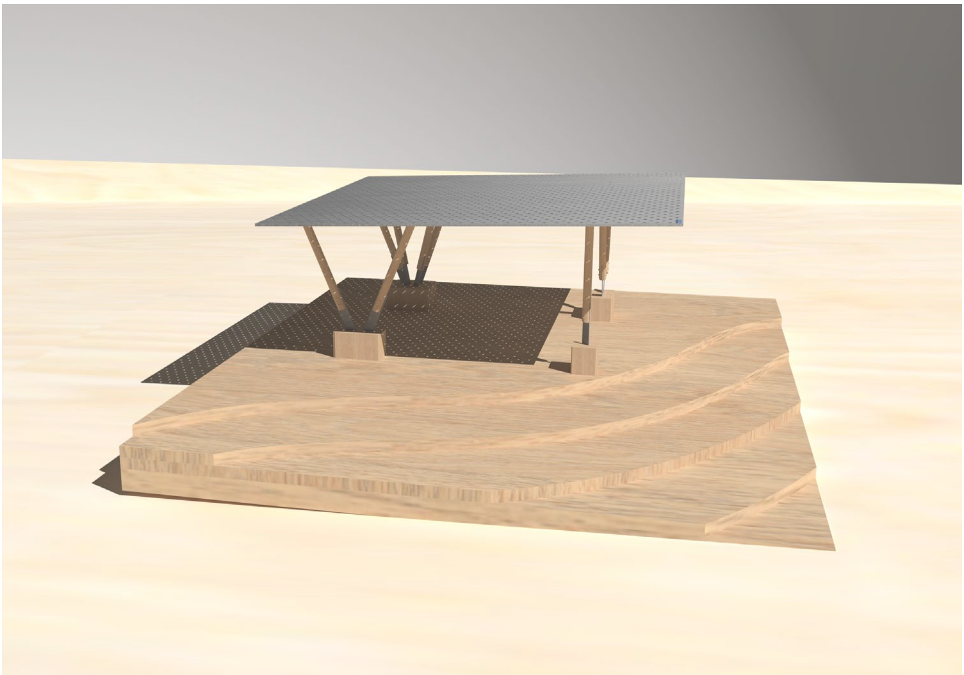
CUMMERAGUNJA PAVILION

FOOTING CONSTRUCTION



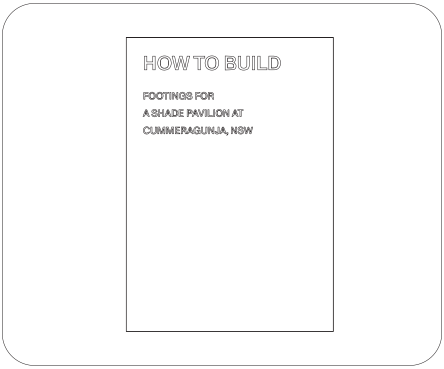
Perri Sparnon. 537719. Construction Methods A. ABPL90286. February Term 2021.

CONTENTS

ACKNOWLEDGMENT

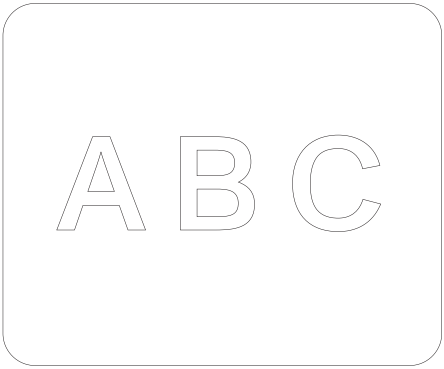
I acknowledge the traditional owner's of the land on which this project was built and journal completed, the Wurundjeri and Yorta Yorta peoples of the Kulin nation, and pay my respects to Elders past, present and future. This always was and always will be Aboriginal land.

