

BUILD A DOME SHELL STRUCTURE

using Bamboo Mesh and Render
Version 4



Christopher Brown and Wolfgang Widmoser

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How to Build a Monolithic Concrete Shell Structure Using Bamboo Mesh and Render

by Christopher Brown and Wolfgang Widmoser

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Disclaimer

The purpose of this Guide is for education and entertainment and to transmit ideas and information from many years practical experience building engineered certified and non engineered certified concrete shell structures. There may be mistakes both typographical and in content.

Chris Brown has in excess of 23 years experience in the design and construction of dome structures up to 9.5.0m diameter utilizing a variety of material systems and methods in search of the most simple and cost effective ways to build strong, safe shelters and living spaces using the most simple materials available. The exact method and principals described here have been used to successfully build structures of various sizes. We rely only on building and structural common sense based on many years of experience in building dome shaped structures using various material systems that have been tested and certified in University test labs.

It is your responsibility to satisfy yourself of the structural integrity of whatever you intend to build when using bamboo.

It is a condition of purchase and, or use of this manual that any person using the information contained herein agrees that they do so entirely at their own risk and the authors, DomesHELLS, its employees or agents shall have neither liability or responsibility to any person or entity with respect to any loss or damage caused or alleged to have been caused, directly or indirectly by the information contained in this Guide

The purchaser warrants to exercise caution and thoroughness in their approach to implementing the processes described in this Guide and to take all necessary action to ensure, that if necessary, you will seek advice and clarifications from DomesHELLS, obtain the services of a professional builder or engineer or obtain further training in the process of construction at a DomesHELLS builder training event. Ensure that whatever you do build will adequately perform its purpose.

Town Planning and Building Regulations

We do not claim to comply with any jurisdictions planning or building regulations. Bamboo is a well accepted building product due to its natural strength. Some countries in tropical regions have a different relationship with bamboo than many western countries and it may be widely accepted for structural use in some countries and not at all in others. It is assumed you are familiar with the requirements in your region.

Health and Safety

You must satisfy yourself in regard to compliance with local building laws in the area where you live. Many countries like Australia have extremely rigorous regulations regarding building standards and particularly measures that must be taken to eliminate or reduce the risk of physical injury.

Construction is potentially a dangerous occupation and requires consciousness of the risks and a determination to mitigate risks which might cause injury. It is your responsibility to take every precaution in the process of constructing any kind of structure. For example some of the most important issues to safeguard are listed below:

1. Ground hazards such as excavation and trenches – just the slightest hole in the ground can cause injuries
2. Working at heights – falls are one of the most common accidents on building sites and for that reason building regulations often specify standards of scaffolding, ladders and other elevated platforms
3. Lifting and carrying heavy weights – there is a right way and a wrong way to lift a heavy object – the right way will prevent most injuries from ever occurring
4. Use of power tools and electricity – using power tools safely requires experience and great care for oneself and other people in the vicinity
5. Chemical hazards – cement is highly alkaline and can be very harsh on the skin and can cause skin irritation for some people - protect skin from prolonged exposure to Portland cement
6. Bamboo can be very sharp – it can easily inflict serious cuts and as a spear could be lethal - wear appropriate gloves when handling bamboo

Everyone is responsible for safety.

If anything is not clear to you please take the time to do further research or contact us with any questions.

Email: diy@domeshells.com.au or a phone call +61 2 6677 0216 Monday to Saturday 9:00 am to 6:00 pm (Australian Eastern Time) <https://domeshells.com.au>

A Message from the Authors – Chris & Wolfgang

Wolfgang Widmoser

Born in 1954 in Munich. http://wolfgangjohanneswidmoser.com/wjw_-_welcome.html

My father was a great architect and collected books about Art and Architecture so I had a fountainhead of inspiration at my disposal as a child.

Given the strict laws and building-codes in Germany at the time I decided to be a painter (artist).

I studied Painting 1973 – 1978 with Ernst Fuchs and Salvador Dali and am practicing this Art until the present.

My interest in genuine construction never subsided.

1982 I moved to Tuscany and build some geodesic domes following Buckminster Fuller.

Fascinated with his philosophy I soon discovered Frei Otto and the principles of lightweight-construction and started to experiment with tensile buildings.

Moving to Bali in 1984 I got introduced to Bamboo as a building-material and erected several Bamboo houses in Bali and Sulawesi. My dream was to develop laminated Bamboo as a main construction-material to eventually replace steel.

Bamboo as reinforcing material is widely used in Asia and structures like the Ceramic-center 1997 in Sayan and the domes in Mentigi Bay 2012 behave very positive so far.

As an architect it is my aim to design economical and ecological structures that combine functionality with aesthetic qualities.

A Bamboo/Mesh reinforced cement-shell can pretty much be shaped in any desired form and this is what this book will demonstrate. It is a guide for you to have confidence to proceed with a project of your own.

Chris Brown

Born Durban South Africa

CEO of Domesells Australia <https://domeshells.com.au>

CEO of Dreamdome Pty Ltd - <https://dreamdome.com.au>

As a young boy I helped build wattle and daub rondavels in South Africa. Later, I became a carpenter, licensed builder, project manager, building materials developer and inventor and I have enjoyed extremely diverse experience in many types of construction.

Pursuit of Simplicity

For 23 years I have been designing and building dome structures, researching and experimenting with many composite materials and methods of fabrication. Seven of those years focused on collaborative research projects with Queensland University of Technology, Brisbane where I was able to test cement based and fibre reinforced render systems, specifically for applications in dome construction.

Every material system and the method of fabrication have pros and cons.

It has always been my mission to find the simplest and most cost effective method of building strong, safe and comfortable dome structures for people to live in.

The Bamboo Dome Building Guide illustrates how we and others have successfully built beautiful thin concrete shell structures that are lived in and used every day.

It covers the process in a logical progression.

We have included images of various stages of a project in Lombok and two projects near Byron Bay. One a sculptural design and the other a traditional dome shape.

We welcome any questions, feedback and suggestions that you believe are relevant to improving the clarity description of the process in this manual. We wish you the very best and sincerely hope that you will enjoy the challenge of building your “Bamboo Mesh and Render Dome Shell”.

Introduction

Building Dome Shaped Shell Structures using Bamboo, Mesh and Render

We show you the latest evolution of how we and others have built concrete dome structures using bamboo mesh and render.

Who is this Guide For?

- People wanting a way to learn how to build a strong and durable shelter or home using the simplest materials and equipment
- Emergency shelter
- Back yard cabin or shelter
- For a storm shelter
- For an underground shelter
- For disaster reconstruction
- For new housing
- It is the simple, low cost means of building storm safe shelter.

This Guide is for anyone who wants to learn how to apply the simplest of materials and techniques to build extremely strong and durable structures with a very low material cost.

It is also for people in countries where access to more main stream materials like timber framing, steel and plywoods is not so available, either because of economic reasons or distance.

In developed countries it may not fit into the building regulations however, that depends on what may be understood traditionally or what may be understood by engineers, architects and builders in a particular country.

In countries where bamboo has been used for centuries as a building product, we hope this information will merely act as inspiration for even greater works.

The information contained here is intended to be of the highest practical value in terms of inspiring construction of structures in high need areas/regions/lands where the economy calls for resourceful use of local materials.

The Essence of this Guide

This system can be utilised by anyone, anywhere in the world.

The basic principals can be applied to small or large structures and there are unlimited adaptations of the system described by varying the specifications, method and materials used.

We have demonstrated a system that will allow you to build an extremely strong cabin, shed, shelter, home or multi- dome home. It can be any shape or configuration that you want. It can be built to withstand the strongest storms and even to take the loads of an underground shelter.

This form of construction is economical in terms of materials used but is high in labour content. Therefore it is favourable to work as a team of people together. It is also much more fun especially when everyone can see the progress at the end of each day.

In todays unsettled times it may be wise to have the understanding and know-how of building a strong safe shelter.

Special Thanks to: Britta Slippens owner of Mentigi Bay Dome Resort Lombok <https://mentigi-bay.com/>

References to Sources of Information Related to Bamboo and Concrete.

Bamboo as Reinforcement for Concrete

There is abundant reference material on the use of Bamboo as reinforcement for concrete. We refer to the following publications and web sites which are free and where you will be able to find detailed information about use of Bamboo as a reinforcement in concrete. These together are very informative.

Authoritative Publications About Bamboo Reinforce Concrete

- 1/. **BAMBOO REINFORCED CONCRETE CONSTRUCTION February 1966**
U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California By Francis E. Brink and Paul J. Rush
<https://www.romanconcrete.com/docs/bamboo1966/BambooReinforcedConcreteFeb1966.htm>

- 2/. **International Journal of Chemical, Environmental & Biological Sciences (IJCEBS) Vol 1, Issue 2 (2013) ISSN 2320 - 4087 (online)**
Can Bamboo Replace Steel as Reinforcement in Concrete, for the key Structural Elements in a Low Cost House, Designed for the Urban Poor?
Chandra. Sabnani, Madhuwanti. Latkar and Utpal. Sharma
<https://www.isaet.org/images/extraimages/D313084.pdf>

- 3/. **There are many articles about using bamboo in construction here:**
<https://www.asce.org/search#q=bamboo&sort=relevancy>

Terminology Skills & Tools

What is a shell structure? Definition from Britannica

“Shell structure, In building construction, a thin, curved plate structure shaped to transmit applied forces by compressive, tensile, and shear stresses that act in the plane of the surface. They are usually constructed of concrete reinforced with steel mesh”

Render also means plaster or mortar – it is the sand/cement formulation used for constructing the domes

Footing refers to the reinforced concrete foundation strip footing in the ground

Slab - means the reinforced concrete slab of the building

Raft slab - means the combination of the slab and the footing when they are poured together

Bamboo lath - means the split bamboo used for the fabrication of the dome shape and reinforcing of the concrete

Skills Required to Build a Bamboo/Render/Dome

Experienced builders should have no problem understanding this manual and applying its principals. Some of the skills required to build a “DomeShell” according to this manual are a combination of regular building skills, hand skills, organization skills, numerical calculation skills and also include:

1. Ability to read plans
2. Ability to apply instructions
3. Supervision skills
4. Common sense
5. A careful approach
6. Accuracy in measuring, cutting, and setting out of critical dimensions
7. Application and adherence to industry standard health and safety procedures at all times
8. Patience and perseverance

The method allows infinite artistry and creativity.

Tools Required

Essential Basic Tools

- Spades and shovels – for digging foundation footings and mixing and moving material
- Plasterers trowels – for applying and finishing the render mix
- Side cutters – for cutting both the mesh and lengths of fine tie wire
- End wire cutters – same as above
- Hand saw – for cutting the bamboo to length
- Hammer – always need a hammer when your building
- Spirit Level – there are some elements that you will want to be plumb and level
- Tools for splitting bamboo (could large sharp knife machete or purpose built bamboo splitter)
- Wheelbarrow – most basic container for mixing the render and transporting it
- Buckets – 10 lit plastic buckets will be very useful for measuring and moving materials
- Sponge and or rags and scrubbing brush – for cleaning up
- Safe raised working platforms – mobile scaffolding
- Step ladder

Very Helpful Tools

This manual utilises very basic equipment and tools. It is possible to substantially improve efficiency by the introduction of:

Concrete mixer – a small concrete mixer takes a lot of the hard work out of mixing concrete and render/plaster

Render (plaster) spray machine – a luxury but very useful for applying plaster onto the surface of the shell. We use and recommend the render spray machines sold on this website: <https://rendersprayer.com.au>

Rebar Tying Machine - this one tool alone can save hours of hand tying bars using the traditional wire tying by hand

Materials Required

- **Bamboo** – a variety that is mature (at least 3 years old) that is suitable for splitting into lath approx 30mm x 8mm

Split Bamboo - treated and seasoned split bamboo of a nominal dimension of 30mm wide x 8mm thick. In some countries this specification can be obtained relatively easily from dedicated bamboo suppliers.

If you are going to source, harvest, split and treat the bamboo yourself we have a specific section on just that

We go into bamboo in more detail further on.

- **Borax** – this is used for treating the bamboo against bugs – (available at most hardware stores or grocery stores) - **Boric Acid** - Used in combination with BORAX for treating bamboo against insect attack. NOTE: There are other methods of treating bamboo against insect attack. Different countries and regions have their favourites. Search Google to find a suitable method for your situation
- **Portland cement** – General purpose Portland cement is the most common type of cement used for concrete (available at hardware and building supply stores)
- **Sand** - Clean washed sand - best is fine washed river sand maximum grain size of 1mm. Otherwise, the best washed sand that is locally used for rendering. This is not usually the same kind of sand used by bricklayers although you could also use a more coarse sand like that up to 3mm grain size.
- **GAL Steel mesh** – chicken mesh (10-12mm diameter hole) OR 10mm bird mesh, a slightly more rigid 10mm square mesh. A bird mesh (sometimes called snake mesh) is more rigid than chicken wire netting and is easier to keep tied down flat.
-
- **Ties - wire** – a role of thin wire commonly used for tying steel reinforcing bars (rebar) – could also use plastic cable ties or similar. The tie wire is used for tying the bamboo and the mesh together.
- **Concrete aggregate** – 10mm to 20mm stone size – blended concrete mix is preferable for foundation footings. For foundations and footings use at least 30mpa ready mix concrete depending on soil conditions. If you are building a substantial dome structure that will be a habitable building then every element needs to be substantial including the footings, strengths of concrete and adequacy of the shell above ground. Mix designs for various grades of concrete can be found here: <http://www.engineering-civil.com/concrete-mix-design-calculations.html/comment-page-4>
- **Clean water** - water should be clean and uncontaminated by any foreign material or chemicals

Design - And Planing Your Bamboo Dome

When it comes to a successful building project, Good planning is essential
Lets just go over some of the things that must be worked out before you start.

What Size and What Shape Structure Will You Build?

Have a Plan

A professional builder requires a plan of the structure. A set of drawings that explain essential dimensions and specifications of materials etc.

We reccommend to make your first project a small one to get the experince and knowhow that will be valuable on a larger dome. The plans in this guide for the 3.5m version are the latest design refined from previous versions. It is a good size for a first dome and is big enough (10m²) for a bedroom with a double bed.

The plans are the documents that everyone involved in your project can refer to for information about the dimensions, specifications and notes of the structure.

This gives everyone an idea of what they are working toward and could include:

1. Plan view
2. elevation views form north, south, east and west
3. sketch section details of the wall thicknesses that you want to achieve
4. section details of openings for doorways, windows, skylights
5. placement of services – water, drainage, electrical

Foundations/Footings

Foundations of a building are VERY important and should be given serious attention.

The foundations are what will hold and allow everything above it to enjoy a long and trouble free life and must be adequate to sustain the loads that will be applied by ground forces and also by forces acting on the structure above ground.

If you are not sure what size foundations to make then take some advice from a local builder who has experience in your area. Show him (or her) your plans and take some advice.

The three axample projects we follow here are all very different and together will demonstrate different approaches.

We Highly Reccommend to Make Your First Project a 3.5m diameter Dome

Index of Logical Path

The Process of Building a Bamboo Mesh and Render Concrete Dome Shell Structure

1. **Design** - the importance of having a clear design
2. **Material - List of materials, options and quantities**
 - It is essential to know before hand how much of each material we will need.
 - Excel spread sheet with exact quantities of the materials you need for any size spherical geometry dome.
3. **Bamboo** Selection, harvesting, splitting, treating and curing. <https://www.guaduabamboo.com/bamboo-preservation>
4. **Site Selection and Preparation**
 - **Levelling and preparing the site** - space for materials, space for mixing render
 - **Services and drainage**
5. **Setting out the building foot print orientation, location of windows and doors**
6. **Footings and Slab**
 - **Digging the footings** and fixing the perimeter formwork for the footings and slab -
 - **Reinforcing in the footings** - where and how to place reinforcing - at this stage you will have decided whether you will pour the footings and slab together or just place the concrete footings and pour the slab inside the structure when it is complete
 - **Starter bars** - in the footing or perimeter of the slab that will connect with the reinforcing members of the dome structure
7. **Setting up the geometry of the dome**
8. **The vertical members of the bamboo**
9. **The horizontal members of the bamboo**
10. **Framing openings - doors, windows and skylight**
11. **Galvanised mesh - what type, how, when and where**
12. **Pre-casting elements - window frames, door frames, skylight hob ring**
13. **The Render Mix**
 - **Mix formulation, additives,**
 - **Using Fibre in the mix**
14. **Apply the render - getting on the first layer, subsequent layers, essential practices, maintaining integrity of adhesion between layers of render, curing times**
 - **Finishing Coates - Internal and external**
 - **Thermal lightweight concrete layer for insulation**
 - **Waterproofing**
15. **Installing windows door and and skylight**

Structural Loads, Openings, Doors and Windows

Ground/Seismic Loads

Soil types – different soils behave differently depending on their composition. For example highly reactive soils which might include a high level of clay material may significantly expand and contract under different conditions (moisture).

This kind of expansion and contraction can easily crack concrete footings, beams and slabs. If you are building in these kind of soils, then compensate by increasing the dimensions of your footing or take some advice from a local expert.

Earthquake

If you live in an earthquake zone, it is recommended to increase the footing dimensions - generally follow the building standards of the particular area or zone.

If you are building over an area that has been filled with soil, make sure that the footing has at least a pier/column bored down to natural ground transferring the load of the footing beam down to natural ground.

Refer to sample footing design see Fig.1 (Page 14)

Is approximately equal to a residential footing design for medium soil conditions in Australia.

Wind Loads

The action of high winds can topple a building and can even rip it out of the ground. For this reason the foundation structure needs to act like an anchor and the connection of the structure to the foundation must be sufficiently robust to prevent these kind of damages.

It is vitally important to have a strong connection between the slab and the shell.

