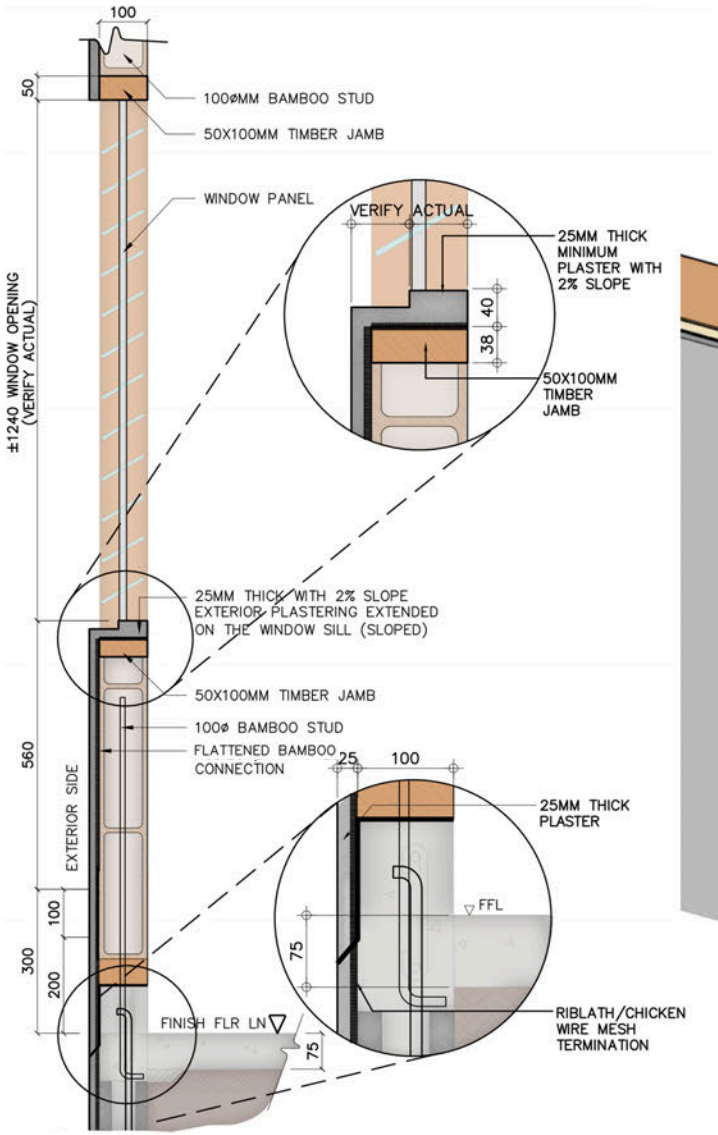


RAFTER TO RING BEAM CONNECTION

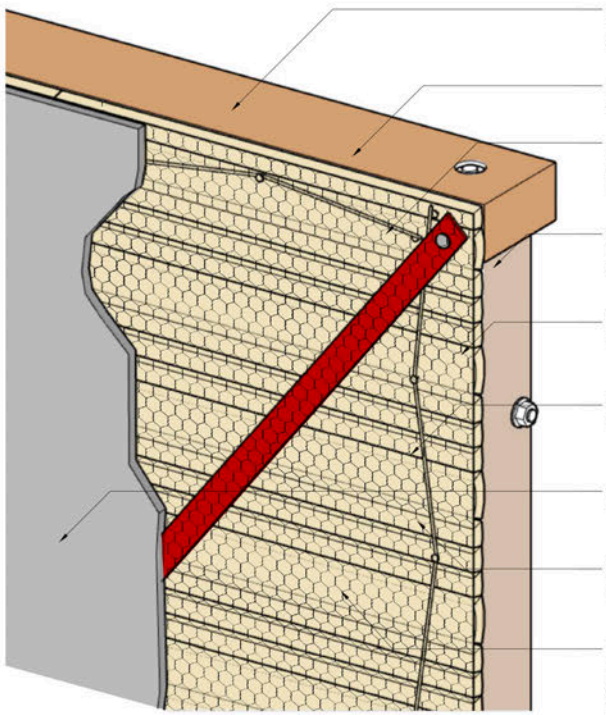


PURLIN TO RAFTER CONNECTION

Annex B: Sample Plans



WINDOW OPENING-PLASTER CONNECTION DETAIL



75MM COMMON WIRE NAIL SHALL BE USED TO FIX THE TADTAD TO THE BAMBOO STUDS. NAILS SHALL BE SPACED AT APPROXIMATELY 100MM HORIZONTALLY

#18 TIE WIRE SHALL BE USED TO STIFFFEN THE CONCRETE WIRE NAILS ATTACHED TO THE RIB LATH

3MM BY 25MM PRE-PAINTED FLAT BAR FIXED TO STUDS WITH ø10MM BOLTS, NUTS, & WASHERS; TO BE LOOSENED BEFORE TADTAD INSTALLATION IN BETWEEN FLATBAR AND STUDS; TO BE TIGHTENED AGAIN ONCE TADTAD IS INSTALLED