A. INTRODUCTION



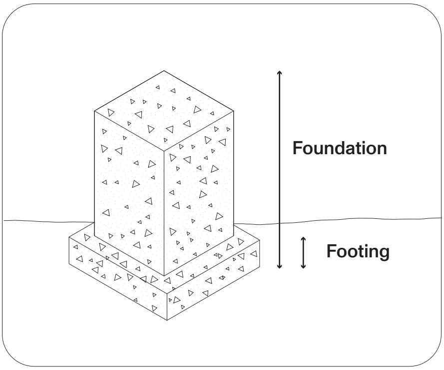
OVERVIEW

This reflective journal provides a set of detailed instructions for initial construction works of a Shade Pavilion at Cummeragunja, NSW. Construction of concrete footings with cast-in steel plates was completed at the University of Melbourne, VIC and Cummeragunja, NSW from 19 - 25 February, 2021.



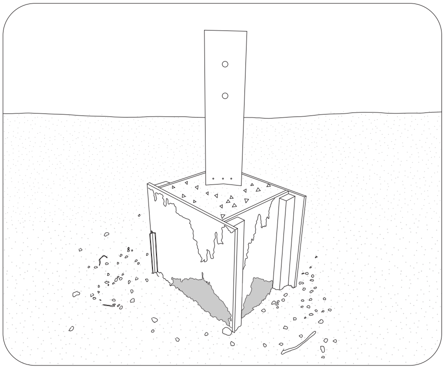
THREE PARTS

This journal documents the construction process in three parts: Part A covers the materials and equipment required; Part B provides step-by-step instructions for building the footings; and Part C reflects on the overall experience of building the footings at Cummeragunja.



PAD FOOTINGS

The footings at Cummeragunja are examples of concrete pad footings. Pad footings are shallow foundations used for the vertical support and the transfer of building loads to the ground. Pad footings are also know as "isolated" or "spread' footings as there are no connections between the footings and they take concentrated loads from above, spreading them across the soil. As we shall see, holes are dug into the ground and fitted with formwork and a reinforcement cage that is then filled-in with concrete.



SINGLE FOOTING

Part B of this journal focuses on the construction process for a Single footing (500 × 500 mm) only. Each step can be repeated for the Double (500 × 1000 mm) and Quad (1000 × 1000 mm) footings, following the measurements provided in Part A.

A.1 SITE PLANNING & LOCATION

View of Site 1 at Cummeragunja, showing the Murray River, camp fire and gum trees.

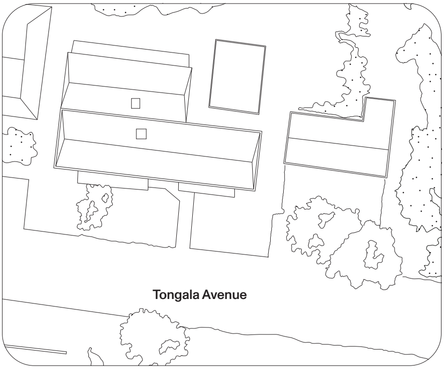
CUMMERAGUNJA

The area today called Cummeragunja has a rich and complex history. Situated in Yorta Yorta country on the Murray River in New South Wales, Cummeragunja Station was founded in June 1888 when residents of the nearby Maloga Mission Station grew dissatisfied. They mounted a successful appeal to the New South Wales Government for the creation of a new reserve.

By 1939, residents had again grown dissatisfied and launched the landmark 1939 Cummeragunja Walk-Off. In protest of the poor living and working conditions, residents packed-up their belongings and crossed the river into Victoria. In 1983, the title deeds to Cummeragunja were returned to the Yorta Yorta people through the newly created Yorta Yorta Land Council. A number of Yorta Yorta families live in Cummeragunja today.