Openings – Doors, Windows, Skylights and Others

Doors and windows in your bamboo dome must be planned and appropriately allowed for. Doors and windows fit best when a properly formed opening is available for them to be installed.

Forming Opening for Windows and Doors

Openings need to conform to the frames of the doors and windows we are planning to install. You need to know exactly what you intend to install before you start and that means knowing the exact dimensions and any other critical allowances you need to make in forming the openings.

One way to achieve accurate opening dimensions is to use a temporary FORM.

The FORM is a temporary element placed at the opening and which will be cast around to form the shape required. The form or former is fabricated to mold the exact shape of the finish we want.

Temporary forms are essentially mold patterns to conform the shapes and details that we want to achieve.

A temporary former is removed leaving a plumb and square opening exactly the shape and configuration that you need to fit the window/door jamb and window or door.

Doors and window jambs can be fitted into openings after they have been formed or they can also be cast into place during construction. Which method you choose depends on your personal choice and perhaps the material of the doors and windows.

Make sure that opening dimensions are sufficient to receive the manufactured frames.

The Bamboo You Use

There are over 1500 different varieties of bamboo. Depending on where you live will determine what is practically available. We suggest that you look locally for a suitable bamboo. If you live near bamboo suppliers seek their advice on what is locally available.

For the Australian project we used a running bamboo called Aurea.

What Kind of Bamboo Do You Need

We are NOT experts in Bamboo however, there are many kinds of bamboo that can be used.

The type you need will be approximately will have anominal wall thickness of 6mm to 8mm a wall thickness that splits easily and uniformly in to widths of between 25mm to 35mm.

The Bamboo We Use Serves Two Purposes

1/. **As a concrete reinforcement** - which in effect will replace reinforcing steel bars (rebar).

The split bamboo needs to be from a mature Culm (pole) (usually 3 years old) that splits easily.

2/. **Used as a framing member to fabricate and create the shape of your structure - like a bird cage.**

The split lengths of bamboo are curved to conform to the shape and tied together in a way that creates and forms the shape of the element or structure we are intending to build.

Ferro Cement Construction

Generally consists of a steel bar frame (possibly 12mm rebar that is wrapped in Galvanized mesh and rendered with a high strength render - Ferro Cement boats for example.

Ferro cement has been well established over decades for building even underground structures since the second world war. Ferro cement has been used for boat construction, water tanks, sewerage tanks and just about everything else.

The system in this Guide is essentially a Ferro Cement shell structure.

It relies principally on a mesh reinforced concrete shell.

In General - A bamboo frame forming the shape of the dome has at least two layers of steel mesh (ideally 3 layers). Joins in the mesh must be lapped 150mm minimum.

At transitions in shape add an extra layer of mesh.

How many layers of mesh you use for any particular application depends on the strength you want to achieve, the size of the structure and your budget. A smaller structure with minimal loading can be adequate with the minimum layers of mesh and thickness of render.

Harvesting & Treating Bamboo

see pages 46, 47

What is the best time to harvest bamboo?

Generally it is best to harvest bamboo in the dry season because at this time the culms (poles) will retain the least amount of starch/sugars and will be least attractive to bugs. Bamboo needs to generally be over 3 years old.

Check with suppliers in your area.

Aurea bamboo (running variety) is just the right diameter for the shell. It also contains less starch than clumping bamboo, making it more suitable for building.

Treating Bamboo

Making Bamboo Bug Proof.

Depending on where you are located there may be specific bugs and possibly traditional ways of treating bamboo for bug protection. One treatment involves soaking the bamboo in a solution of BORAX and Boric Acid.

- The bamboo should receive treatment immediately after harvesting - start on the same day.
- Leave some foliage near the top of the pole.
- Stand the poles in buckets or containers of a solution of Borax and Boric Acid (20 litre commercial plastic buckets work fine)
- Use hot water to dissolve the Borax crystals
- Mix proportions - 1 x cup Borax and 3/4 cup boric acid per 20 litre bucket
- Leave for 2 weeks
- Top up the buckets as the poles will draw up the solution

It could be argued that bamboo encased in concrete does not need any treatment for bugs, however we recommend the above procedure. All the bamboo used in both projects has been treated with Borax and Boric Acid.

Bamboo can be a juicy target for bugs and it will rapidly deteriorate under damp conditions so we need to take precautions against both bugs and moisture.

The Way it Was Done In Lombok

The split bamboo was completely immersed in a trough of BORAX/Boric Acid Solution for approx. 2 weeks.

The Way It was Done in Byron Bay

Immediately after harvesting the bamboo culms/poles were stood up vertically in tubs of BORAX/Boric Acid Solution for 2 weeks allowing the bamboo to draw up the borax solution.

BORAX and Boric Acid

Borax is a common household and commercial chemical. Borax is also known as sodium borate, sodium tetra borate or disodium tetra borate.

Borax has many uses on its own, plus it is an ingredient in many other products. Here are some uses of borax powder and pure borax in water:

- insect killer - roach killing products and moth-preventative (10% solution on wool)
- fungicide
- herbicide
- desiccant
- laundry booster
- household cleaner

Splitting Bamboo & Quantity Required

see pages 46, 47

Split the bamboo immediately after standing in treatment solution. Green bamboo is by far easier to split than dried bamboo which goes hard and brittle. The bamboo also needs to be green to maintain flexibility for the purpose of our construction.

If you have poles around 50mm to 70mm wide then a 4 or 5 way splitter is perfect.
Start splitting from the top of the pole (the narrow end)

Go here to see typical bamboo splitting and other tools.

<https://www.google.com.au/search?q=bamboo+splitter&espv=2&tbm=isch&tbo=u&source=univ&sa=X&ei=pWMqVJb5GI2k8AWVpYD4Ag&ved=0CBwQsAQ&biw=1216&bih=927&dpr=0.9>

Depending on what part of the world you live some of these tools may be available near you.

Quantity of Bamboo Needed

Work out the approximate quantity of bamboo you need for your project.

Bamboo with a diameter of 50mm to 70mm will split 4 ways and larger will split six ways. Splitting bamboo can be done using a sturdy blade or by the use of a purpose built bamboo splitter. A purpose built splitter works the best. Start the splitting from the top of the pole at the thin end.

(we hope to have splitters available for purchase on our website in the near future)

Working Out Material Quantities

Included here are some basic formulas which will assist you in calculating the quantities of materials you will need for your project.

Remember Pi – this is the symbol π

Pi (π) is the number 22 divide by 7
 $22/7 = 3.143$

Area of a Circle (floor area) = πr^2

Circumference = πD

Surface Area of Sphere = $4\pi r^2$

Surface area of a hemisphere = half a sphere

Example for a 3.0m diameter dome that has an almost vertical section of 1.0m under the dome hemisphere.

Therefore:

Floor area of a 3.0m diameter circle = $\pi r^2 = 22/7 * 1.5 * 1.5 = 7.07m^2$

Circumference of a 3.0m diameter circle = $\pi D = 22/7 * 3 = 9.43$ lineal meters

Dome External Surface Area of a 3.0m diameter hemisphere with 1.0m high vertical wall under the dome
= $(22/7 * 4 * 1.5 * 1.5) / 2 + (9.43 * 1) = 23.57m^2$

Typical Nominal Concrete Foundation and Footing Design Fig 1

Raft slab or strip footing beam - (Australian Conditions)

It's a choice whether to pour the slab and footings together or make the footing first and pour the slab after the shell is complete.

The principals of slab and foundation/footing design are the same for any building system.

Ideally, you need a continuous strip footing reinforced with steel or bamboo and with vertical steel or bamboo uprights at approximately 200mm centres (8 inches).

The depth and width of the continuous strip footing may vary slightly depending on soil conditions. Nominally we will say 300mm wide by 400mm deep.

The continuous footing maintains the structure in stable condition. It anchors the structure above to the ground. It holds everything together when there are slight movements in the ground and stops it blowing away in severe wind conditions.

Bamboo replaces what would be steel bars.

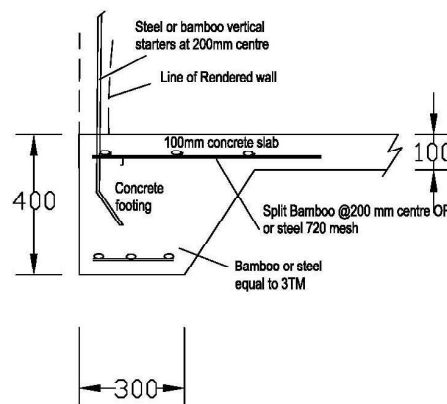
There is more than one approach to building foundations and footings for a building. In some countries there are traditional approaches and depending on the ground composition and local materials you may take a different approach.

Foundations are intended to uniformly carry and hold the loads of the structure above

Fig 1.

SECTION: Typical footing beam foundation options

Raft Slab Design Ring beam and slab cast as one



o 11

Domeshells Australia Pty Ltd P.O.Box 820, Billinudgel, NSW 2483 Tel.02-8680-6600 Email: contact@domeshells.com.au			References Approve Checked Drawn Scale:	Typical footing beam, wall connection and wall detail Typical Slab and Footing Detail	Sheet - of A3 -Scale 1:20 DRG. No. REV.
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Ferro Cement Shell Structures & Mix Design

In engineering terms the method of construction discussed here produces a “**Monolithic Shell Structure**”. That means it is a structure in one piece. It has no joins. Even though it may be fabricated in sections or layers the finished structure is one shell.

Ferro Cement Shell Structure

The closest structural system is ‘**ferro cement**’ construction.

Ferro cement was first developed by an Italian architect, Mr PL Nervi who defined it as a highly reinforced cement mortar, in which the proportion and distribution of reinforcement was increased to a maximum by spreading out steel meshes through the thickness of the element. Ferro cement construction is used extensively in marine for constructing boats.

Ferro cement was reported by A Kamsundarra Rao and C S Kallapa Gowder, in their paper “A Study of the Behavior of Ferrocement in Flexure” to have the following advantages over normal steel reinforced concrete.

- cracks are very small at ultimate load
- only a minimum of formwork is required for the construction so it can be adapted to any shape
- it has a higher ultimate strength than normal reinforced concrete
- the spacial structure can be built very thin and economy can be achieved due to the reduction in dead weight
- it has greater durability and its maintenance costs are also minimum

Warning! There are aspects of the construction of both the case studies of this Guide that do not necessarily conform to the following

Guidlines for Building a Bamboo/Ferro Cement Monolithic Shell Structure

Suitable for an above ground dome structure up to 12.0m diameter total thickness 25mm

Render Mix:

Cement	Ordinary (general purpose) Portland Cement
Sand	Fine washed riversand 1mm grain size (dry)
Water	potable (tap water)
Proportions:	Sand/Cement 2:1
	Water cement 0.4:1

Reinforcement:

Main Frame: Split bamboo - 25mm to 35mm wide x 5mm - 8mm thick
200mm centres vertical, 200mm centres horizontal

Mesh: 10mm chicken netting and 10mm x 10mm x 0.7mm (guage) galvanised wire avairy mesh (or equivalent)

Around openings and transitions increase the percentage of mesh reinforcement.

Water Proofing and Insulation

It is preferable to place any insulating material on the outside of the shell because it mitigates continual expansion and contraction of the shell and hairline cracking.

The external part of the shell must be waterproofed by a paint or other system. If painting directly to the shell without insulation it is preferable to use a light colour - white is best to mitigate heat absorption.

Summary of Project Case Studies

Project One: Lombok Luxury and Exotic Accommodation

Several domes have been built simultaneously at Lombok. These domes are now part of a very unique Luxury Resort at Mentigi Bay.

For the purposes of this Guide we will primarily follow construction of one dome structure but will also refer to and display images of adjoining elements including bamboo reinforced suspended slabs.

Enjoy Mentigi Bay

Video: <http://youtu.be/8sk0PUqEw5M?list=PLDSgMEJrMhpbkCh4ruYMI2CXjnL0Tlzws>

Website: <http://mentigi-bay.com>

For Bookings - Telephone: +62 353292447 - Email: mentigibay@hotmail.com



Project Two: Byron Bay Fire and Survival Shelter or “Goblins Cave”

This is a much smaller, sculptured, single dome structure on a rural property in the hinterland of Byron Bay.

It is on private land owned by a local artist and sculptor. Its architectural shape is an art work as it is to a great extent, a Free-Form Structure. This dome has been designed to perform as a partially earth covered fire and storm shelter, a spa and a sleep out.

Most of the labour on this project was by the owner (Tracy) and many helpers at different times over a period of months.

Almost all these people have NOT had any previous construction experience.

Project Three: Byron Bay Healing Practitioner Dome

This project is the one we recommend that you follow for building your first dome.

It has the most detailed design and plans that you can easily work from.

Each project shows a very different approach and is substantially illustrated with colour photos.



NOTES:

The Mentigi Bay Lombok Domes Project

by Wolfgang Widmoser

The Golden Eggs

Mentigi Bay, Lombok, Indonesia Project 7.0m diameter Catenary Arch (egg shaped) Dome

When Britta asked me to design a villa-project in Lombok I became very excited.

The idea was to build red-brick-domes and we immediately began to plan and draw whilst travelling on one of Britta's boats, a wooden schooner from Sulawesi heading from Bali to Lombok.

As I had learned from Gernot Minke the optimal shape of a brick dome is not a sphere but a more elliptical shape, kind of an egg cut above the middle the choice was made to use that shape as a basis. All the forces are lead along the shell directly to be held by the foundation.

However, Indonesia has many earthquakes which makes a brick only dome potentially dangerous. A cage-constructions or shell structure would be much more appropriate.

I've build a huge ceramic factory 1997 in Sayan that was a bamboo-reinforced cement-shell with a tensile roof. The structure has performed well until now so I would construct similar shells in Mentigi-bay.

While the ground was prepared I worked on 3D models of the structures and also build some real models that could explain to the local workers what we would erect.

Bamboo was split into long laths that would be woven together on site. We prepared the foundation-trusses to be inlaid in two cement brick walls of 30cm height with a gap of 12 cm.

Every 50 cm a bamboo - vertical would stick out to be used later to weave the structure. Cement was poured in the gap and the foundation was done.

We prepared a set of rings at specific heights and the for great parabolic doors and wove the bamboo-structure. Additionally fine chicken wire was applied on the inside and a coarser one on the outside to trowel the concrete on the structure.

Some buildings were 2 shells organically united and had second floors or balconies to make more floor-space. Ceilings were reinforced with 2 layers of bamboo-mesh nets. Grid spacing of the bamboo mesh at 20cm and each layer at 6 cm apart with addition of 2 layers of chicken wire resulting in a 12cm thick slab.

On the top of the eggs was build a skylight of 80cm diameter for ventilation and light.

Tensile strength of bamboo is 6 times stronger than steel and it does not rust.

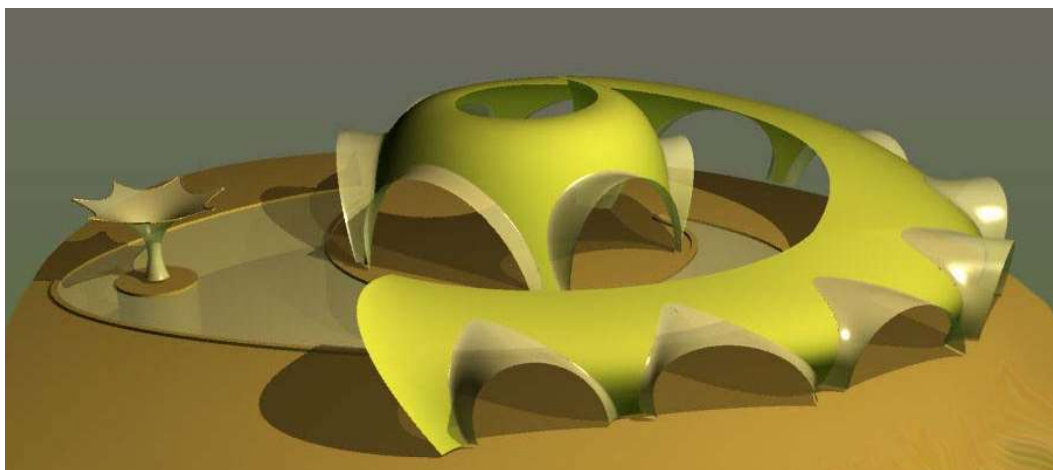
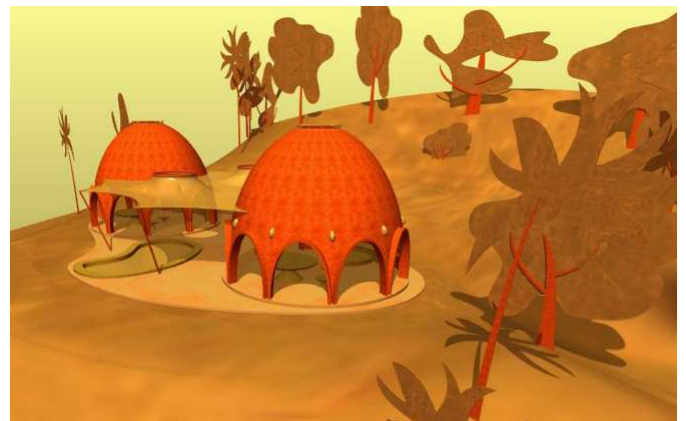
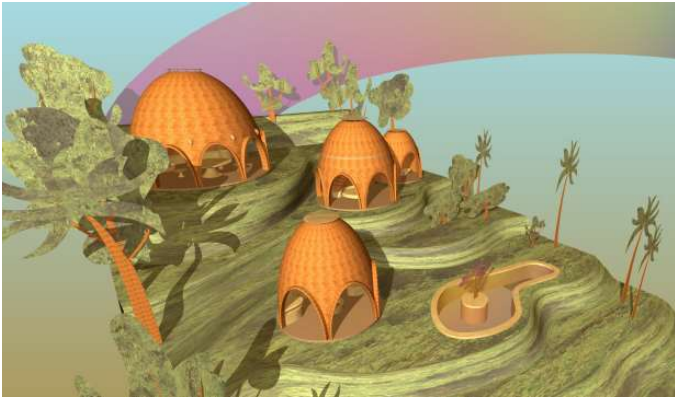
It could be of great advantage especially in humid climates to build in this way.