ø100MM DIAMETER TREATED BAMBOO STUDS SPACED MAX AT 600MM FRAMED AT TOP WITH ø100MM BAMBOO PLATE THROUGH FISHMOUTH CONNECTION WITH J-BOLT

FLATTENED BAMBOO OR TADTAD POSITIONED HORIZONTALLY & PERPENDICULAR TO THE BAMBOO STUDS

#18 TIE WIRE SHALL BE USED TO STIFFFEN THE CONCRETE WIRE NAILS ATTACHED TO THE TADTAD

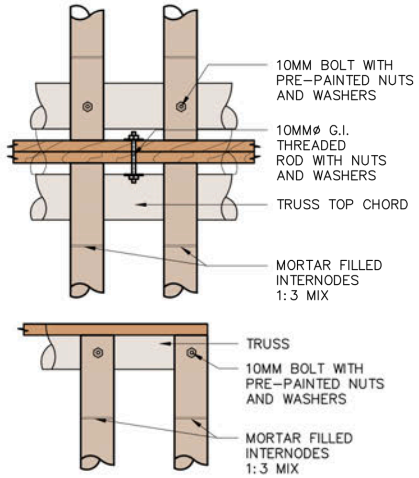
CEMENT PLASTERING SHALL BE DONE ONCE THE TADTAD HAS BEEN STIFFENED & INSTALLED PROPERLY

32MM COMMON WIRE NAIL SHALL BE USED TO FIX THE TADTAD TO THE BAMBOO STUDS. NAILS SHALL BE SPACED AT APPROXIMATELY 100MM VERTICALLY IN ZIGZAG/STAGGERED POSITION.

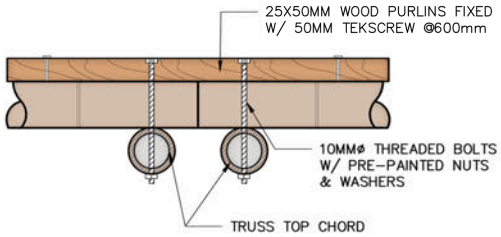
18-25MMø HOLE #20 CHICKEN WIRE MESH TO BE INSTALLED TO THE WALL ONCE TIE WIRE INSTALLATION TO THE NAILS ARE DONE. IT SHALL BE FIXED ON THE EDGES AND ON THE MIDPARTS THROUGH (#50 STAPLE WIRE)GUN TACKER WITH #18 TIE WIRES ATTACHED TO THE FLATBARS.