1 Red Gum Logs
2 Tongala Avenue
3 Community Centre
4 Medical Centre
5 Pavilion Site 2
6 Pavilion Site 1
7 Camp Fire
8 Murray River

Site Context Map 1:2000 @ A5

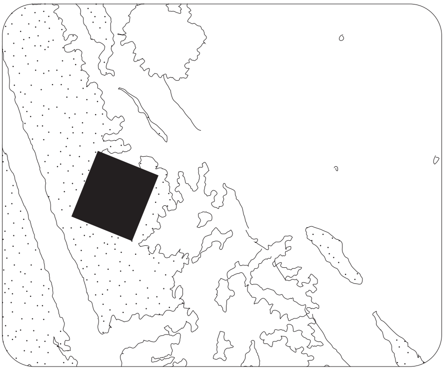


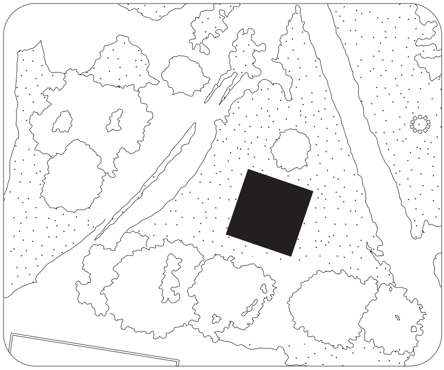
SITE ADDRESS

Tongala Avenue, Cummeragunja, NSW (Behind Medical and Community Centres).

SITE PLANNING

A site was initially selected through consultation with community leaders, including Uncle Col and his family. Red Gum *(Eucalyptus camaldulensis)* had been felled from a nearby area of bushland. Some logs were reserved for constructing the new Shade Pavilion.





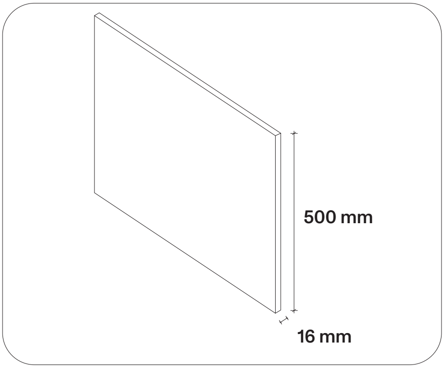
SITE 1

The client, representatives of the Cummeragunja community, communicated a preference for the pavilion to be located near the banks of the Murray River and campfire. For this reason, the Pavilion was originally located to the east of the unsealed road. The Pavilion's proximity to the road was not deemed a concern as the client expressed the ability to move the road.

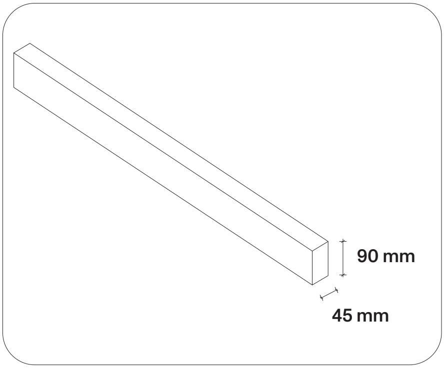
SITE 2

Further community consultation revealed a preference for the Pavilion to be located further away from the river bank. The footings were consequently moved west of the unsealed road, to an area of non-curated vegetation near the Medical and Community Centres.