The local boys I trained in Lombok for 5 months are now capable of erecting similar structures on their own without my help and that makes me feel very good.

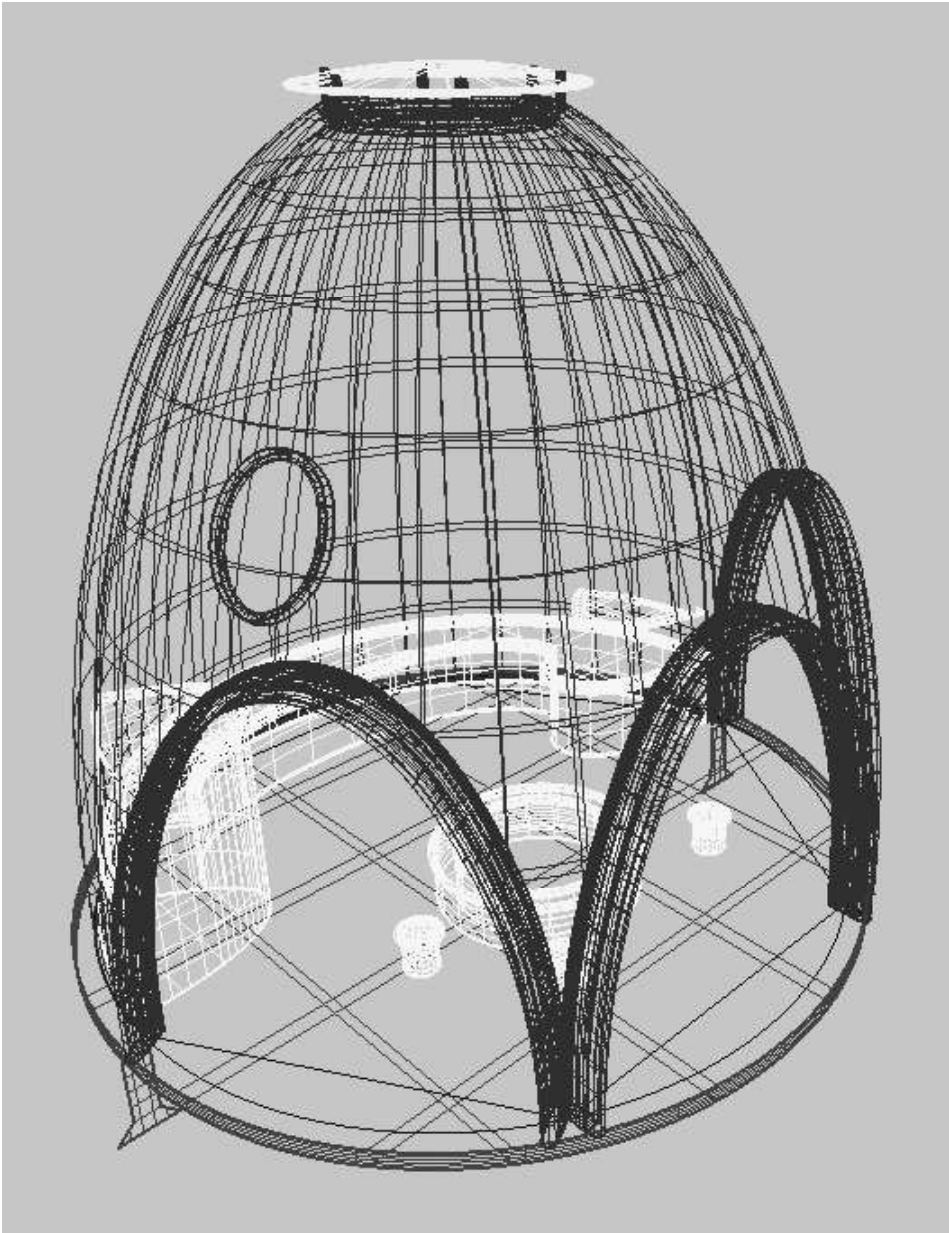
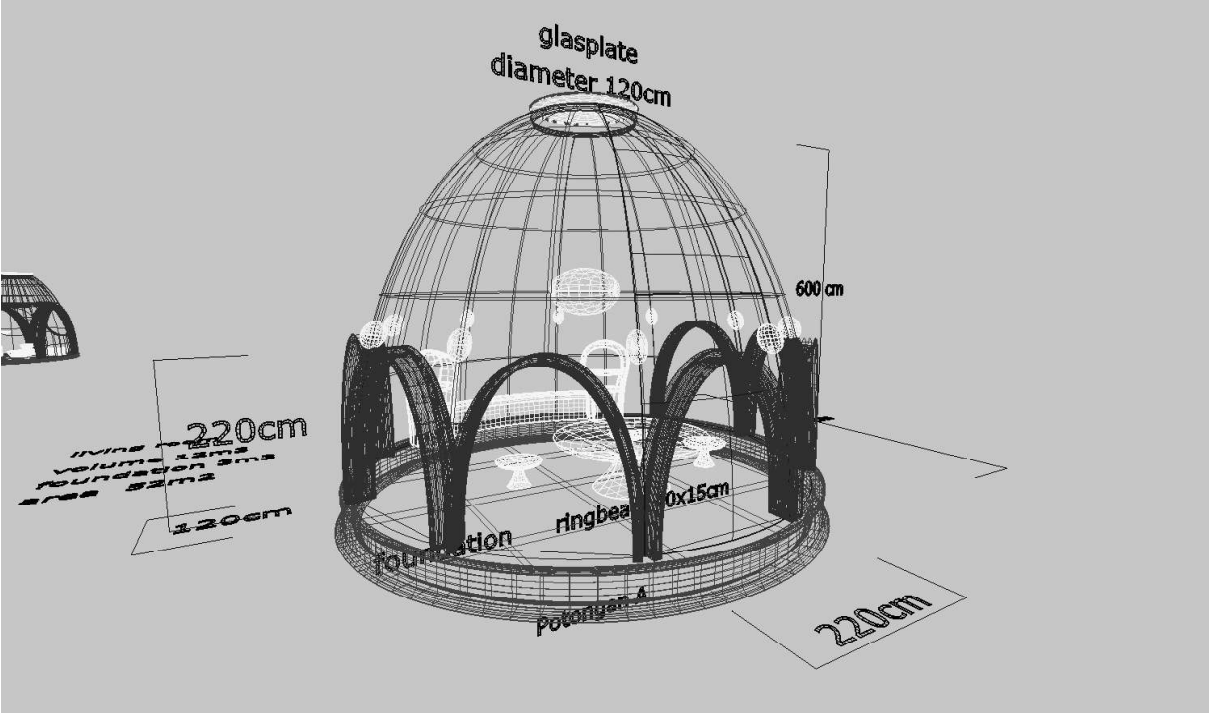
Wolfgang Widmoser 2014

<http://www.ubud.com/wolfgangwidmoser/>

Mentigi Bay Project - Early Design Ideas and Sketches



Mentigi Bay Project - CAD Concept Design



Lombok 7.0m Diameter Dome Foundation

In this case the trenches are lined in brick to form a 200mm wide trench. The trench is reinforced with a bamboo truss arrangement to reinforce the footing beam.



Forming the Strip Footing

Locally excavated small rocks are used to form the sides of the concrete footing beam. Bamboo starters protrude from the strip footing ready to tie to the vertical members of the bamboo. Note the center point from which to check dimensions



Establishing Basic Profiles with Bamboo Lath

For this design, the arches that will be the door openings are fabricated first. They have also at this stage been covered with at least one layer of mesh. The arch elements are temporarily supported in place



Setting the Geometry

Initially it may take some time at the start to work out and set up some of the essential geometry and guides of the shape of the structure



Taking Shape

Vertical uprights are tied to the starters coming out of the slab and horizontal hoop members are attached with a number of props in place to hold the form in position



The Process

As the bamboo dome shape takes form, part of the first 1- 1.5 meters of the base has been meshed and had at least one layer of render applied. This has the effect of stiffening up the structure and holding the bamboo frame in place above.

Note the temporary outrigger poles which are also holding the bamboo frame in place and ensuring that the shape remains uniform.



Setting Up the Arches for the Openings



Framing the Skylight Opening Ring

A ring is prefabricated for the apex skylight opening



In this case a prefabricated bamboo ring connects the vertical bamboo members. The up stand makes way for a raised hob ring at the apex to prevent water from being blown over the edge and into the building



Electrical Conduit

Electrical conduit is attached over the first initial skin of render and travels around the bamboo frame. It will be encased in the plaster wall system.



Progressing the Render

Note the use of wet **hessian sacking** to retain moisture in the render for optimal curing



Internal Rendering

The inside layers of render is following up the wall. Note the lap of the vertical bamboo laths. Typically lap joins by 400mm



External

The outside of the dome has one full cover of render over the bamboo frame.

It requires 3 layers of render each side of the bamboo. That is 3 layers of about 10mm to achieve an overall thickness of not less than 70mm.



External Cladding System - The Local Red Terracotta Paving Brick

The domes in Lombok are all externally clad with a local terracotta paving brick laid on edge. This is the architectural look/finish decided at the beginning. It is the external weathering and decorative cover over the bamboo, mesh and render shell structure.



Building a Staircase

Some of the domes in Lombok have stairs up to a mezzanine level with doors that open to a higher ground level above. The images below illustrate how the stairs were constructed using the exact same bamboo lath and wire mesh and render system



Bamboo Reinforced Suspended Slabs

Suspended slab for the second floor. All bamboo reinforcing instead of rebar. Note, two layers of bamboo lath on a 200mm grid - one layer 60mm above the other - one layer of 20mm steel mesh top and bottom.



Internal Rendering is Complete and the Floor Slab is Laid

Getting ready for the windows and doors to be installed



An outside sink formed with bamboo mesh and render



Ready for Windows

Some internal decorations are taking place - waiting for the window frames. Note the inside of the window hoods is not complete. This is because the frames will be pinned and propped in place while a final coating of render is applied up to the frames to encase and hold the frames in place



Door/Window Frames are Installed

The main doors are made by local carpenters as complete units. They are fixed into the openings and the arches are rendered up to the frames locking the frames in position. Note final thickness of the rendered arches is approx 70mm - 80mm thick plus the brick.



Fixing the skylight.

Skylight consisted of a steel frame supporting a flat sheet of glass which extends at least 250mm over the opening all the way around and designed to allow the free flow of air. Skylight openings at the apex of a dome contribute to excellent ventilation and airflow which is absolutely necessary for the good health and comfort of the internal space.



The First Dome is Complete!



Inside a 7.0m Dome at Mentigi Bay

Inside one of the 7.0m diameter domes now an exclusive mini resort in beautiful Mentigi Bay, Lombok.



**Examples of Bamboo Sculptures
from
Lombok International
Bamboo Architecture Festival
2013**



Bamboo Sulptures in Lombok International Bamboo Architecture Festival 2013



Mentigi Bay Domes

Comment by Chris Brown

I have been involved with many sophisticated building systems using a variety of high-tech materials however, I am very excited about the Bamboo/Mesh/Render building system because it is so simple.

This system is essentially a “Ferro cement” building system where the larger steel elements (the reo bar) is replaced with bamboo.

Mentigi Bay domes are substantially built by local trades people who are proficient in using bamboo for building all kinds of structures however, the Byron Bay dome proved that anyone can do it because it has been mostly built by people with no previous experience.

Building with Bamboo, mesh and render is simple and effective and I want to make this information available for the benefit of as many people as possible around the world because it opens up the possibility for people to build strong, comfortable, permanent shelter and homes at a fraction of the cost of any conventional building system.

This building system allows you to build substantial structures as well as being infinitely creative in the shape of your design.

NOTES:

Byron Bay, Australia

Project No. Two Case Study

41

A Creative Sculptural Experience

We built the first Bamboo structure in Australia near Byron Bay, New South Wales, Australia on a bush block property.

It was going to be a sculptured partly earth covered sleep out and a fire bunker.

Tracey is a painter and sculptor and she understood the concept of how creative the method could be.

We agreed to build an earth covered, bamboo and mesh reinforced dome capable of human shelter in event of bush fire to whatever shape Tracy decided.

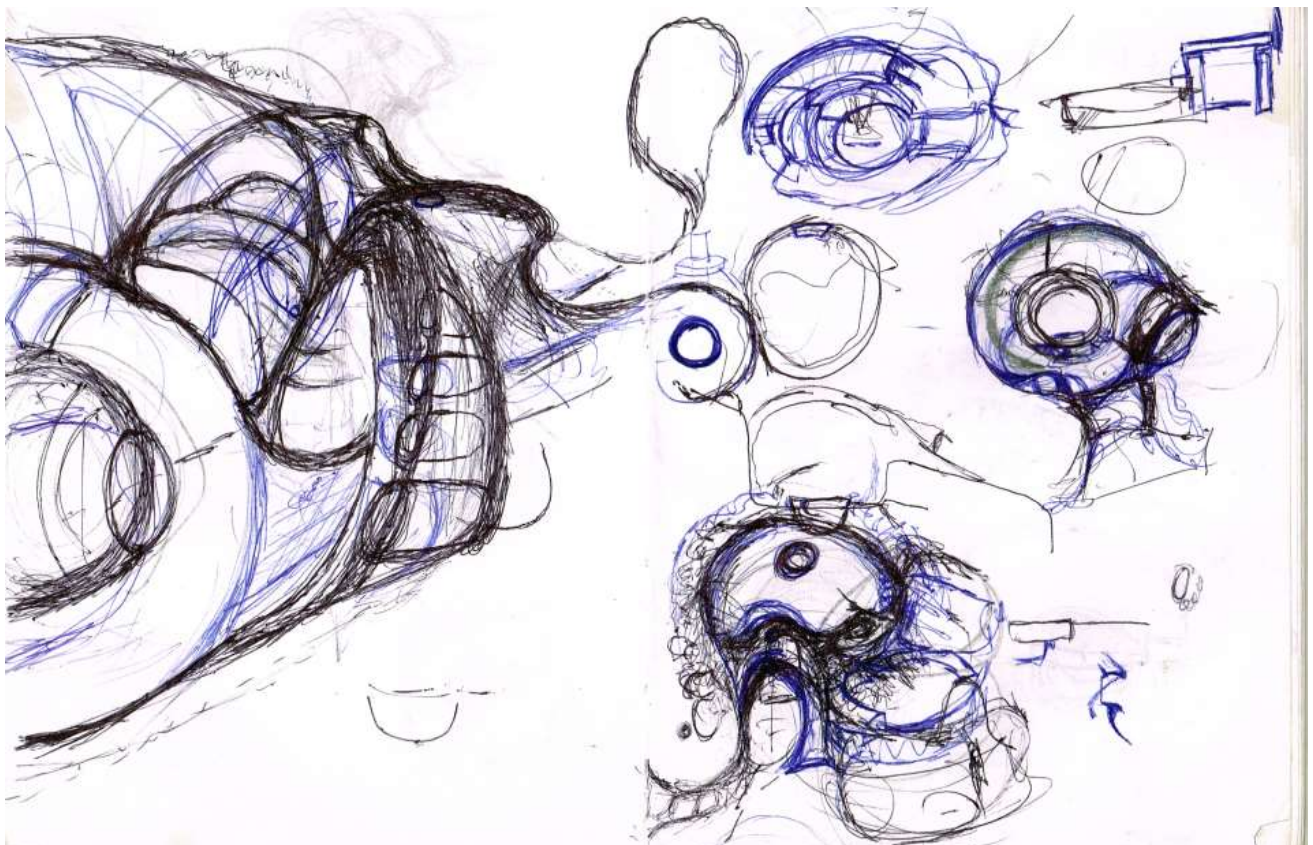
It has to be strong, well drained, non-combustible and provide shelter in a bush fire. It also has to be totally seal-able from the outside.

The final result is a 2/3rd earth covered, sculptured, shell structure. The exposed part of the dome is covered in a 40mm layer of crushed perlite render, an excellent high temperature insulation material.

Acknowledgments to people who worked on this project most of whom have had no previous building experience

Tracey, Chris, Nick, Nelly, Alex, Georgio, Roberto, Freja, Ben, Enrico, Jacob, Axel, Trysten, Ziani, Davide, Stijn, Parks, Laura, Thomas, Merlin, Jerremy, Matthieu, Louis, Tim, Goran, Cornelia

Below - is the sketch provided by my client - How would you know where to stat?



42 The Excavation - An Organic Process

This project has been completely organic. It has developed in design according to the space we had to work in and the sculptural vision of Tracey.

We made a sketch, discussed the overall plan and next minute the machine was there digging a hole.

The deeper hole in the middle of the excavation is there to place a large 2.2 meter diameter round GRC bowl which would be used for a conversation pit with seating around the edge or even as a plunge pool if desired. Note the trench from the base of the hole extending out down the hill. This trench will drain any ground water and also accomodate the waste drain at the base of the bowl.



Keep the Water Away

A swale drain was made above the main excavation to direct water away. Tarpaulins cover the edges of the banks to safeguard against erosion in case of rain.



Installing the Bowl

Care was taken to ensure very adequate drainage to remove any ground water that may get through.

A deep drain under the bowl was dug out to the side of the hill. Agricultural drain pipe and gravel filled the voids to ensure any water or moisture has a path out.

The crane lowered the bowl into position where we connected the pipes and back filled the voids around the bowl with gravel.