FLATTENED BAMBOO INSTALLATION DETAIL

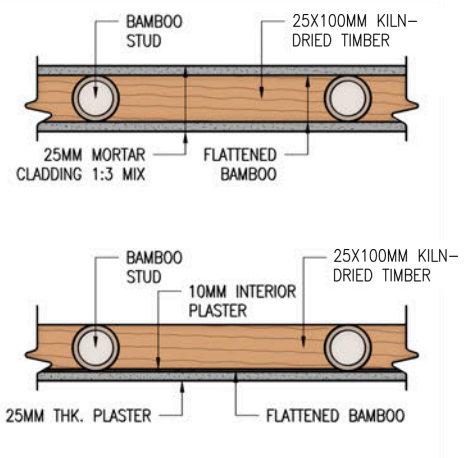
Annex B: Sample Plans



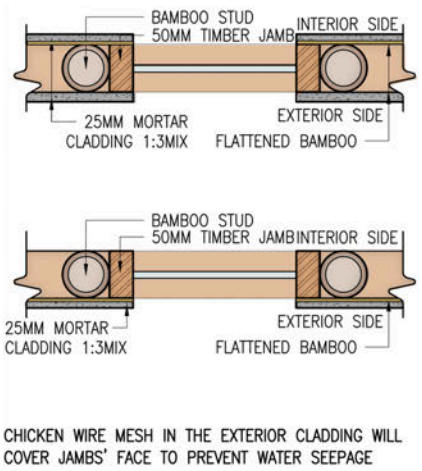
PURLIN-SPLICE CONNECTION DETAIL



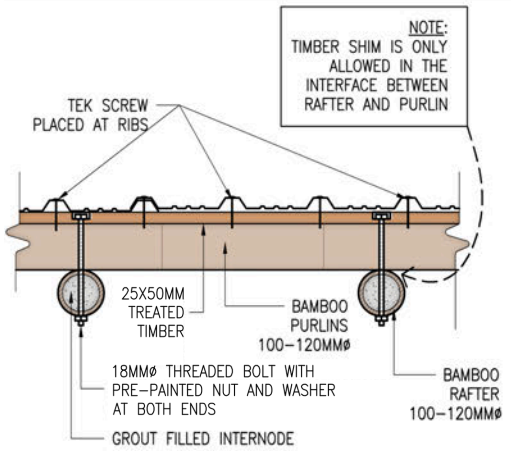
WOOD PURLIN DETAIL



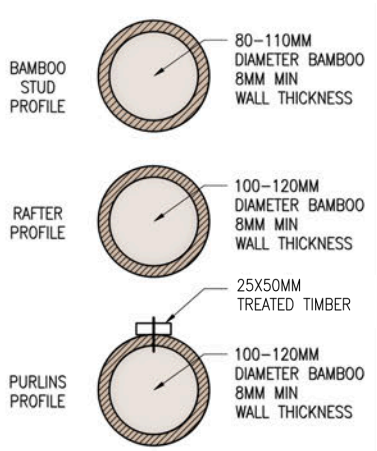
CLADDING DETAIL



CLADDING DETAIL AT OPENING



G.I. ROOF FIXING DETAIL



BAMBOO PROFILE

Annex B: Sample Plans

PLUMBING

Plumbing Notes

Material Specifications

Domestic Water Lines	For risers/downfeeds & distribution lines shall be galvanized steel iron,
Flushing Water Lines	(G.I.) Pipe, schedule 40, standard conforming to ASTM A-120-80. Fittings shall be malleable iron, class 250, use screwed connection from 15 mm∅ to 65 mm∅ and flanged connection from 75 mm∅ and larger. For inside toilets & baths shall be polyethylene pipes, high density, Polypropylene/or chlorinated pvc pipes. When buried underground, tapping water lines from the subdivision service Water main to cistern, pipe shall be galvanized iron (G.I.) Pipe schedule 10 with corrosion protection, coated with coaltar and wrapped with burlap.
Hot Water Lines	For distribution lines shall be polyethylene pipes, high density, polypropylene/or chlorinated pvc pipes. For inside toilets & baths shall be polyethylene pipes, high density, Polypropylene/or chlorinated PVC pipes. Alternate materials shall be chlorinated polyethylene pipes, high density, Polypropylene/or chloride PVC pipes, conforming to ASTM D-2846 SDR II.
Sewer Lines	Shall be hubless cast iron soil pipe (CISP) and fittings, conforming to CISPI Standard 301 ASTM A-888 or ASTM A74. For outside building-shall be concrete sewer pipe (CSP) T&G connection, cement, mortar joints.
Waste Lines	Shall be polyvinyl chloride (PVC) pipe series 1000 II. Fittings shall be solvent cement joint to ASTM D2564.
Vent Pipes	Shall be polyvinyl chloride (PVC) pipe series 1000 II. Fittings shall be solvent cement joint to ASTM D2564.
Downspout/ Drain Lines	Shall be hubless cast iron soil pipe (CISP) and fittings, conforming to cispi standard 301 ASTM A-888 or ASTM A74. Alternate materials shall be standard galvanized iron (G.I.) Pipe, schedule 40, conforming to ASTM A-120-80. For outside building shall be concrete drain pipe (CDP), tongue & groove, mortar joints, reinforced for 300 mm ∅ & larger.
Underdrain Pipes	Shall be polyvinylchloride (PVC) pipe, class DWV.

Annex B: Sample Plans

Plumbing Notes

Legend

Water System

DWL	POTABLE/DOMESTIC WATER LINE
HWL	HOT WATER LINE
FWL	FLUSHING WATER LINE
DWR	DOMESTIC WATER RISER
HWS/HWR	HOT WATER SUPPLY/HOT WATER RISER
FWR	FLUSHING WATER RISER
DWDF	DOMESTIC WATER DOWNFEED
FWDF	FLUSHING WATER DOWNFEED
GV	GATE VALVE
CV/PCV	CHECK VALVE/PUMP CONTROL VALVE
SACV	SURGE ANTICIPATING CONTROL VALVE
PRV	PRESSURE REDUCING VALVE
FC/VC	FLEXIBLE CONNECTION/VICTAULIC COUPLING
HB	HOSE BIBB
WM	WATER METER

Storm Drainage System

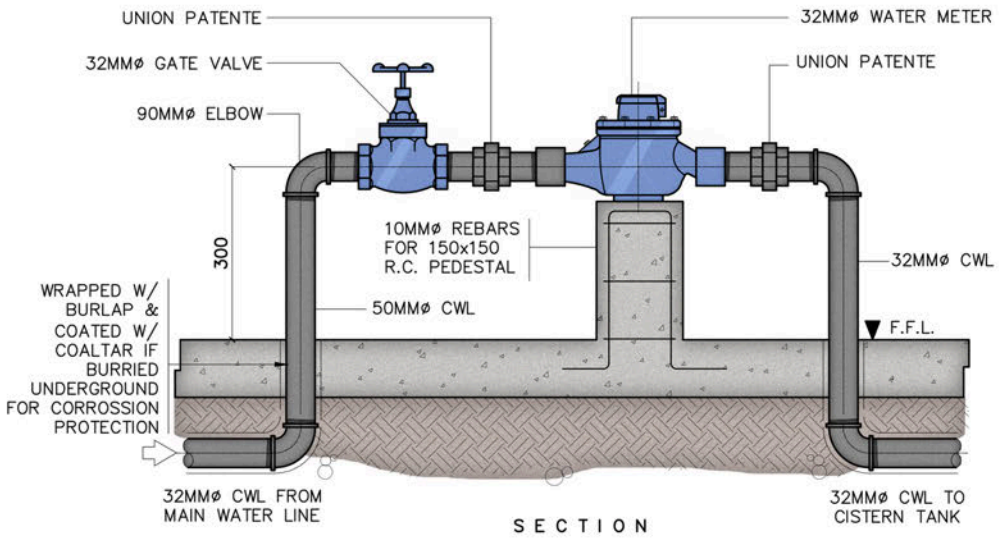
DS	DOWNSPOUT / WASTE STACK
DP/UDP	DRAINAGE PIPE / UNDER DRAIN PIPE
AD/CB	AREA DRAIN / CATCH BASIN
DD/GD/BD	DECK DRAIN / GUTTER DRAIN / BALCONY DRAIN
PD/TD/FD	PARKING DRAIN / TRENCH DRAIN / FLOOR DRAIN
CDP/RCDP	CONC. DRAIN PIPE / REIN. CONC. DRAIN PIPI