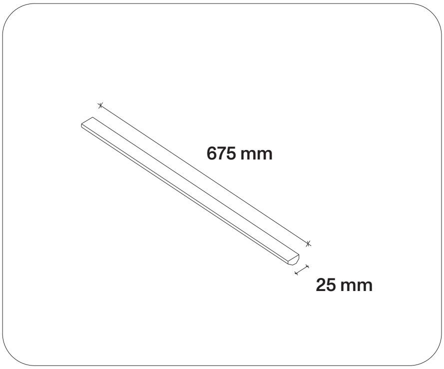
A.2 MATERIALS



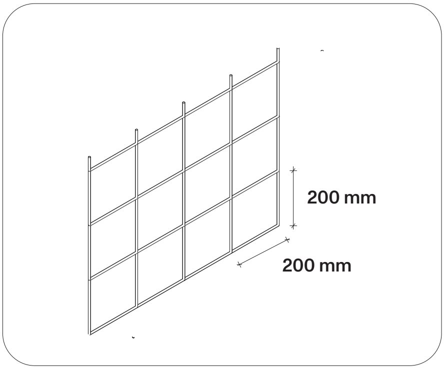
FORMPLY R17 (UNTREATED PINE 16MM)
This Structural Plywood is combined with a special plywood lamination process, making it ideal for both structural and architectural uses.



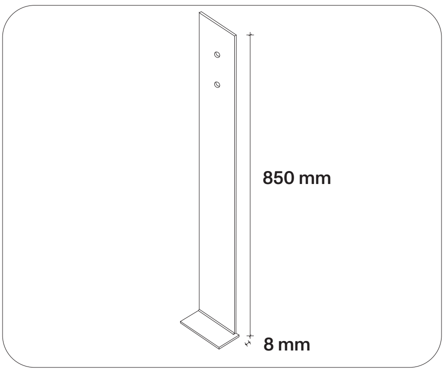
MGP10 UNTREATED PINE
This pine is used for structural framing as its high stiffness grade (10,000 MPa) resists elastic deformation under heavy loads, thereby maintaining structural integrity.



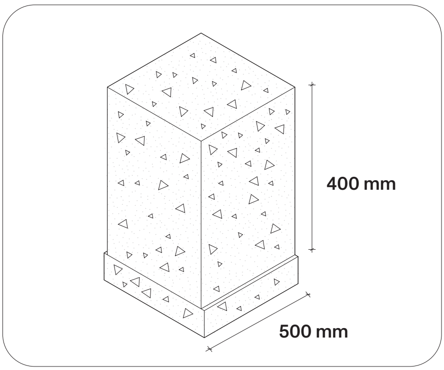
TRIMOULD PRIMED PINE TRI QUAD MOULD
A lightweight timber with a triangular profile that is used to provide a neat finish to joins and as a chamfer for Formwork that protects edges from chipping.



REOMESH 71403 HEAVY DUTY
Steel bar reinforcement sheeting is used for improving the tensile strength of concrete and preventing cracks to structural elements.



STEEL PLATE 8MM
This case-in steel plate was made by compressing multiple layers of steel sheeting together into a single plate of steel. The plate was cut and welded to form custom posts for the Pavilion.



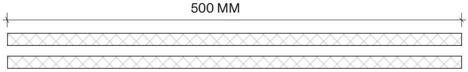
WASHED CONCRETE 25 MPA
A common class of concrete with a good compressive strength consisting of 1-part cement, 2-parts sand, and 3-parts aggregate. Normally used for applications such as slabs and footings.

The “Single” footing showing formply, cast-in steel plate, and concrete.

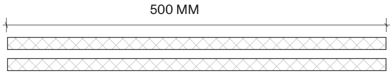
A.3 CUT LIST

SINGLE FOOTING (500 × 500mm)

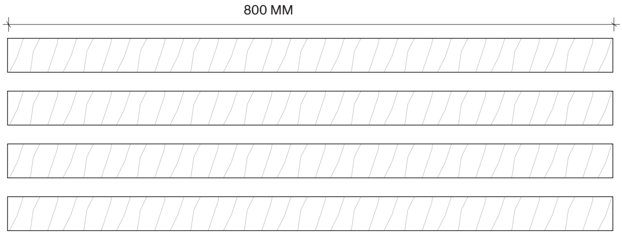
Formply F17
(Untreated Pine 16mm)
700 × 500 × 16 mm
(x 2)