44 The Bowl Installed

The bowl is connected to a drain and levelled in position. All the remaining cavity around the bowl is filled with a gravel drainage material. The rest of the floor area is also covered with 30mm of gravel to allow water to drain and also to keep our feet off the muddy soil which becomes very guggy when it gets wet.

Note the red dotted line around the edges where we started to mark out the outer line of the concrete foundation footing.

The graded area covered in gravel will be the main dome hall and we will dig a footing within the excavated area



Adequate space is allowed between the excavation and where the wall of the dome will be so we have enough room to safely work and at least 300 mm gap at the base between the footing and the bank for drainage material to be filled between the bank and the concrete footing.

The Concrete Strip Footing

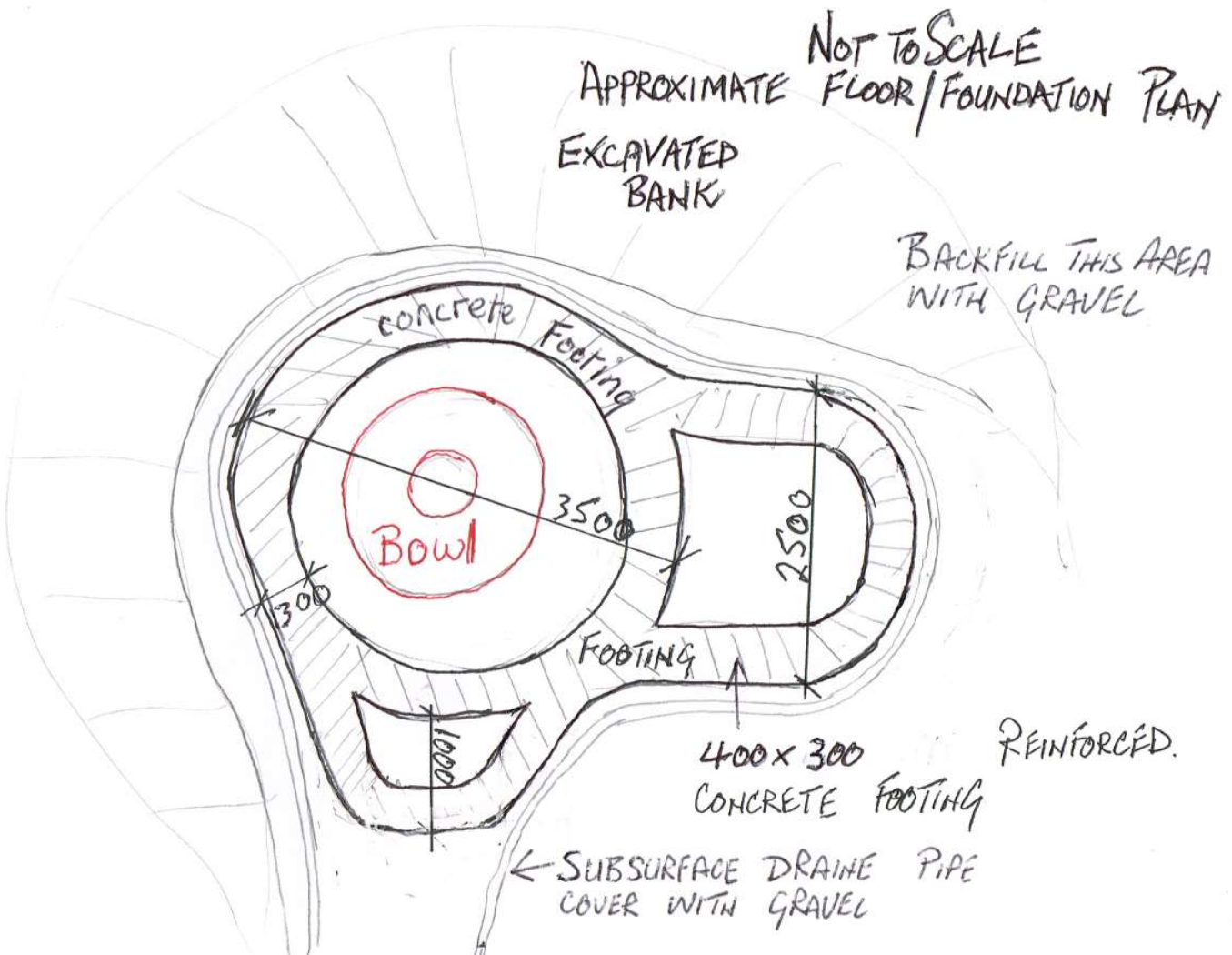
We used traditional methods of forming a concrete strip footing using plywood and stakes to hold the form.

The dimensions of the footing are nominally 400mm high x 300mm wide.

Left over reinforcing steel of varying sizes from previous jobs was used for the reinforcement for the footings and for embedding uprights around the perimeter of the footing to fix and tie our bamboo frame above. *See diagram of minimum footing design.*

The steel in this case could be substituted with bamboo

The Plan



Setting up Formwork for the Footing

Looking toward the planned location of the entrance.

The footings are formed in plywood. Reinforcing steel is placed in the trenches and concrete is poured to a consistent level with steel starter bars embedded in the footings

In addition we lined the concrete footing with polythene plastic to provide a moisture barrier to the concrete. This was just additional insurance against damp coming through because the structure was going to be substantially earth covered.



Ready to Pour the Concrete

“Concrete Mix” blend delivered to site is mixed by hand in a mixer, slide down the corrugated slide, into the wheelbarrow and into the trench.

The concrete mix we used consisted 1 cement: 2 sand, 4 aggregate



Nick inspects the poured concrete. Note the assortment of steel bars and straps sticking out around the perimeter of the footing. We use these to tie the bamboo and the mesh further in the process.



48 The Bamboo - Harvesting & Treating

Bamboo used for this project is called "Aurea". It is a running bamboo (not a clumping bamboo). This bamboo was about 50mm at the base - was just the right size for splitting into 4 - 6 strips

Calculate Quantity of Bamboo Strip

It was difficult to calculate the quantity of bamboo strip because everything was so organic we weren't sure exactly what the final shape or surface area would be.

Allowing 200mm (8in) vertical and horizontal spacing for the bamboo frame for 50m² (approx 50sq yds) of surface area.

At 200mm spacing - there are 12 lineal meters to the m² therefore: 50m² x 12 = 600lm. (lineal meters)
To make sure we had plenty of bamboo for the unexpected I calculated we would allow for 800 lm of split bamboo.

I knew the poles were at least 6.0m tall and we would allow an average of five split strips per pole gives us 30m of strips per pole - we will need - 800/ 30 = 27 poles.

We will harvest 27 bamboo poles



Treating the Bamboo

Cut off all the branches of the bamboo up to about 1.0m from the top. Leave the top leaves and branches on.

As soon as possible (within hours) stand the cut ends of the poles into buckets that contain a solution of Borax and Boric acid in the following proportions:

per 20 litres
1 cup Borax
3/4 cup Boric Acid

Check the levels in the buckets regularly and top up when necessary.

The branches at the top of the poles will help draw up the solution.

Bamboo is treated this way for two weeks before we start splitting the Bamboo.

Nick and Nellie demonstrating their machete skills - Champion bamboo splitters

After the poles have soaked in their buckets for two weeks. Cut the branches off the top
We had very little experience with bamboo and Nick and Nellie and many others who helped on this project had virtually NO experience with bamboo.

We used machete to split the poles - Not the best way - Splitter is preferable!
We also learned that when splitting bamboo - start from the top of the pole.



Knock out the Nuckles

After the bamboo is split remove the internal knuckles by knocking them out with a hammer.



knuckles

Curing the Bamboo

The poles are split, the internal knuckles are removed.

Bundle the split bamboo into manageable bundles and store the bamboo under cover in a dry place to allow it to dry out.

The bamboo below was cured for 4 weeks under cover in warm weather before we used it.

50 Establishing the Height of the Dome and the Arches

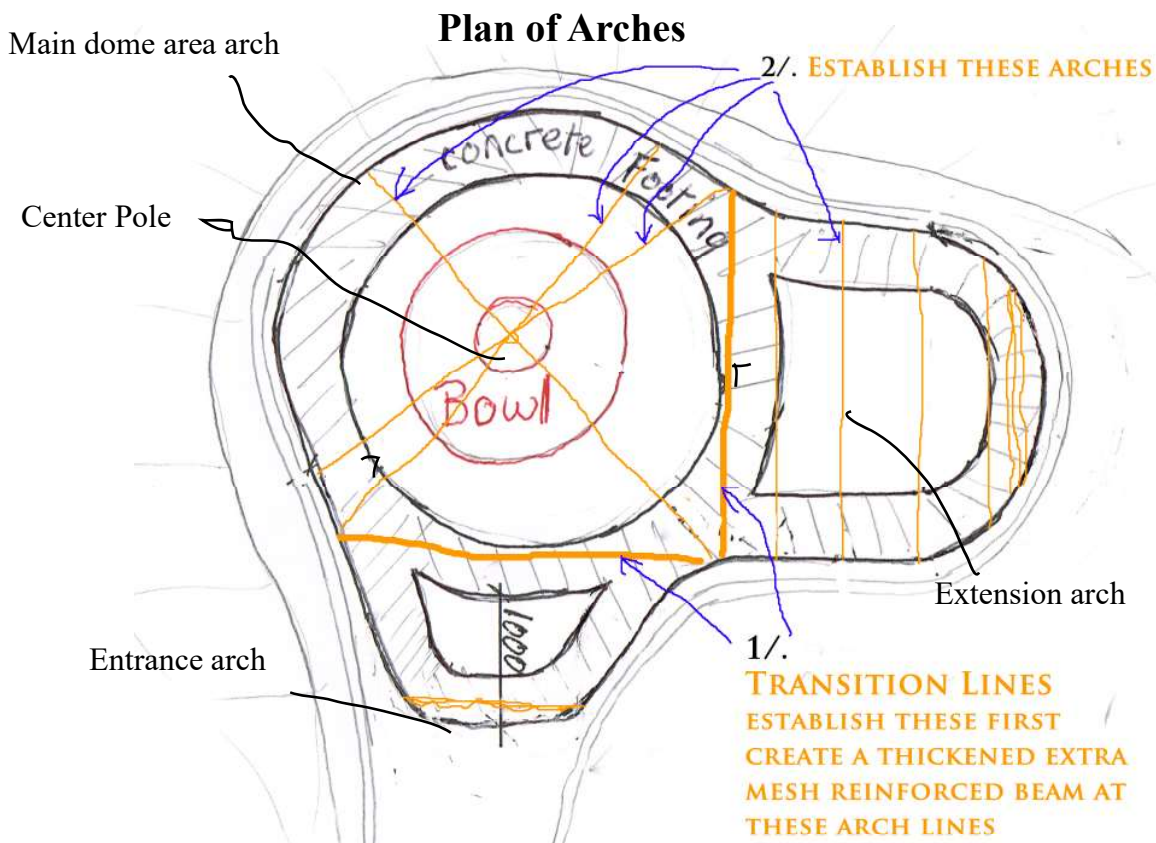
At this stage we are not exactly sure what the overall profile of the dome will look like. The shape of the dome will be an organic process once the foundation are laid (usually as a builder I like to have everything planned including the shape, form and dimensions).

We start by fixing short lengths (about 750mm) to the vertical steel protruding from the perimeter of the slab.

Center Pole

Fixing a pole in the centre of the main dome area give us a way to test and fix the height of the dome at the apex.

In our case - See the Sketch below indicating 'On Plan' the approximate lines of the initial arches that need to be established first



Using lengths of split bamboo Tracey experiments with the exact shape she wants.

Start by establishing the arch shape at critical points - see Plan of Arches

In our case we had:

- The main dome area shape
- The entrance arch shape
- The extension arch shape

These need to be established first at the critical points of where one shape transitions into the other.



Horizontal bands are attached to the uprights to tie them together and define the perimeter wall of the structure



Progressing the Shape - Arches

We set up bamboo arches to set the design for the main dome, the entrance area and the bubble extension off to one side of the main dome



It's a process



The Centre Pole is used to Set The Height and Overall Shape Follows

The center pole enables us to fix the height of the main dome area. All the arches tie together here



The Dome Shape Becomes a Cage

Create a CAGE of vertical and horizontal members tied together firmly to create a stiff and rigid cage in the shape of the structure

For a couple of days the crew continue:

- fix vertical starters to the ties in the footing
- set the shape of the arches
- finish vertical uprights
- fix horizontal lateral laths
- tied all together tightly



End-cutters cut the wire to the length. They can be used to grip the ends of the two wires and pull and twist the wires simultaneously tightening the connection and locking it by a few twists before cutting off the long ends.

Using Tie Wire and End Cutters

End Cutter tool is the best tool for this purpose.
The wire is about 1mm thick



The Bamboo Cage Forms the Shape of the Dome

Our intention is to create a rigid cage to fix the wire mesh to.

It may not look like it's been done by an expert basket weaver but it does the job which means now we have the beginnings of a cage framed up in split bamboo.

When layers of mesh are tied down flat all over the frame the structure becomes a completely interconnected mesh grid, making this frame structure even more rigid.



It's Ready for the Steel Mesh



A Ferro Cement Structure

The layers of continuous mesh encased in concrete (render) will be doing the structural work of the shell.

1/. Cover the entire form of the bamboo dome frame in at least three layers of 10mm Galvanised Chicken Mesh. The mesh must extend from the concrete footing or slab.

2/. Alternative Mesh - 1 layer of 25mm basalt fibre mesh (300gsm) and 1 layer of 5mm basalt fibre mesh (125gsm).

3/. The mesh will need to be cut at appropriate places to allow the sheet of mesh to conform. Any joins should lap at least 200mm

4/. Where the dome has openings or transitions into a different geometry add at least one extra layer of mesh.

5/. It works best to lay all three layers on the outside of the bamboo frame.

6/. Here we used a 10mm bird mesh rather than chicken wire because it is stiffer and more rigid than chicken wire and easier to fix flat on the frame. However, chicken wire is also suitable

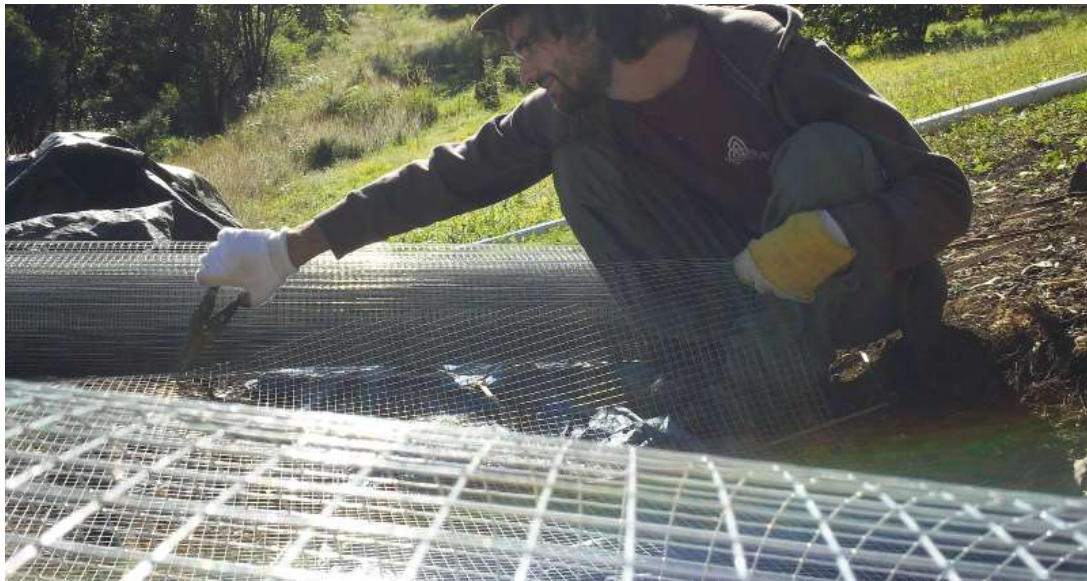
8/. Tie the mesh to the bamboo every 200mm

9/. Tie mesh to mesh at laps every 200mm

10/. Ensure the mesh is tied flat with no springyness anywhere

11/. Ensure the mesh is well tied to the uprights in the footing

12/. Cut the mesh into sizes that are easily handled



Starting the First Layers of Mesh

Although the image below shows that some of the bamboo is woven, it is better to keep the horizontal hoops all on one side of the verticals - the outside works best.



The Structure Becomes More Rigid as More Mesh Gets Fixed On

The structure is looking more like a bird cage with a lot of mesh.

Note the two drainage pipes coming out from each side of the front entrance. This drainage pipe travels all the way around the footing and is covered in gravel to allow water to drain and find its way out of the excavated area.



The Mesh is fixed

Almost there. Still missing are a couple of openings that are formed later for small windows. These can be formed once the render starts coming up the walls and the structure is stiff enough in places to support human weight for reaching higher up.

The skylight hole had not been made yet.

Now, it is ready to start applying the first layer of render starting from the base.



Applying The Render

Reccommended Render Mix Formulation

Use a sand to cement ratio of 3:1 (3 sand to one cement) by volume

fine white washed river sand x 3

portland cement x 1

water 0.4% of weight of cement (or the minumim required for a self supporting workable mix)

Adding Polymer to the Mix - If we can, We replace up to 50% of the water with a liquid polymer such as bondcrete to substantially improve, workability, stickabilty and waterproofing of the concrete

Exact quantity of water will depend on how dry the sand is - best if the sand is completely dry to start.

As a rule of thumb, mix enough water to make 'mud' that will stand up on it's own - the mix must be workable but use as little water as possible for two reasons:

- 1/. Too much water makes the mix too thin and you will not be able to get much thickness in a layer.
- 2/. Too much water also effects the curing and lowers the final strength of the concrete.