Plumbing Fixtures

WC	WATER CLOSET
LAV	LAVATORY
WB/PS	WASH BASIN / PANTRY SINK
UR	URINAL
GT/OI	GREASE TRAP / OIL INTERCEPTOR
S	SLOPE

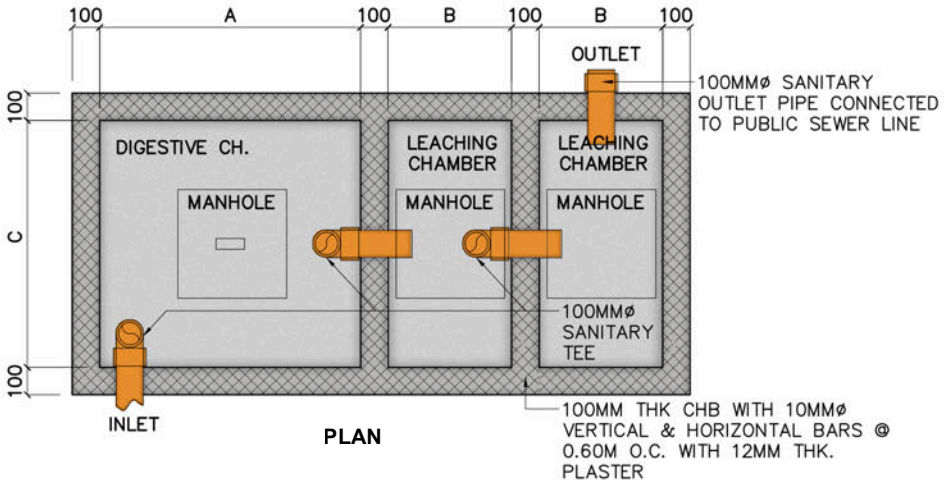
Water, Sewer, and Vent System

WP/SP	WASTER PIPE / SEWER PIPE
SS/WS	SOIL STACK / WASTE STACK
VS	VENT STACK
VSTR	VENT STACK THRU ROOF
V/VAC	VENT / VENT ABOVE CEILING
FCO/CCO	FLOOR CLEANOUT / CEILING CLEANOUT
SD/FD	SHOWER DRAIN / FLOOR DRAIN
SMH	SEWER MONHOLE