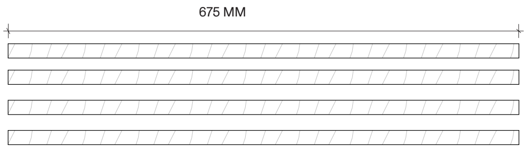
Formply F175
500 × 500 × 16 mm
(x2)



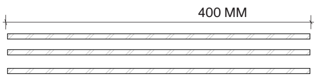
MGP10 Untreated Pine
800 × 90 × 45 mm
(x4)



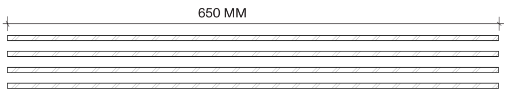
Trimould Primed Pine
Tri Quad Mould
675 × 19
(x4)



ReoMesh 71403
Heavy Duty 7mm
400 × 400 × 7
(x3)



ReoMesh 71403
Heavy Duty 7mm
650 × 400 × 7
(x4)



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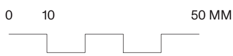
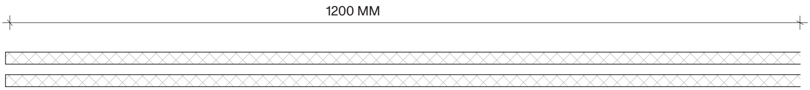
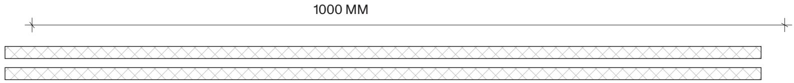


DOUBLE FOOTING (500 × 1000mm)

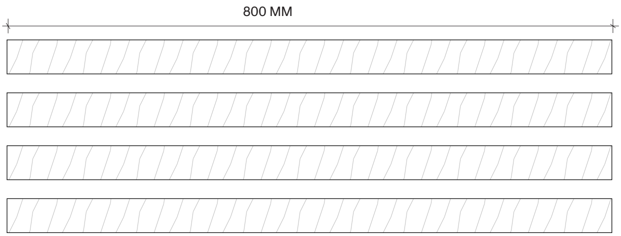
Formply F17
(Untreated Pine 16mm)
1200 × 500 × 16 mm
(x 2)



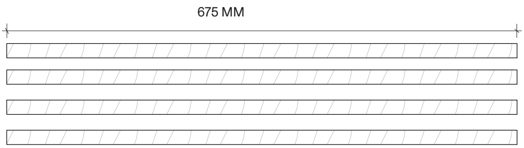
Formply F175
1000 × 500 × 16 mm
(x2)



MGP10 Untreated Pine
800 × 90 × 45 mm
(x4)

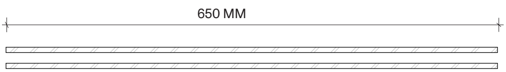


Trimould Primed Pine
Tri Quad Mould
675 × 19
(x4)

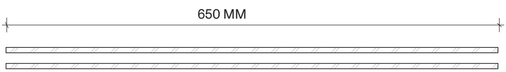


ReoMesh 71403
Heavy Duty 7mm
800 × 400 × 7
(x3)

ReoMesh 71403
Heavy Duty 7mm
650 × 400 × 7
(x2)



ReoMesh 71403
Heavy Duty 7mm
650 × 800 × 7
(x2)



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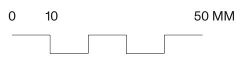
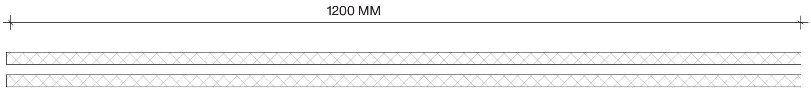
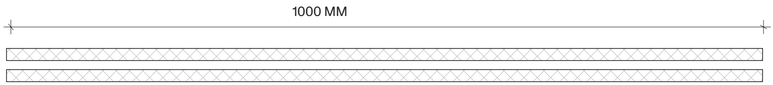