1. **Curing The Render - For at least 7 days** - Keep the render covered from direct sun during the curing period when not working on the dome to prevent the concrete loosing moisture too fast.
2. Once the render is initially set keep it moist for a period of at least 7 days. Spray the render with water daily and keep covered.
3. If there is a gap of a few days between coats, mix a slurry of water and cement only, and use this slurry to paint over the surface of the old work immediatly prior to continuing on with new render. This will ensure excellent bonding of new render onto the surface of already cured or partially cured render.

Fiber (Optional)

We have used various types of chopped fibre for different applications.

With this ferro cement system we dont need it as there is a strong matrix of reinforcement in the mesh.

10 Liter Buckets are a Great Way to Measure

10 lit plastic buckets in our batching process for the render mix.

3 x buckets of sand to 1 x bucket of portland cement



Copyrite Christopher Brown

62 What Makes Good Render (Good Mud)

Training the girls in how to use the concrete mixer to make good mud (the render mix)



A PERFECT mix - Not too much water and not too little.

If you look closely you might be able to see just a little fiber in the render mix. This is going to help prevent the first layer from falling through the mesh.



The first layer of render is applied gently over the mesh and not too thick or it could tend to push through the mesh and fall off.

When that first layer is set we will have something solid to press against and we are able to apply the render in much thicker layers..



A test patch



64 The Rendering Process 1



Note the pipe protruding out the side of the shell. This is one of three pipes which are later extended and then brought up through the surface to provide additional ventilation into the inside.



The Rendering Process 3



Looks Like a 'Land Whale'



Always start the rendering process from the slab up



68 **Installing the Steel Ring Opening for the Skylight**

We could have used bamboo but Tracy had fabricated a steel ring from 40mm x 2mm steel. Using the steel ring we traced around the bamboo at the apex and cut out the bamboo just enough to fit in the ring to form the apex opening.

Nick is connecting the ring to the cut bamboo members and the mesh. Around this area we apply several layers of mesh which also wrapped around the ring to hold and reinforce the render.



Looking Up Through the Skylight Ring

Note the coil of thicker (fencing wire) wrapped around the perimeter of the steel ring and spiraling outward.

This is providing additional continuous reinforcement in certain places like this opening.



First Render Coat Almost Complete

Just a little bit more at the top and the whole structure will have at least one coating all over



The centre pole is removed since we installed the skylight ring. The timber sticks are there to push out and hold the shape of the structure at that point during the time we get on a couple of layers.

With 5 of us working together we were easily able to apply one coating to the whole structure in a day.

2 people mixing and delivering render to 3 plastering. Sometimes it was the other way around depending on how the flow was going.



72 **Forming Openings and Building the Render Thickness**

See one of two beaked shape openings artistically formed in mesh by Tracey



Openings are formed according the designers choice. At the edges of openings the mesh is rolled into a thickening to provide extra reinforcement to the curled up lip for channeling water away.



The outside has received at least two coatings of render and now we focus on the inside which is slower going because it takes time to pack the render through the mesh.

Always ensure that voids are filled with render.



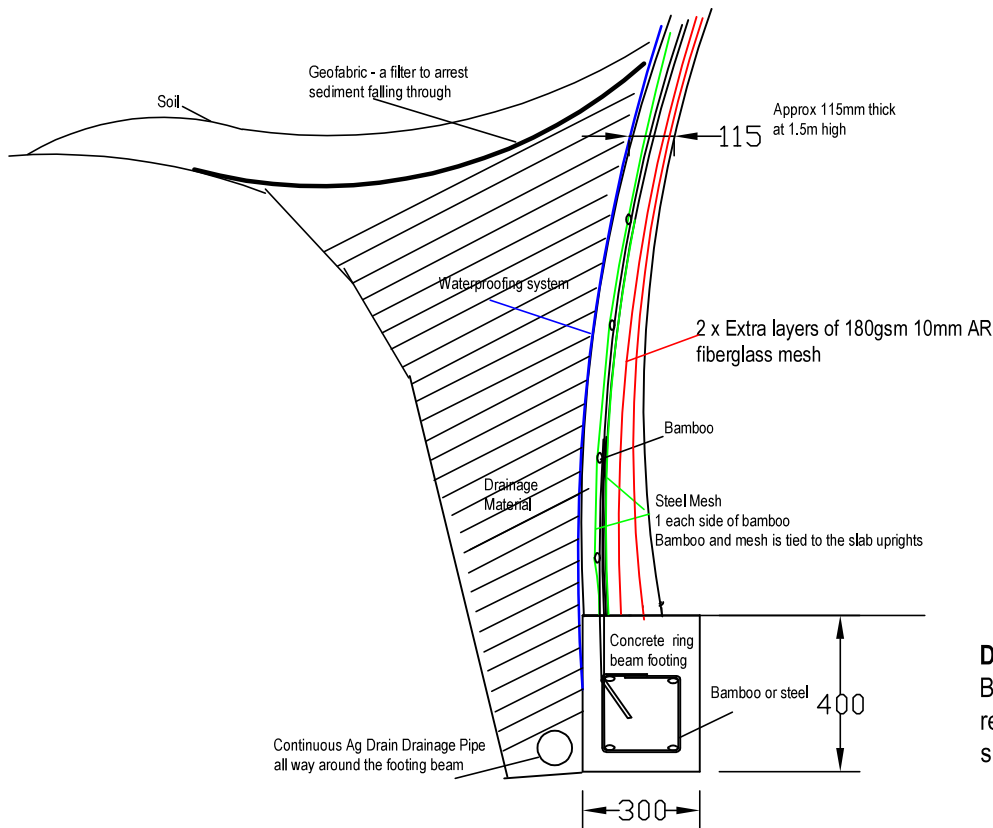
Using a Spray Machine

For a few days we used a small render spray machine.

If you plan to build several structures with this building system, a small render spray machine can make the job easier even though the size of the crew needs to be about the same to keep feeding material into the machine.

For a high quality hand held hopper spray machine: <https://rendersprayer.com.au>





Detail - Section
Byron Bay Bamboo, Mesh and render partially earth covered dome shell

Weathering and Waterproofing

The Lombok dome shells are clad using a local terracotta paving brick. The brick provides a great looking finish and keeps water from direct contact with the shell. The bricks are further treated with a waterproof coating.

Byron Bay Dome has several coats of a cementitious waterproofing material over the concrete shell. It is then lined with two layers of heavy duty polythene plastic laped below the top of the footing to prevent any direct moisture having contact with the concrete

The void between the bank and the dome was filled with 10mm gravel.

The system was designed to allow any moisture to travel down below the top of the foundation where it would continue around the perimeter of the footing and find its way out of the ground. No water would be able to get near the concrete shell.

A thin layer of soil was placed over the gravel to allow grass to grow.

Making Internal Beams

This dome is earth covered and will have extra load. I do not want to take any risk of failure of the structure.

Rolled mesh is pinned to the surface and rendered forming significant reinforced curved beam members to ensure the structure has extra support and strength.

From this stage it took weeks of part time work to build coat after coat after coat of render until we achieved the required thicknesses.



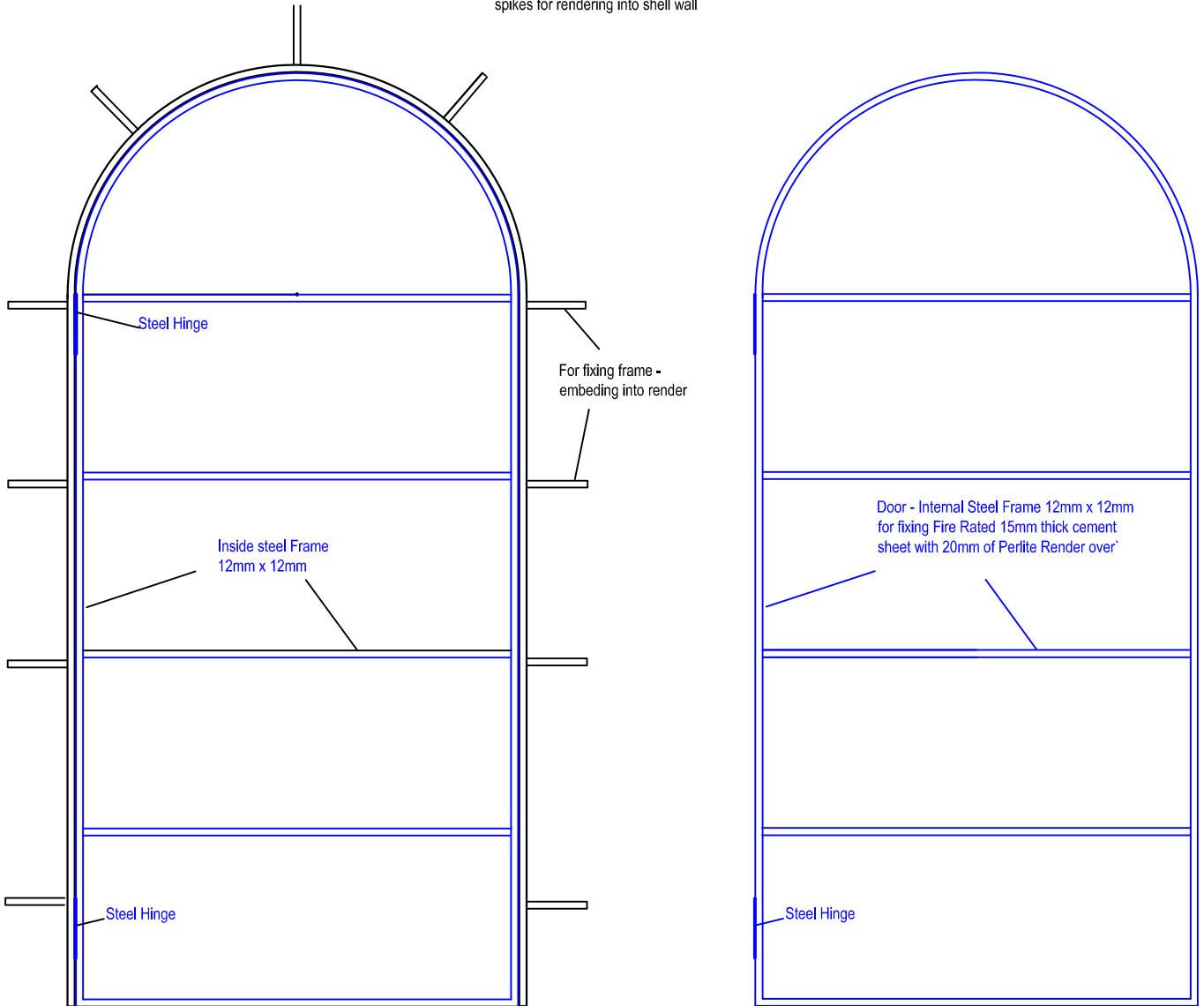
Tracey had a custom made steel door and a window jamb frame with hinged steel frame. The half moon window is made the same way.

Here the door frame is rendered into position. The frames are made with spikes welded to the outside at 300mm intervals to be cast into the opening.



78 Elevation View of the Steel Door Jamb and Frame

External 12mm x 12mm Steel Frame with eternal 1000 spikes for rendering into shell wall



Cementitious Waterproofing System

The structural work is complete with three coats of a cementitious waterproofing system is on.



Applying the Perlite Insulation Layer

We apply a layer of lightweight concrete over the shell for thermal insulation and also additional fire protection.

Mix proportions of 550kg/m³ density concrete using PM400 perlite
1: cement, 1: sand, 5 perlite

Crushed Perlite is a fairly common material found all over the world. It is widely used in agriculture.

Other materials may have similar properties. Crushed pumice stone would also be a great material to use because it will retain air and provide insulation in the same way.

If you are NOT sure about any material - TEST it before you use it.



Backfilling is Done

10mm gravel has been backfilled behind the dome up to the bank and now the earth is being pushed in around the dome.

Two layers of heavy duty plastic membrane cover the surface of the dome before the gravel and the earth is backfilled, which prevents both gravel and earth having direct contact with the render.

This is just the first stage. Now the real landscaping can begin and the finishing touches made.



Finishing the Inside

Here Freya is applying pure white cement render for the final coating inside giving a natural white stone finish and of course making thousands of percent difference in the reflection of light.

Lime render is a nice way to finish off the inside of a concrete dome



The Difference after the First Coat of White Plaster



Half moon window is a steel frame with a hinged sash. The frame is cast into the opening.



How to use earth bagging for building is another whole manual in itself. Earth bagging can even be used to build domes and just about anything else.

Tracey is using earth bagging to build drains, retaining walls into the entrance to the dome and for creating a seating alcoves.



84 Rendering EarthBags

The earth bags are covered in chicken mesh.



Bags placed around the edge of the dome are rendered and shaped to carry rain water into a pool which has also been created using earth bags.

For more information on using Earth Bags for Building follow this Link - **Earth Bags**

Landscaping Continues

Tracey has built an earth bag/concrete drain around the shell to collect water which will eventually be diverted into a pond.



A Few Weeks Later

Plants are growing and the dome and the walls are painted and its starting to blend in with the surroundings





Adding Colour

The perlite render layer is coloured using concrete oxides





Internal Complete



Project No. Three Byron Bay

Constructed at Temple Byron

Six students over 7 days built the shell from the slab up.

Included with this guide is a full set of drawings for a 3.5m dome using basalt as a reinforcing material. Everything in these drawings is the same except you will replace the basalt rebar with split bamboo.

Drawing on the next page is the cover of a set of detailed drawings of every step of the way.

The Site, Set Out and Slab Form

The location is chosen and the excavation has been completed for the set-out of the slab



The slab footprint is determined from a centre peg from which we trace the outer edge of the slab. Pegs are hammered into the ground around the circumference on which to fix the perimeter 7mm plywood forms.

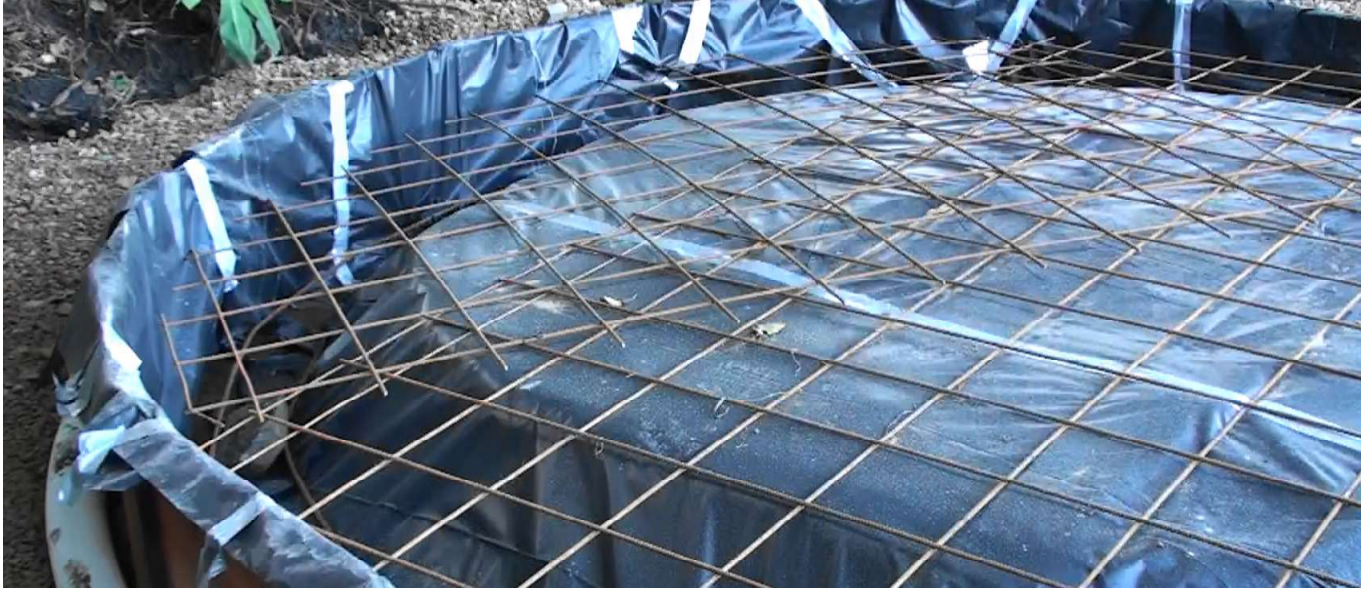


The excavator took out a lot of stumps and we had to raise the ground level in the centre of the slab area. This is river sand and we compacted to avoid any sinkage. We have made the slab formwork level so that we can screed the concrete to the top.



94 Reinforcing Steel and Concrete

SL82 mesh - 8mm bar at 200mm grid mesh. See reinforcing details on the drawings.



The concrete has just been poured and bull floated, almost ready for a trowel finish. Notice the coil of pipe. It is an ag-drain-pipe with a sock to provide drainage around the slab that will be backfilled with gravel as the relative ground level is low and requires good drainage.



At this stage we insert the starter bars. In this case we have used a 10mm rebar with a 100mm angle bent at the end. Push down in the concrete 200mm while still wet. In this example the bars are sitting in from the edge of the slab by 50mm and they extend about 500mm from the slab level. The only part of the slab that does not have starters is where the doorway will be.



We fix a bamboo pole at the centre of the slab. We do this by pinning blocks to the slab to which we can fix and brace the pole in place.

The centre pole will temporarily support a ring at the apex that will form the opening and to where the vertical bamboo bars will be fixed.

NOTE: the caps over the steel starter bars - a safety measure to avoid injury in case of a fall.



The centre pole is fixed and braced from two sides to hold it plumb.

Now, we are ready to start fixing the vertical bars. The bars are spaced 200mm apart.

We have a long pole at the centre so that it can also support a tarpaulin over the structure while we work.