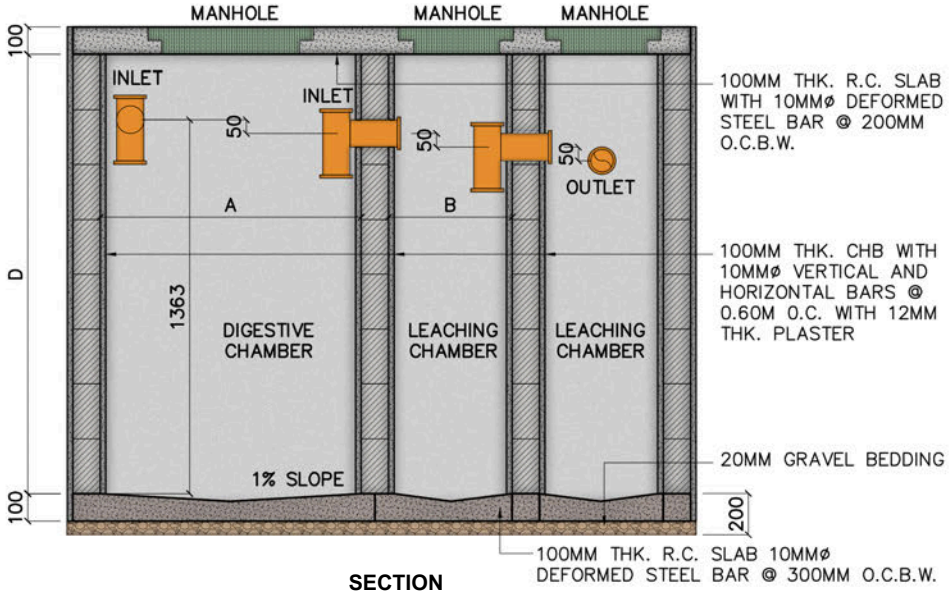


WATER METER DETAIL

Annex B: Sample Plans



PLAN

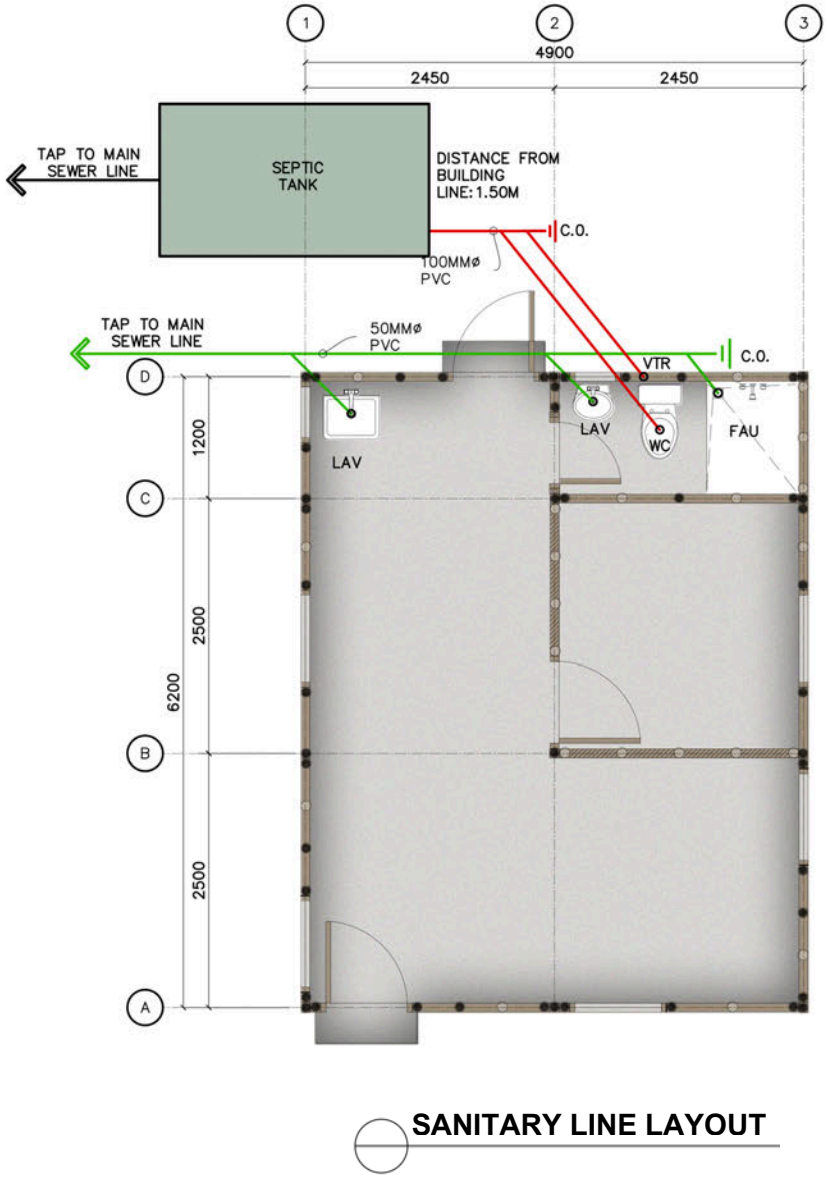


SECTION

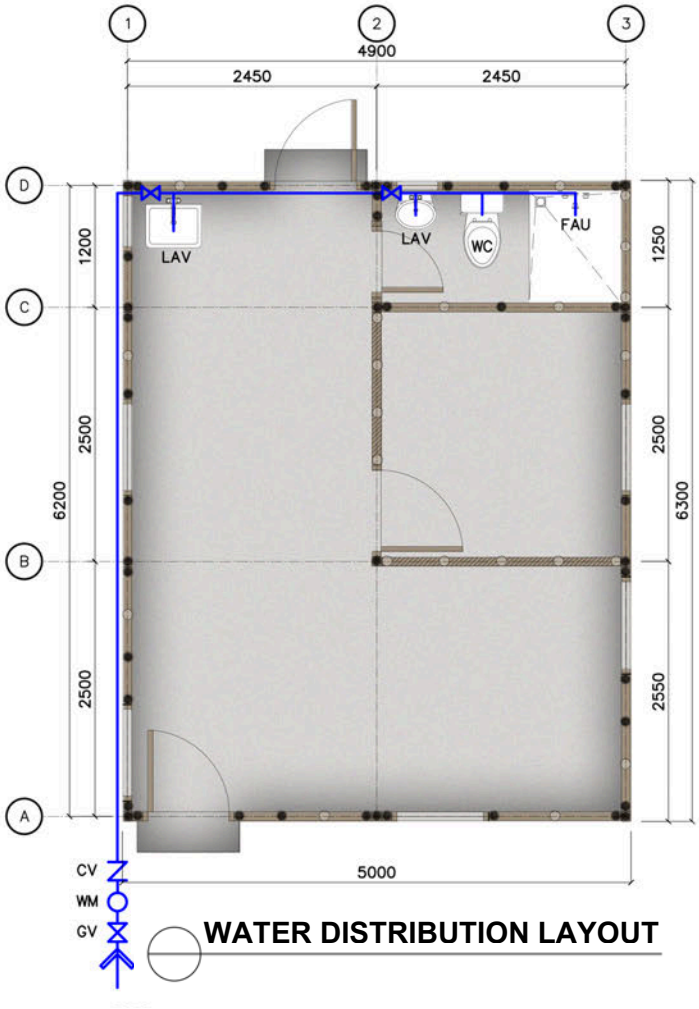
SEPTIC TANK DETAILS

SEPTIC TANK DIMENSION					
Gallon Capacity	Household to Serve	(A) Digestive Chamber Length	(B) Leaching Chamber Length	© Septic Tank Width	(D) Height
1000	1	1150	550	1500	1500
1200	2	1700	800	1200	1500
1500	3	1750	850	1500	1500
2000	4	2000	1000	1500	1800

Annex B: Sample Plans



SANITARY LINE LAYOUT



WATER DISTRIBUTION LAYOUT

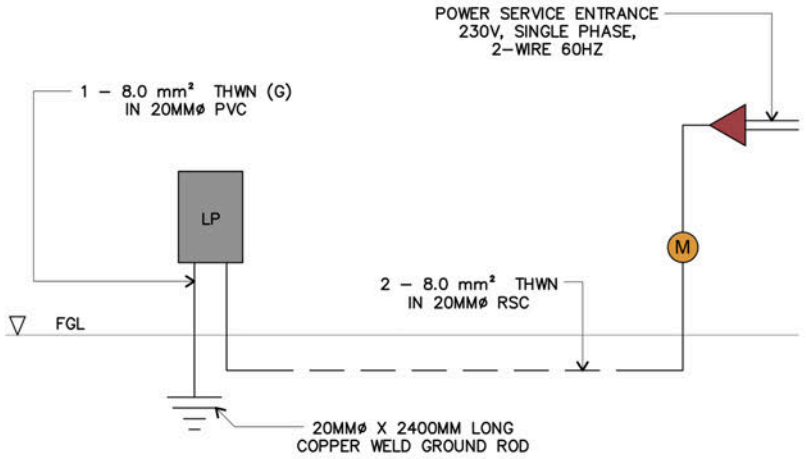
Annex B: Sample Plans

ELECTRICAL

Electrical Notes

Legend

SYMBOL	MTG HEIGHT	DESCRIPTION
O_a	RECESSED	LED WARM WHITE DOWNLIGHT, 230V, 60HZ. REFER TO ARCHITECT'S SPECIFICATIONS. SUBSCRIPT DENOTES CONTROLLING SWITCH.
•Sa	1200mm AFFL	LIGHT SWITCH, 10A, 1–DEVICE, 1–GANG, 250V, WALL MOUNTED, SUBSCRIPT DENOTES FIXTURE CONTROLLED
• Sab	1200mm AFFL	– DITTO – EXCEPT 2–DEVICES, 2–GANG
=⊖WP	300mm AFFL	DUPLEX RECEPTACLE OUTLET, WEATHER–PROOF, 16A, 250V, GROUNDING TYPE
=⊖	300mm AFFL	DUPLEX RECEPTACLE OUTLET, 16A, 250V, GROUNDING TYPE
▭	1830mm AFF	PANELBOARD, RATING AS INDICATED
LPA–2 →		HOMERUN TO PANELBOARD LETTER AND NUMBER INDICATE PANELBOARD DESIGNATION AND CIRCUIT NUMBER RESPECTIVELY
◉ GR ⏚		GROUND ROD, COPPER, 16mmø x 2400mmL