QUAD FOOTING (1000 × 1000mm)

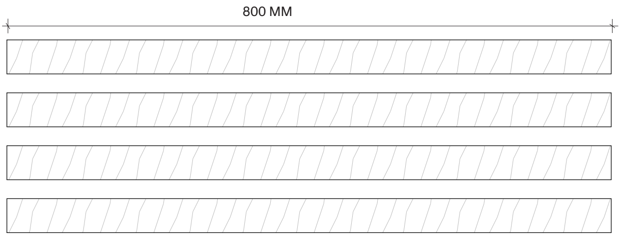
Formply F17
(Untreated Pine 16mm)
1200 × 1000 × 16 mm
(x 2)



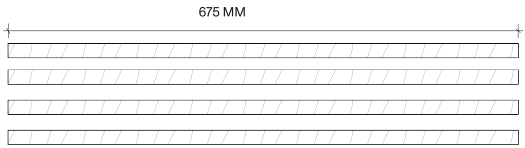
Formply F175
1000 × 1000 × 16 mm
(x2)



MGP10 Untreated Pine
800 × 90 × 45 mm
(x4)

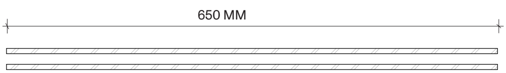


Trimould Primed Pine
Tri Quad Mould
675 × 19
(x4)



ReoMesh 71403
Heavy Duty 7mm
800 × 800 × 7
(x3)

ReoMesh 71403
Heavy Duty 7mm
650 × 800 × 7
(x2)



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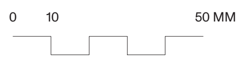
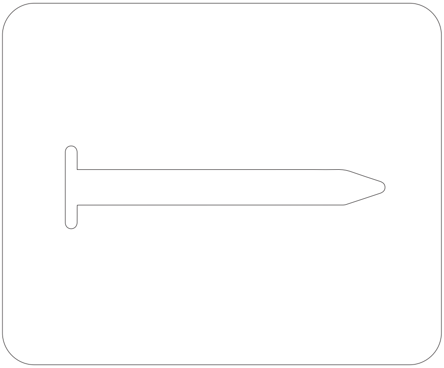


Trestles set-up on site for cutting rebar with the angle grinder.

A.4 FIXINGS

TYPES

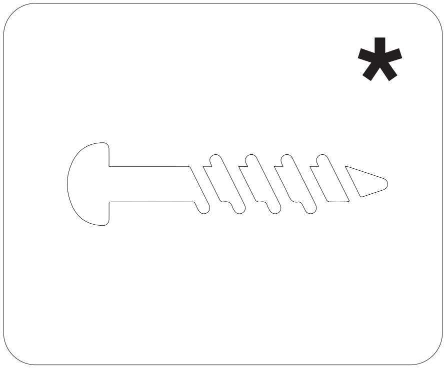
Four key types of fixings were used when constructing the footings at Cummeragunja. Metal fixings are typically used in construction because they allow connections between members to have a higher-resistance to loads (both shear and tensile) and increase stiffness at corners. Note that it is important to consider how these fixings are “driven-in” to materials and that they are “flush” with edges when required.



FLAT HEAD NAIL

Used for a range of applications when constructing the footings, including making the hurdles and fixing the Trimould to the Formply.

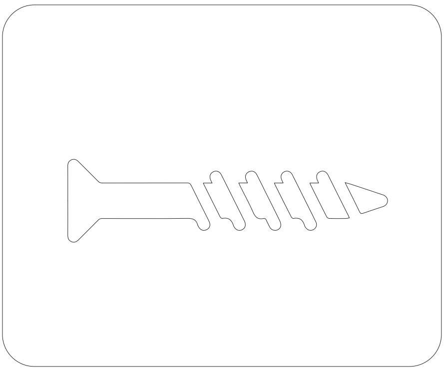
Paslode 50 × 2.8mm 500g Flat Head Galvanised Nails - 170 Pack



TEK SCREW

Primarily used to externally fix the Formply to MGP10 Untreated Pine. *Note that Tek screws are *half* the cost of batten screws and should therefore be used wherever possible.