96 Fixing the Vertical Split Bamboo

Here we undo the bundles of split bamboo that we harvested ourselves weeks beforehand so that we have plenty of time to treat the bamboo in Boron/Borax solution for borers and worms.

see page 46 for the Boron/Borax mix proportions

When the poles are treated this way for about 5 days it gets split into strips approximately 30mm wide



In this example we tie the vertical bamboo bars to the starters using cable ties tied tightly in 2 places. The verticals we tie to the starters are long enough to bend to the profile of the dome all the way up to (and beyond) the apex. The verticals will be tied to a ring at the apex where we will form an opening.



We have fixed a vertical bamboo to all the starters and at this stage they are standing up almost vertical. We go around the slab and bend the bars slightly outward to meet the curvature of the dome profile. This may differ depending on the size and shape of your structure.

Here we have started fixing the horizontal bars from slab level at every 200mm.

It is important to continue the horizontal bars all the way around, even at the doorway opening. Later we will cut them out but at this stage they will hold the cage together.



NOTE: That in both these images you can see a curved profile in the background. We cut this profile out of form ply to the curved geometry of the shell to use as a guide to maintain a consistent geometry of the dome.

The curved guide extends from the slab level all the way to the apex where it meets the ring that will form the skylight opening.



98 Tying the Vertical Bars to the Apex Ring

Below, the horizontal members are fixed about three quarters of the way up. Note again in the background you can see the curved profile.

From this point we will curve the vertical bars over to fix to the ring that we have mounted on the centre pole.



We are tying the vertical bars to the ring. If the ring becomes too congested with bars we can cut some bars shorter. They will be held in place by the horizontal bars as they are fixed.

The strips of bamboo tied together in this way naturally want to spring apart. It is always important to maintain the integrity of the dome shape and sometimes means that we will tie a rope to pull in or pull out a section of the frame.

If you look carefully at the images, you will see some rope that is exactly performing this function.



Join bamboo strips by lapping about 200mm (8in) and tying them together at each end.



The cage is taking shape and dome shape is almost complete.

Note that at the doorway the horizontal bars continue past the opening with just enough crawl space to be able to get in and out on the cage.

Also not that we have not started on openings for the windows yet.

It is critically important to first form a complete and consistent cage in the geometry of the dome



100 The Door Opening Former (the door opening mold)

We have already decided that we will use a standard 820mm wide external solid core flush panel door. We like to use solid core doors for this purpose because the door can have a radius cut at the head which looks a lot better than a square top.

Another reason it is preferable to have the radius cut is that it allows more fitting room to swing under the arched hood we will fabricate over the door entrance.

With the smaller domes, we also cut the door down in height from the bottom once we have cut a perfect radius off the top.



The frame here is fabricated out of form ply. It is cut and assembled to create a jamb opening in the concrete the exact shape of the door plus 3mm all the way around for fitting.

It is a mold for creating the opening to form a rebated jamb allowing the door to be fitted into the formed opening.

The opening will not require an architrave as it is formed by the mold. The finished opening will look like a typical door jamb.



Stand the door frame exactly where it needs to be on the edge of the slab. It will be necessary to cut away some of the horizontal bamboo to allow for this.

IMPOTANT: before cutting away any bamboo members ensure that where necessary you use an alternative method to temporarily hold the cage from springing in any way, out of shape.

Beware to leave in some of the horizontal members around the door. If you take too many out, it may be necessary to use some rope to hold a springing cage together.

Pin the feet of the door former to the slab and brace the door mold frame to hold it in the vertical position. Check and double check that the frame is perfectly positioned.

Paint the former with oil as a release agent. Any oil will work - vegetable oil or old engine oil.



Creating the profile shapes of the hood over the doorway.



102 Fabricating the hood Over the Door Opening

With the door frame mold securely fixed in place we can now commence the process of fabricating the arched hood over the door. The hood shape can be any shape you like.

We begin by creating the outside shape of the hood by using a length of bamboo bent around in that shape. We temporarily hold it in place by tying short lengths of bamboo to hold it in place.

With the external shape determined we can begin to bring horizontal members from the dome to tie to the outer edge of the opening.



In the image below you can see how we have started to create the horizontal joining members to form the roof of the hood.

Notice also that we have several temporary pieces of bamboo tied in certain places to outer edge of the opening. You can also see a rope that is holding the shape of the dome cage together.

Note also the profile of the door mold. When concrete is applied and packed around the perimeter of the mold it forms the jamb rebate for the door to close into.



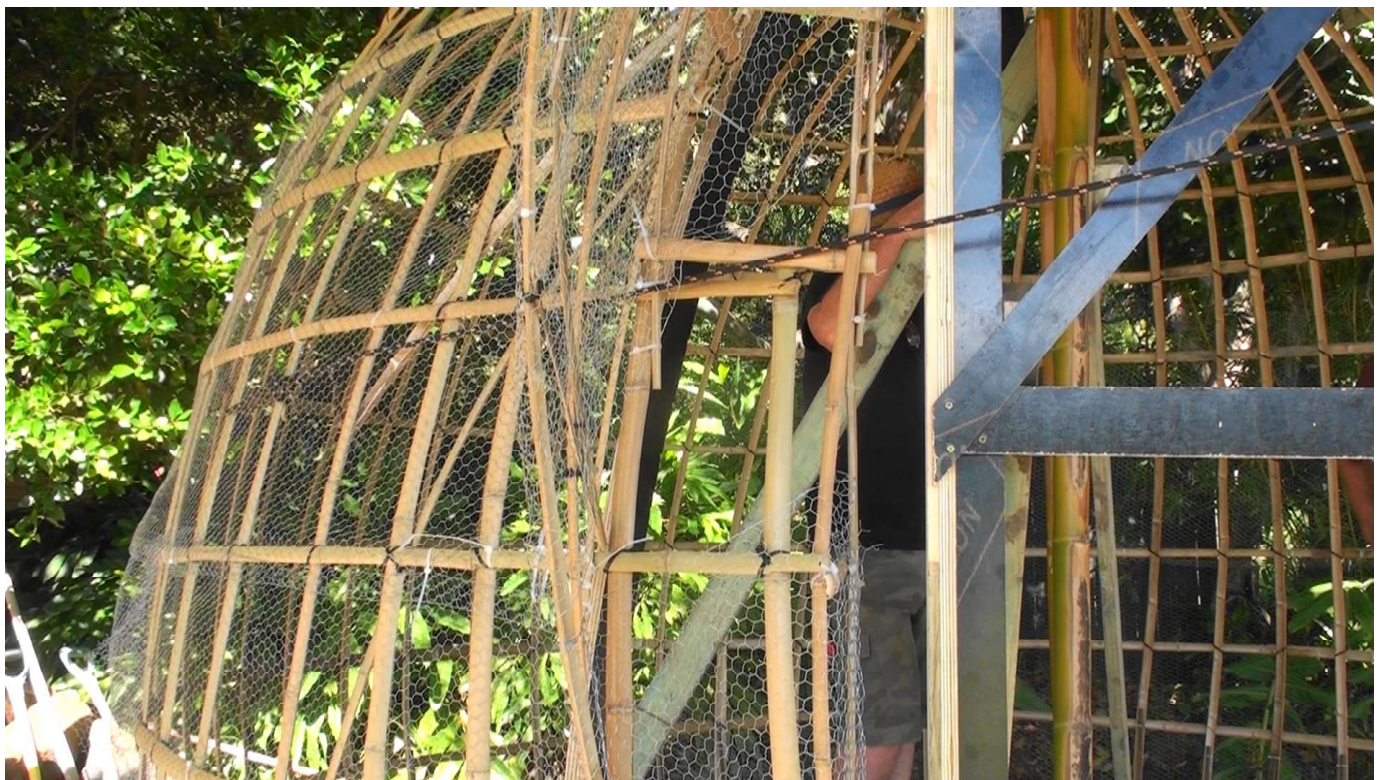
Here we are making a final test to ensure that the door will be able to fully open under the arched hood when the door is open at 90 degrees at least.

We are placing the edge of the door close to where it will swing from and extend it out at 90 degrees to check that there is clearance under the hood when the door is fully open



The dome framing is curved. It meets the door jamb which is straight so at this intersection we have to frame a transition.

A transition between the curved shape of the dome cage and the vertical plane around the door frame. We create this transition with split bamboo to create a frame to hang the mesh on.



104 Primary Purpose of the Bamboo Frame

There are two primary purposes.

1/. Making a Cage - Split bamboo is an ideal material for creating a light-weight frame with structural properties. Bamboo can be split into any width in long lengths. Being lightweight and flexible with tensile properties equal to steel it a perfect natural material to fabricate any kind of cage.

In our case a cage of the shape of the structure.

2/. A Frame to Hang the Mesh - A ferro-cement boat is constructed by first making a frame out of steel bar. Over the bars are tied layers of mesh that reinforces every square millimetre of the thin concrete that is rendered to form the hull.

We are using a similar technique except the frame in our case is made of bamboo.

Now we will wrap the frame in 3 layers of lightweight galvanized mesh - two layers of 10mm chicken wire and 1 layer of what we call snake mesh or bird mesh over the first two.



We have fixed the first layer of mesh up to 1.0m high all the way around and over the door hood frame.

Now we will go and install the window frame moulds that we fabricated out of formply similar to the door mold but in the shape of the window frame



In this project the windows are brand new powder coated aluminium fabricated with a radiused head. The mold to make the jamb rebate is made from formply to the exact dimensions of the aluminium frame - Plus 3mm all the way around for fitting.

When this mould is removed, the window frames will be inserted into the formed concrete jamb - no timber architraves are needed.

The window frame is fixed through the frame directly into the concrete. The 3mm gap around the perimeter is sealed with a high quality polyurethane sealer.



The window frames also need to be temporarily supported in place and braced in position so they cannot easily be disturbed. Ensure such frames are level at the sill, are plumb both ways and not raked or twisted.

The sill protrudes at each side in relation to the curvature of the dome.

With a combination of minimal bamboo framing and mesh, form a sill under the window frame sill that will later be rendered with concrete.



106 Fixing First Two Layers of Mesh to the Dome Frame

Starting from the base, we fix three layers of mesh to the outside of the dome frame with a combination of zip ties and tie wire. Tie wire is often necessary to pull the mesh really tight against the frame.

Begin two layers of 10mm chicken mesh.

Fix one layer at a time.

Meshes come in rolls of 1.0m wide or 1.8m wide. It is easier to use the 1.0m wide rolls that are fixed to the bamboo frame all the way around starting from one point all the way around to the starting point.

Chicken wire has quite a bit of flexibility in it. It is important to stretch the meshes as tightly as possible.

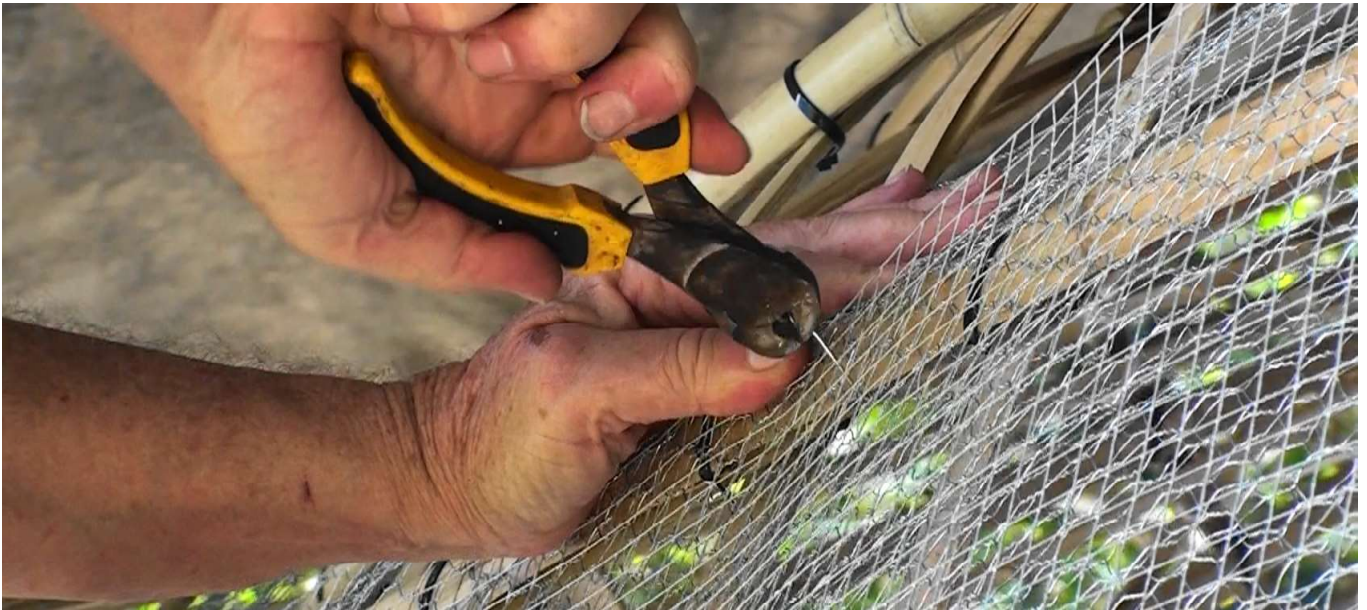
The compound curved shape of the bamboo frame means the mesh will only be tight against the frame at one horizontal line leaving the mesh below and above that line floppy.

The meshes must be as flat as possible to the bamboo frame all the way around. The floppiness needs to be made smooth.

One way to do this is to fold a tuck. Press the fold together and wire it down flat to the frame.

Another way is to take a pair of snips and cut from the edge of the top and the edge of the bottom of the mesh towards the touch line (but not all the way) and then fold the cuts over each other, pull each side tight and tie them together.

Any cut mesh must have a patch wired over the cut extending 150mm past each cut side to ensure continuity of the mesh.



The third layer of mesh used here is a 10mm **square mesh**. The finer the mesh the easier it is to plaster on the cement render.

Square mesh is rigid compared to chicken mesh and to tighten flat against the dome frame means a lot trickier tucking and cutting and patching to get it flat.

When done meticulously the three layers of mesh will appear tight against the bamboo frame.

The three meshes form a continuous matrix of reinforcing all the way though the concrete shell structure including the hoods, window surrounds, or any other augments that are desired to be included in a design. Lap all joins by 150mm. Allow for 400mm laps around the hood to dome transition



108 Meshing the Door and Window Hoods

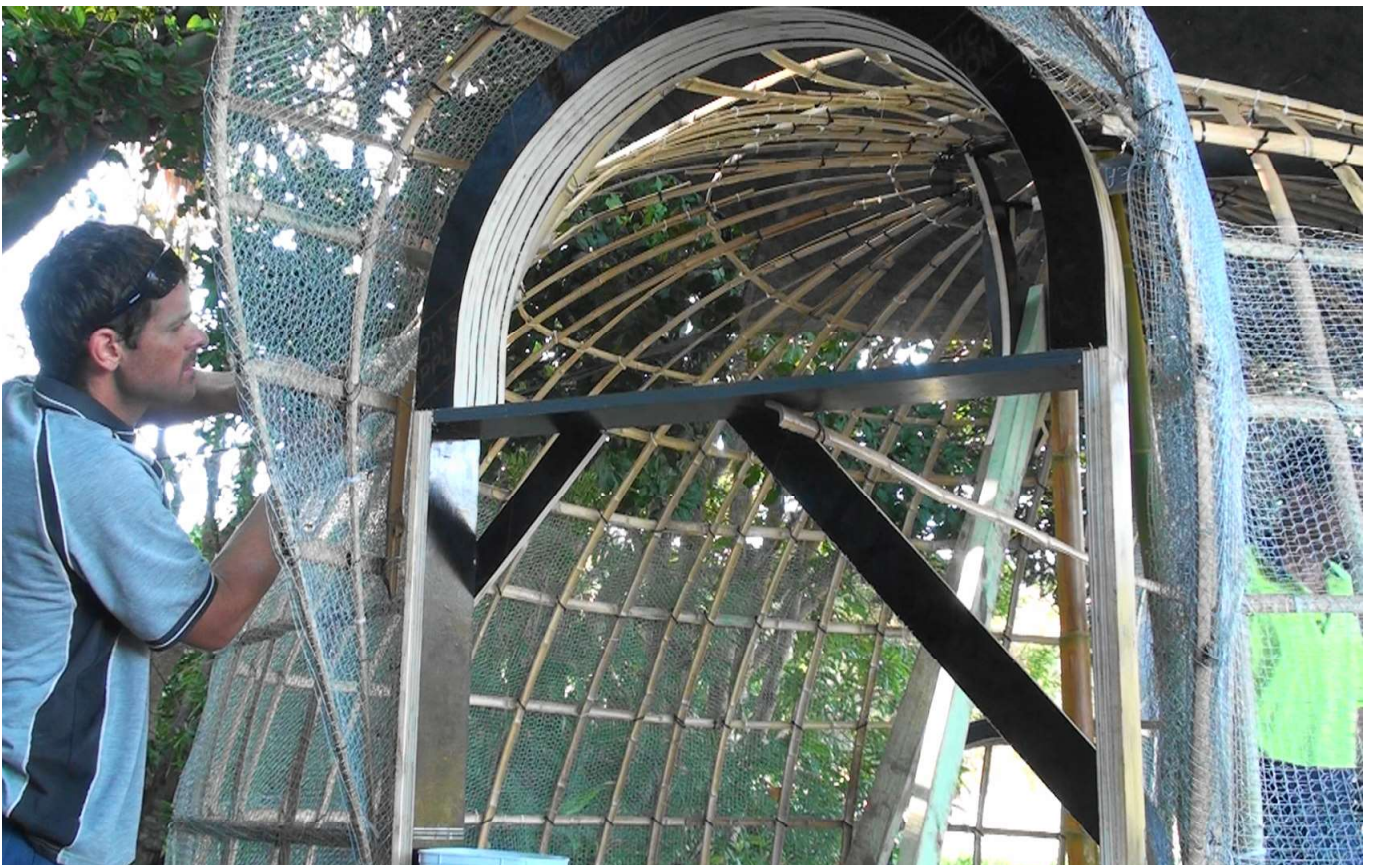
The window and door hood receive the same treatment.