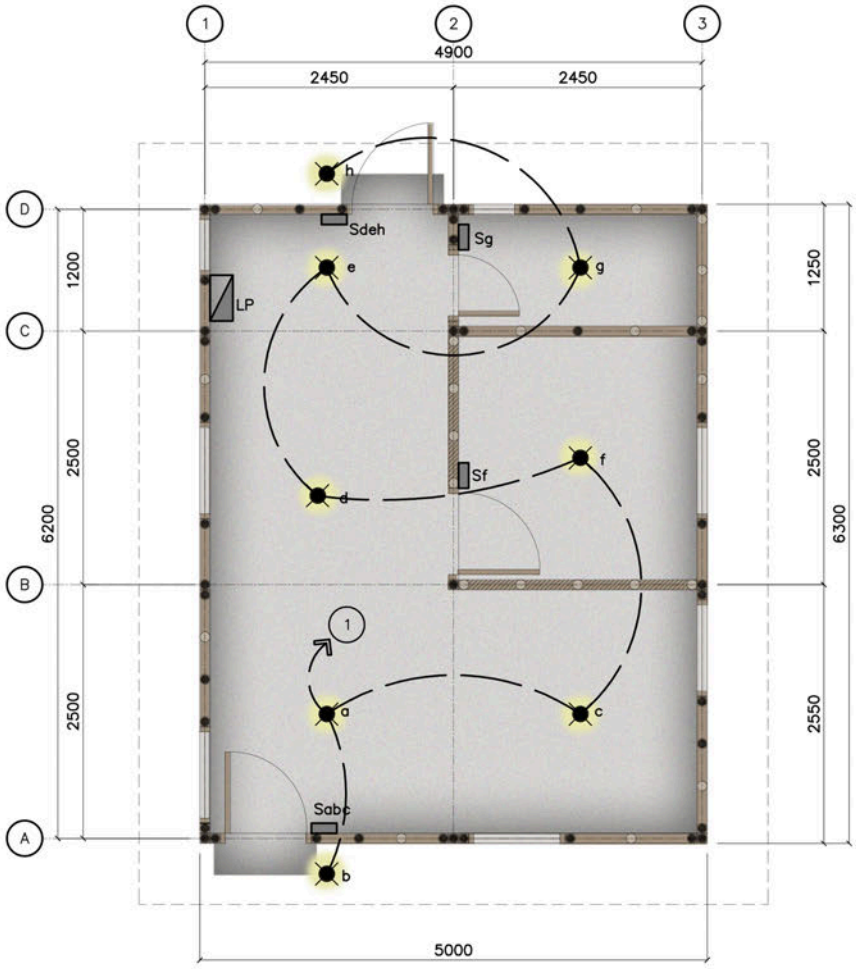


RISER DIAGRAM

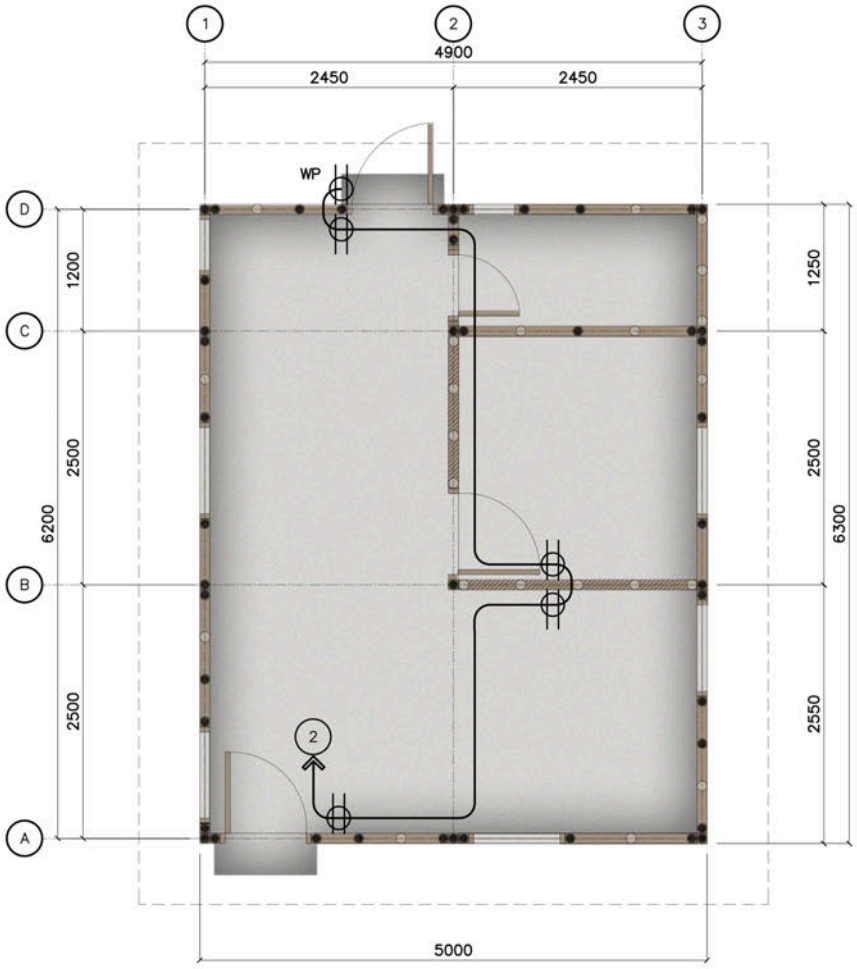
LP	FLUSH MOUNTED						MAIN: 50AT/100AF, 1P, 250V MCB 10KAIC WITH SOLID GROUND BUS			
CKT NO	OUTLETS		OTHER LOADS	VOLTS	VA LOADS	AMP LOAD	CIRCUIT BREAKER			WIRES/CONDUITS
	L.O	C.O					AT	AF	P	
1	6			230	600	3.04	15	50	1	2-2.0MM2 THHN IN 20MM DIA CONDUIT
2		4		230	600	3.91	20	50	1	2-3.5MM2 THHN IN 20MM DIA CONDUIT
3			SPARE	230	1000	4.35	20	50	1	EMPTY, 20MM DIA CONDUIT
4			SPARE	230	1000	4.35	20	50	1	EMPTY, 20MM DIA CONDUIT
TOTAL					3600	15.65				