Ensure adequate **lapping of all intersections and joins.**

Where possible keep joins in each layer in a different place from the under layer.



Tying mesh around the hoods



Meshing Around the Door and Window Hoods

The window and door hood receive exactly the same treatment.

Ensure adequate **lapping of all intersections and joins** .

Where possible keep joins in each layer in a different place from the under layer.

Line both sides of the hood with mesh



110 Apply the First Render Coat

Use the same sand cement mix designs we refer to at page 61

Get your water content right from the start to give yourself a perfect batching consistency.

Commence applying the first layer of plaster from the base.

The first layer is to be applied thinly and does not necessarily need to totally cover the holes in the mesh.

Its main purpose is to provide a good key for the next layer that will be able to be applied much thicker.

This applies to the vertical areas or negative angle areas of the dome around the base.

After the first coat (the skim coat, apply three more layers 10mm thick up to just past the diameter line or until a 15mm thick layer will hold



The ideal work method recommend is:

Fix the three layers of mesh up to the height of about 1.8m (equals 2 x a 1.0m roll allowing for lapping the top layer over the lower layer by 150mm.

NOTE: Once the rendering process starts keep the applied render shaded and damp until the last coat of render is at least 5 days cured. Layers of render stick best to green render substrate.

All substrate render must be damp before applying the next coat to avoid the substrate drawing the moisture out of the new render. (If the substrate has cured more than two days it may be necessary to apply a polymer (bondcrete or similar) coating immediately before applying a subsequent layer of render.)

Apply the first two external coats of render about 1.6m high from the slab and a coat over the hoods. This will considerably strengthen the structure for being able to move over the the top of the dome

The next day the render will have cured sufficiently to provide considerable rigidity to the structure providing support to reach over the top part of the dome to fix the higher layers. Tie the mesh all the way up to the skylight opening ring reinforcement. Complete two layers of render over the crown of the dome

Next - Apply render coats to the undersides of the hoods, thoroughly finger pack render into and around the door and window frames to expel any air pockets. It's tedious work packing render into upside down cavaties.

Once the rendering process has started its best to just keep going continuously until all the rendering is done. About 5 people for 5 days will do it.



112 **Rendering Around the Door and Window Hoods**

Below the hoods have at least one coat of render over the outside.
It is best to get at least two external coats of render on before starting the inside or underside.



We have inserted the frames to create the rebate frame for the door and window to fix and close into. The mold needs to have render packed tightly into every corner to ensure there are no air bubbles. Using gloves and render that is stiffer, with less water, using your fingers, pack the render around the frames working into the corners and building out a solid concrete frame around the whole. This takes time and will need to be done in more than just one go (one layer)



114 Render Crown of the Dome & Install the Apex Hob

The sides of the dome are rendered up to what can be reached from the ground making the structure relatively rigid.

In this case we have fabricated a ring of folded chicken mesh to create the reinforcing for a raised thickening at the apex to form an opening that will finish with an inside diameter of 400mm (it can be larger). Working off a stepladder through the apex hole we can load buckets of render onto the roof and around the apex opening and we place the hob reinforcing in the render.

The dimensions of the hob ring will match the opening allowed for at the apex.

Allow for the hob to project above the finished roof line by at least 50mm.

Therefore, ensure you allow for the thickness of the structural shell plus the thickness of any insulation over that.





116 Installing Electrical Conduit

In this dome we have installed electrical conduit to power a light at the apex controlled by a switch at the door and 2 double power points that are all fed from a 15amp caravan socket to the outside.

Mains power electrical work is required to be performed by a licensed electrician. We highly recommend speaking with a licensed electrician about your electrical plan to ensure that any conduit you place for cable complies with regulations and that an electrician can fix off the wiring and face plates.

Here we have wired conduit to the inside bamboo frame before we apply any internal render. Ensure the conduit is tight against the frame and render from the outside coat.

At terminations such as power points, light switches and light fixtures, we terminate the conduit to a plastic box that is also screwed tightly through a bamboo element.

The round boxes in this case are mounted so that they are flush with the finished thickness of the dome shell or a little higher where the thickness of the render may be increased.

Cover the boxes with tape to protect from the concrete and to make it easy to clean later.

When rendering around the boxes, where there will be wall plates fixed, make a flat plane around the wall box to allow the wall plate to sit flat.





118 Installing Electrical Conduit - continued

Note: The bamboo pole up through the skylight hole. Its holding up a large tarp to shade the outside render and us while we are working.

Conduit can be seen travelling up to the ceiling to provide a light point in the ceiling and then it travels down to a second two-way switch on the other side of the dome.



The lower image shows a power outlet point with a TEE joint allowing cable to rout two ways



Apply the second layer of render to the outside.
We have completed a first layer all over the dome.

Using the hand sprayer (<https://rendersprayer.com,.au>) we can easily apply a good 10mm layer on the sides. Once the dome begins to incline over more horizontally and, on the crown, the render can be tipped on with a bucket and spread.

Using a hand trowel, smooth the render over the shell - fill in the hollows around the dome surface.

The third and final structural coat over the second coat will allow for a second smoothing and filling of hollows or lower areas on the dome surface to make it as symmetrical and smooth as possible.



120 Building Up the Outside Layers - continued

Two layers over the external dome are complete.

Tomorrow, we get the final external layer, two layers on the inside of the hoods and we get the first layer on the inside.



Start Rendering the Inside and Overhead

We start at the base. Here we start with the combo sprayer.

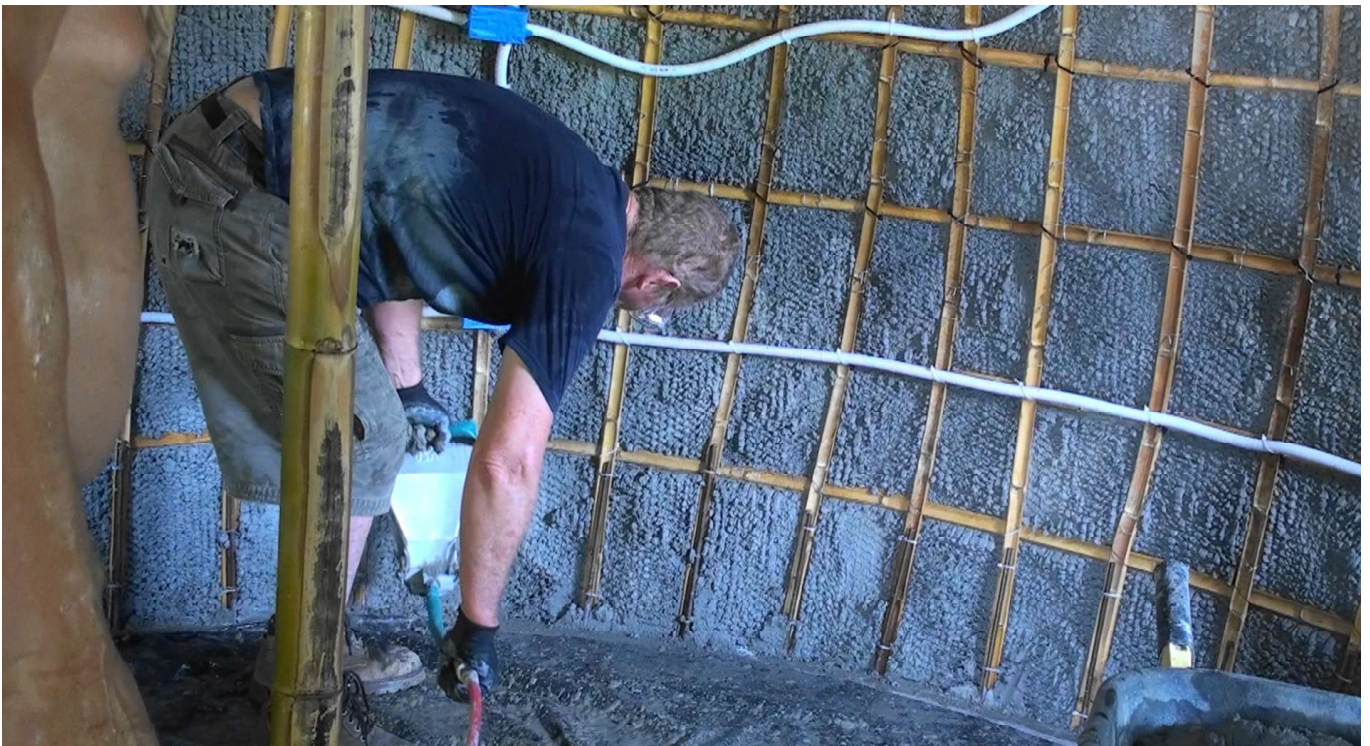
Adjust the mix to hang 15mm render coating to the lower dome wall.

As the dome wall curves upward it will only be possible to hang thinner render coats.

Work the render around the underside of the conduit each side, to ensure encapsulation of render around the conduit.

Trowel over the top of each layer to compress the render into the mesh and create an even base for the next layer.

Aim to fill low spots and cavities with each layer to achieve an even smooth finish to the wall.



122 Rendering the Inside and Overhead - continued

Sometimes the only way to get the render into deep spots is by hand.

It is important to work the render through the mesh to the render behind it.

It can be a bit tedious using the heel of the hand to push in a handful of render into a crevice.

Some of the deeper holes may need to be filled first before coming over again with the rest of the first coat.



Now, we have one render coat over the whole inside of the dome sufficient to just cover the bamboo frame.

Its still pretty rough at this stage.

Note a thickening around the conduits.



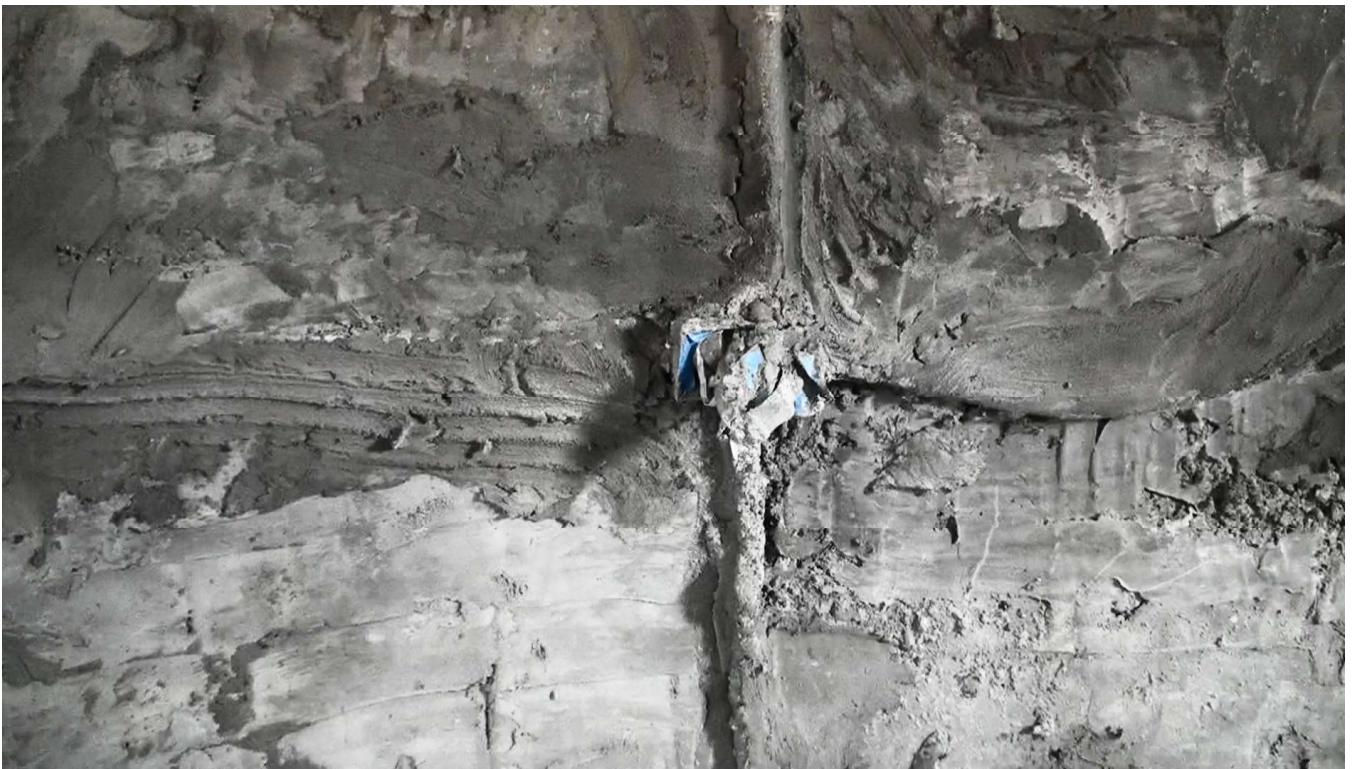
124 Rendering the Inside and Overhead - continued

The arches of the door and window are also fully rendered

Render is well packed around the door and window mold frames and trowelled evenly around the mold.



A TEE junction of the electrical conduit still needs some extra materials under the right hand side.to be ready for the next layer.



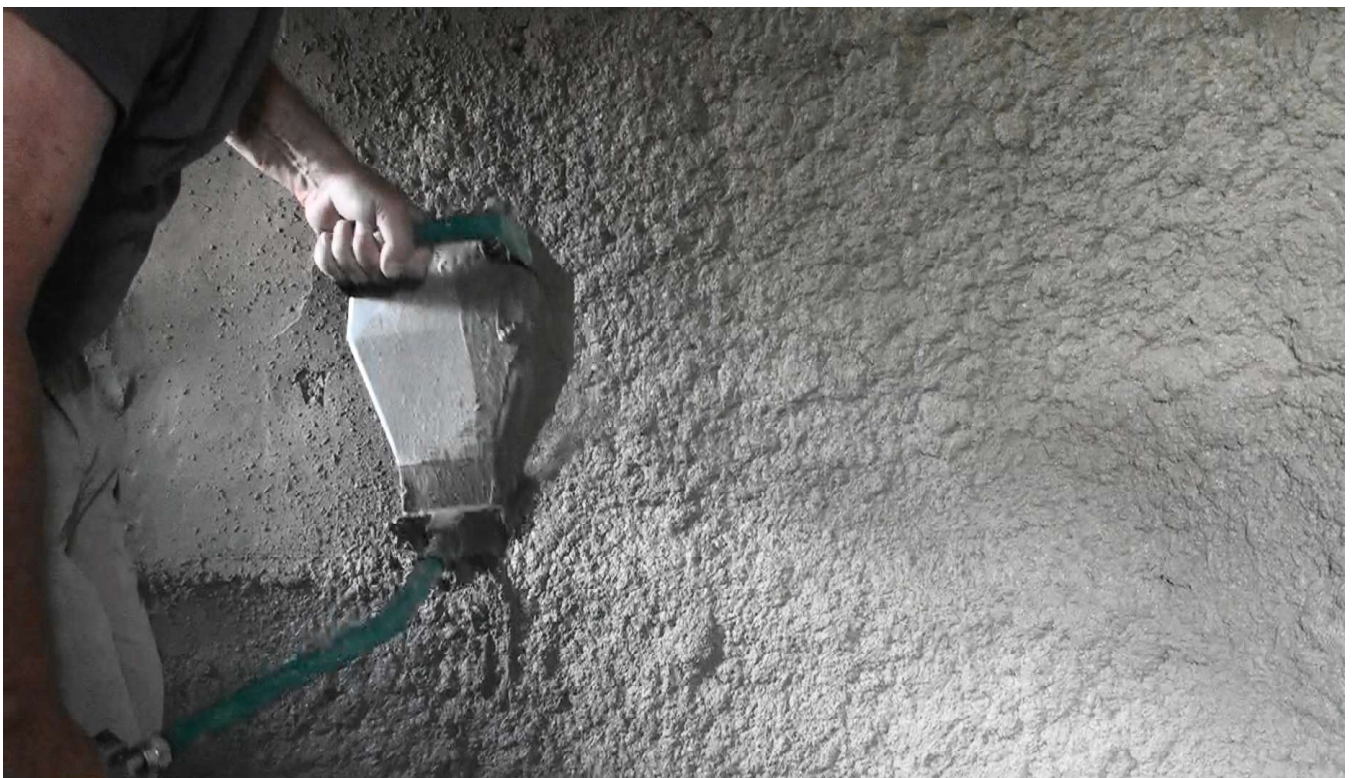
The second layer is sprayed on.



The second coat is sprayed on.

Trowel behind the sprayed layer to obtain the best finish.

The third coat is applied in the same way.



126 **Finish on the Final Layer**

The way we finish the final layer is by using a damp sponge to wipe the surface in a circular motion that polishes the surface.

This way small irregularities can be blended out to achieve a smooth consistency to the render.

The render needs to be just at the right stage of curing to get the smoothest finish by working the sponge in a roundabout motion as if to polish the concrete.

If this is done too early, the finish will be rough as it is likely to move the render.



Remove the Door and Window Molds

Removing the timber door and window molds must be done gently to avoid cracking the edge of the jamb.

begin by lightly tapping with a hammer all the way around to loosen the mould.

Continue tapping all the way around until the frame begins to move away.

Maintain gently tapping all the way around until the mould comes out.



128 **The Finished Shell**

The surface finish can be whatever you want it to be. The inside can look and feel great with a thin coat of lime render.

It takes practice and skill to get a fine finish first time.
Take your time or hire in a couple of professional renderers.

The sponge method of polishing the final finish is still one of the best.



After removing the door and window molds, fill air bubbles with render or builders bog and sand smooth.

Make sure the door and window jamb openings are sharply finished and that the smoothness and texture are what you want before doing any painting.



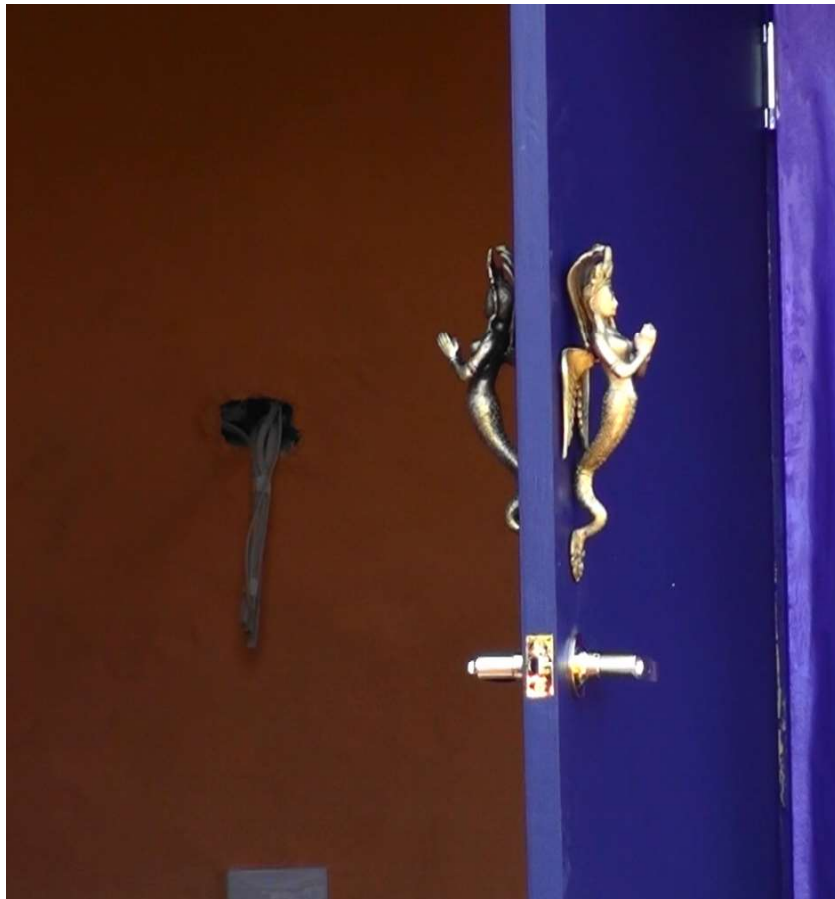
130 The Painted Shell

The pre-manufactured windows fit perfectly into the rebates that were formed by the mold forms.

The aluminium frame window (without reveals) is fixed directly into the jamb frame through the sides.

The 3mm gap between the frame and the opening is sealed with PU sealer.

The door is hung on wide 100mm hinges fixed directly into plugs drilled into the concrete jamb frame.



The Painted Shell - cont.

The external surface has one coat of a cementitious waterproofing system and two coats of external acrylic paint.

The inside has 2 coats of acrylic paint.

A floor could be ground and polished or simply painted with a concrete paint or a 2 pack epoxy system.



132 **Landscaped and Open for Business**

This dome can be seen at Temple Byron in Byron Bay NSW Australia



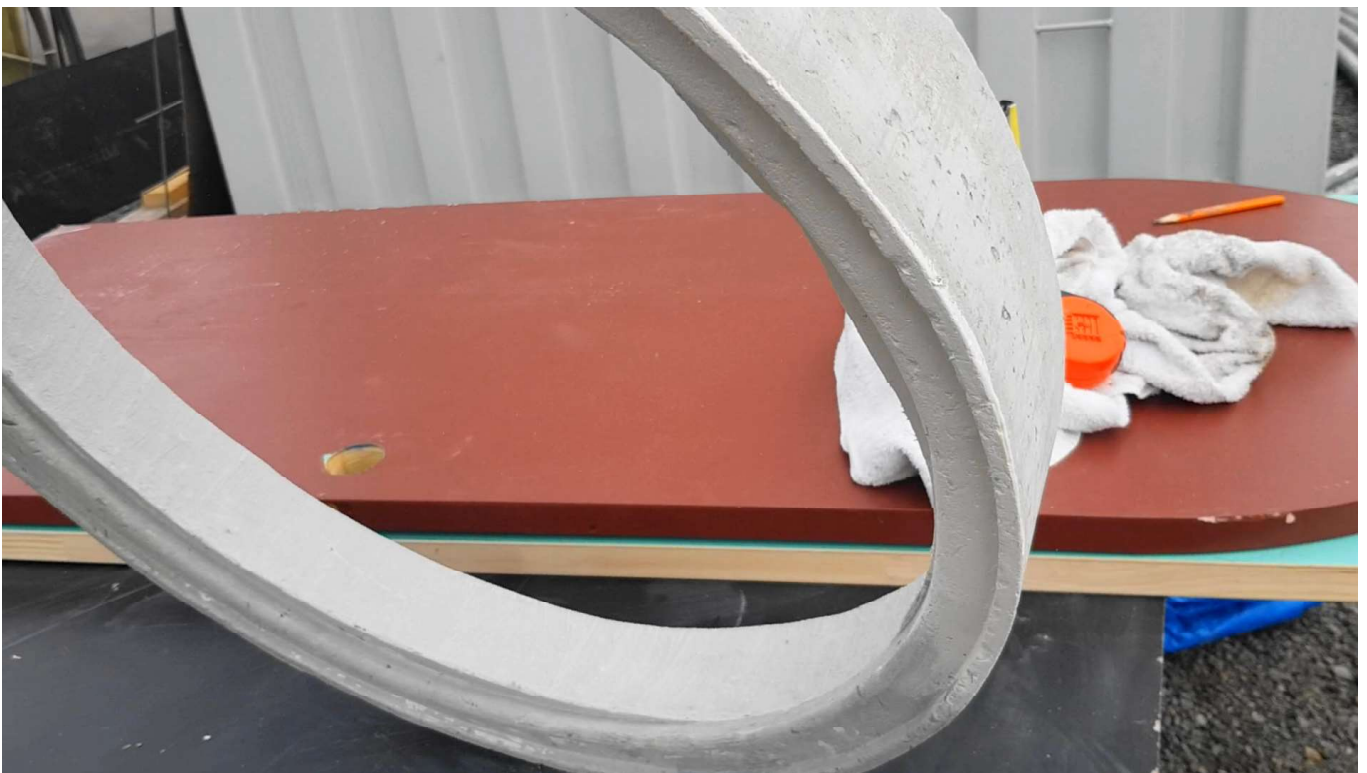
The apex opening can be any size. In our case we have created a 400mm diameter opening at the apex of the dome. Projecting above the opening is an upstand hob about 50mm high, to prevent water coming in under the skylight ring once it is placed over the hob.

We start by making a mold out of plywood.

See drawing on the next page. The dimensions shown are related to what we have done. If the size of your apex opening is different then you will need to change the dimensions.

What is important is how we fabricate the ring.

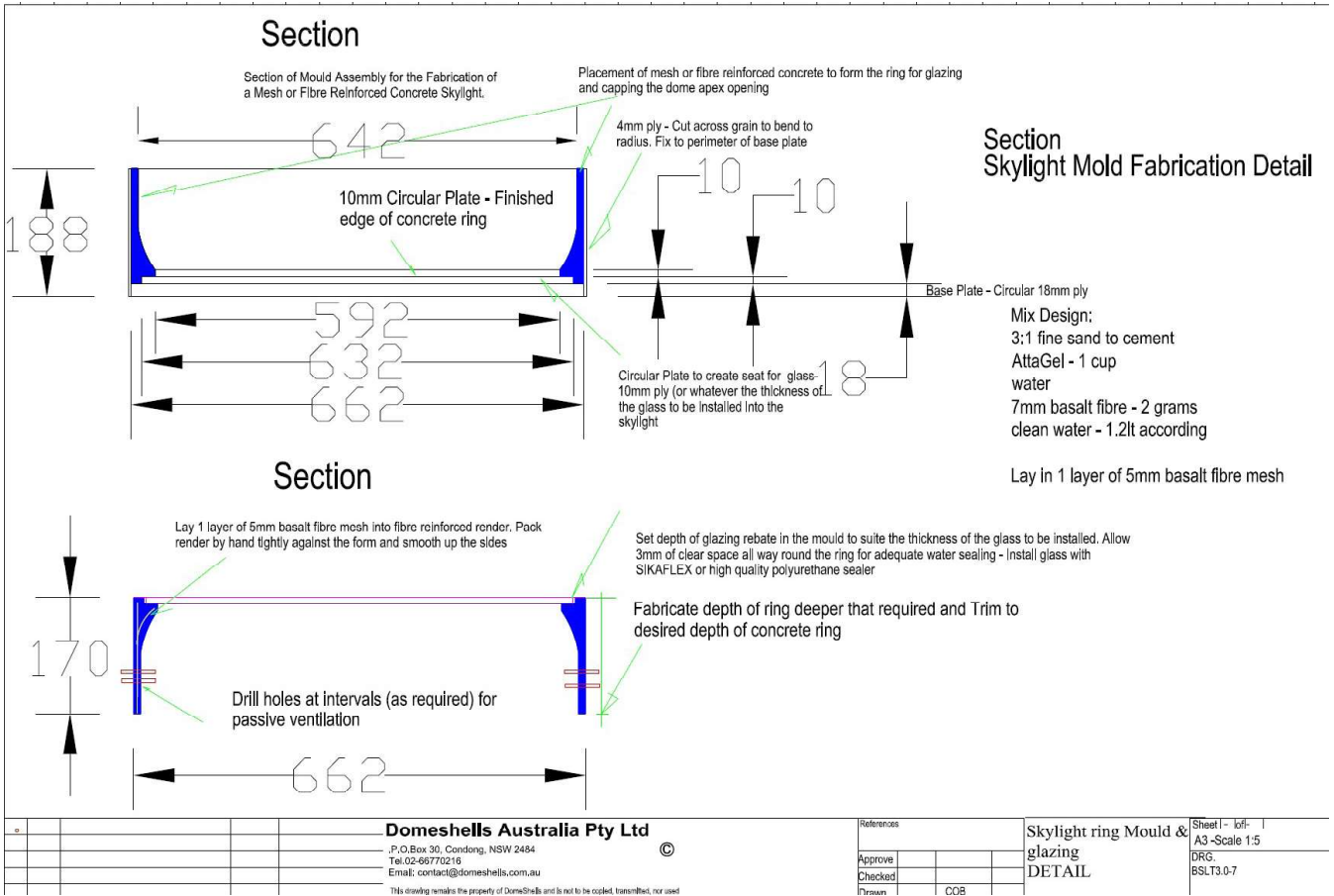
Below is the finished skylight ring with a rebate to allow for glazing - polycarbonate or laminated glass.



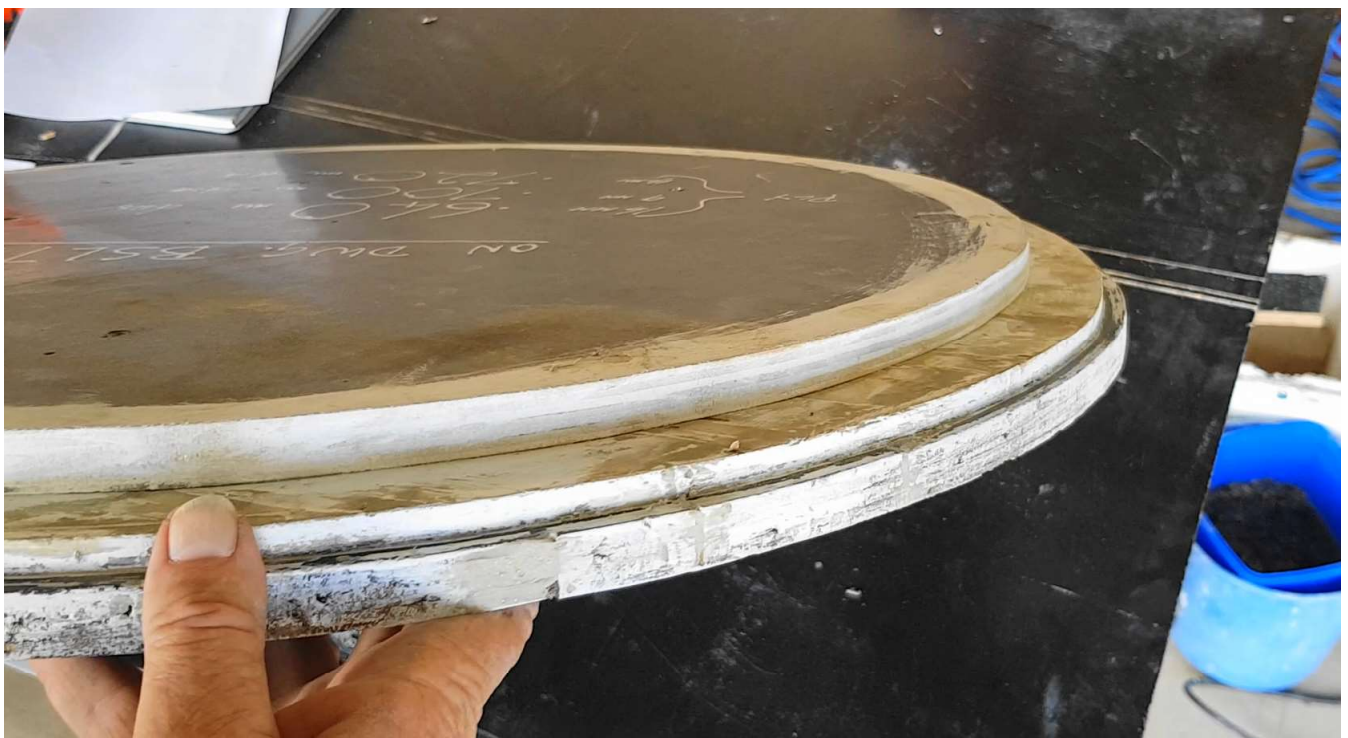
134 How to Fabricate the Skylight Concrete Ring Mold

We make a mold to fabricate the ring out of plywood.
Cut three disks of ply to form an edge rebates as in the image below.

The drawings shows a cross section of the mold - **make according to the dimensions you require.**



Below is the configuration of the three disks screwed together that will form the edge of the ring





Once the three plates are joined, we cut the upstand out of a 4mm plywood. We cut the ply across the grain so that it will easily bend around the radius of the ring plate.



The upstand is fixed around the circumference of the plate. The joins in the vertical sides are taped to hold them together.

The mold is ready for casting.

Remember to apply mold release to the plywood. Simply wipe with any type of oil.



136 Casting the Skylight Ring

When fabricating individual thin concrete elements like the skylight ring, we use a higher strength mix design and also incorporate chopped fibre in the mix and or use a mesh for reinforcement. It is OK to reinforce with GAL mesh.

The base of the mould is configured to provide a rebate for installing the glazing.

The intention is to pack render up the sides of the mold so that the top of the mold is about 10mm thick render.

The plywood sides of the mold are at least 50mm higher than we need. It will be cut to size later. be careful to NOT make it too thick.

High Strength Render mix

1:1 sand to cement

1 sand: 1 cement

(if you have access to some polymer to add to the mix it will be easier and more plastic to work with.)

It is CRITICAL to compress and work the render to into the rebates at the base of the mold with fingers to ensure there are no air bubbles.



De-Molding the Skylight Ring

Firstly, remove the screws hold the ply sides.

Gently peel off the outer ply.

Now, gently tap out the base with a hammer. Work around the edges tapping until the base is loose and it gradually releases.



138 **Cut the Skylight Ring to Height**

The ring is fabricated taller than we need to allow us the luxury of cutting the sides to the exact height we need and also end up with a nice solid finish at the base of the ring.

Cast concrete elements always need touching up. If you have not compressed the render material, it may have bubbles that need to be filled. Sharp edges can be lightly sanded or ground smooth.

Below we have used an angle grinder to cut the ring to the exact height that works for us is about 100mm.

The ring will easily fit over the apex hob.

In our case we got 9mm tinted, laminated glass to fit into the rebate.

An easy way to secure the glazing is simply to embed in a bed of polyurethane sealer.



Ready for painting and glazing



We hope that you have found some value in this e-book guide and that you are inspired to design and build your very own **Bamboo/Ferrocement Shell Structure!**

The reason for the publication of this guide is to provide a simple formula for constructing a shelter or home wherever you are. It is particularly for people with limited funds.

What's Next?

We look forward to continuing the development and distribution of this simple building system to the world.



Stay in Touch

If you have question, feel free to contact us anytime.

Look for the Facebook - “Bamboo Dome Builders” group page where there is a lot more about bamboo

Warm regards,

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NOTES:

Quantity of Mesh				
3 Layers of mesh + 20% for laps & spare = 5	116.35	m2		
10mm Chicken mesh	75	m2		
13mm Aviary mesh	40	m2		
Electrical Conduit – 10m	1	coil		
Cable ties – 200mm x 100	15	packs		
Cable ties – 150mm x 100	12	packs		
Cable ties – 250mm x 50	5	packs		
Rendering System				
Render thickness 70mm x 33m2 = Volume of render	2.31	m3		
Sand - 40 mesh (fine white)	2.5	m3		
Bags cement delivered	60	bags		
Bags fly ash	13	bags		
Bags White Cement	6	bags		
Perlite Aggregate Layer (or other lightweight concrete)				
At 50mm thick - require	1.5	m3		
Hire				
Concrete vibrator for the slab	1	of		
Bull float - for the slab	1	of		
Formply for Blockouts and moulds	4	sheets		
Door – 820 Solid Core Door	1	of		
Window – second hand wooden	2	of		

Total Bulk Material Cost of the Dome