FULL LOAD CURRENT AT 100% DEM. FACTOR
IFL=15.65A
USE: 2-8.0MM2 THWN IN 20MM DIA RSC

Annex B: Sample Plans

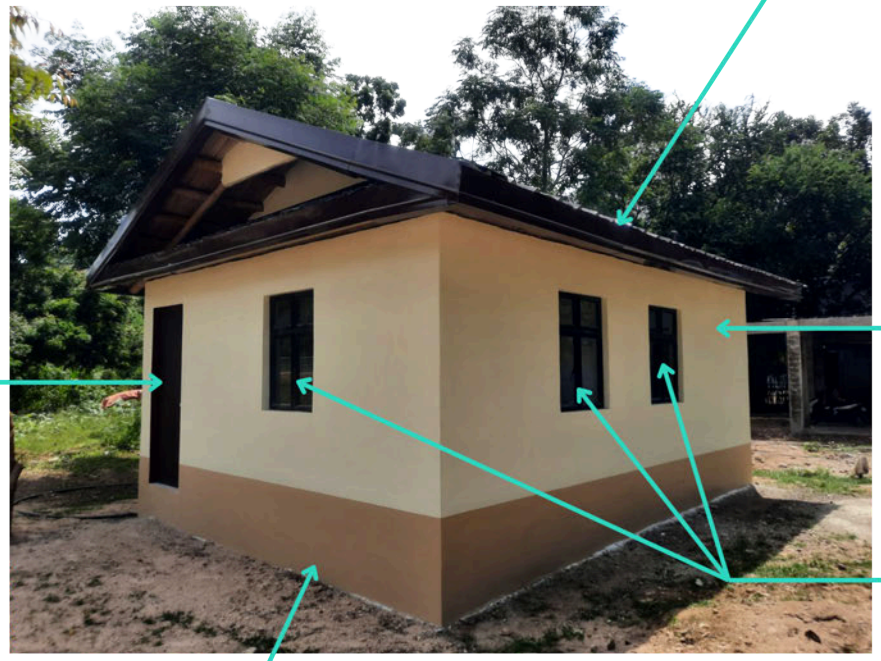


LIGHTING LAYOUT



POWER LAYOUT

Annex C: Aftercare Guide (House Exterior)



VICINITY

Check for:

- Clogging and damage in the existing drainage system in the area.
- Leakages in plumbing system.

Do:

- Direct surface water away from the house.

Avoid:

- Planting trees within a distance from the house that equates to their mature height.
  - *The roots will eventually spread underneath the footing and cause soil shrinkage.*
- Allowing water to be trapped or pond near the house.

ROOF COVER

Check for:

- Rust and dust accumulation on surface of roof sheets.
- Loosely fastened roof covering to purlins.

Do:

- Clean the surface by brushing off dirt and accumulated dirt and dust.
- Apply paint primer to avoid the occurrence of rust.

DOORS

Check for:

- Infestation of beetles, termites, and other insects on door wooden jambs.
- Loose screws of door hinges.

Do:

- Lubricate the door hinges with machine oil.

WALL CLADDING

Check for:

- Big cracks on the cement plaster cladding.

WINDOWS

Check for:

- Infestation of beetles, termites, and other insects on window wooden jamb.
- Loose glass jalousie blades.

FOUNDATION WALLS

Check for:

- Cracks
- Traces of termite infestation
- Surface delamination
  - *Check by pinging the concrete surface with the hammer. Delaminated areas send back a hollow sound instead of the hard ringing of sound concrete.*
- Erosion due to storm water
  - *If house is located on sloping terrain, erosion will eventually expose portions of the footing and then scour the subgrade.*

MAINTENANCE SCHEDULE — *Daily* | *Monthly* | *Every 3 months* | *Every 6 months*

Annex C: Aftercare Guide (House Interior)

ELECTRICAL SYSTEM

Do:

- Clean light bulbs with dry cloth to remove accumulated dust.

PLUMBING SYSTEM

Check for:

- Leaks on water line connections and faucets.
- Slowly sinking wastewater on floor drains and p-traps.

FLOOR SLAB

Check for:

- Cracks on floor slab.

ROOF TRUSSES

Check for:

- Infestation from beetles, termites, and other insects on bamboo poles.
- Developing longitudinal cracks on bamboo poles, particularly those that cut across the node.
- Holes on bamboo poles that will serve as entry points for insect.
- Corrosion on bolts and nuts.
- Loosely fastened nuts.

ROOF COVER

Check for:

- Leaks underneath the roof covering, particularly on the nail fasteners, end, and side lapping.

CBSW PANELS

Check for:

- Infestation from beetles, termites, and other insects on bamboo poles.
- Developing longitudinal cracks on bamboo poles, particularly those that cut across the node.
- Holes on bamboo poles that will serve as entry points for insect.
- Corrosion on bolts and nuts.
- Loosely fastened nuts.

MAINTENANCE SCHEDULE — *Daily* · *Monthly* · *Every 3 months* · *Every 6 months*