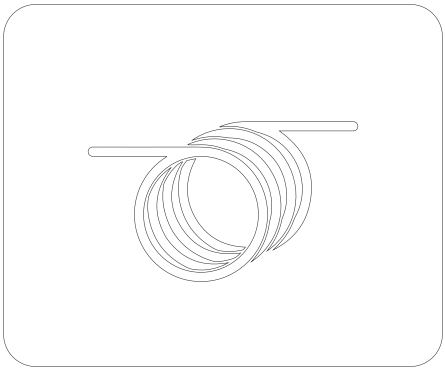
Buildex 12-14 × 50mm Hex Metal Timber Tek Screws - 100 Pack



BATTEN SCREW

Primarily used to internally fix the Formply to the MGP10 Untreated Pine. The screws were drilled-in flush with the Formply to achieve a straight edge for the concrete pour.

Buildex 14-10 × 50mm Type 17 Bugle Head Timber Batten Screws - 500 Pack



TIE WIRE

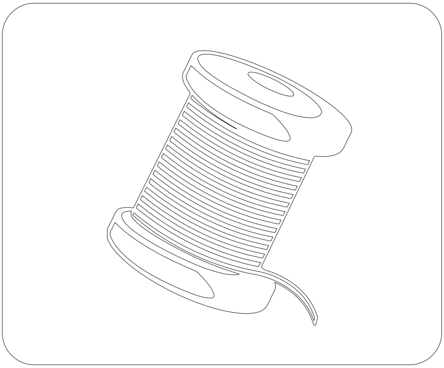
Tie Wires were used to fix the 7mm Rebar sheets together when creating the reinforcement cage.

Whites On-Site 1.25 × 250mm 1kg Cut Galvanised Tie wire

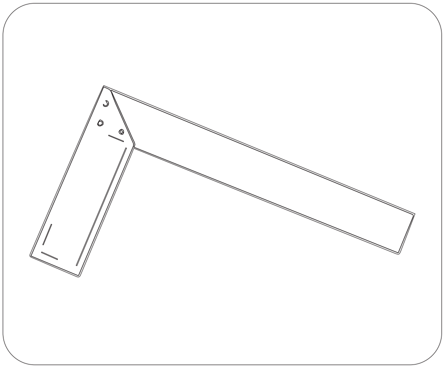
PRODUCT	QUANTITY		DIMENSIONS (MM)
SINGLE FOOTING			
Flat-Head Nail	16	-	3”
Tek Screw	16		50 mm
Batten Screw	16		50 mm
Cut Galvanised Tie Wire	10		1.25 × 250 mm
DOUBLE FOOTING			
Flat-Head Nail	16	-	3”
Tek Screw	20		50 mm
Batten Screw	20		50 mm
Cut Galvanised Tie Wire	15		1.25 × 250 mm
QUAD FOOTING			
Flat-Head Nail	16	-	3”
Tek Screw	30		50 mm
Batten Screw	30		50 mm

Use of plyers to twist and cut the Tie Wire.

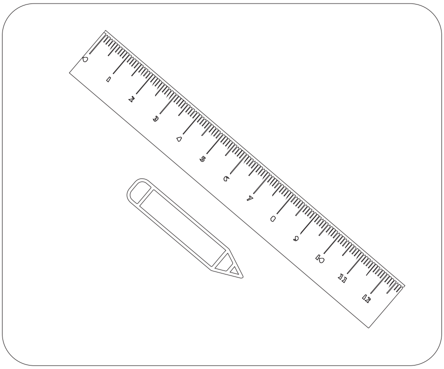
A.5 TOOLKIT



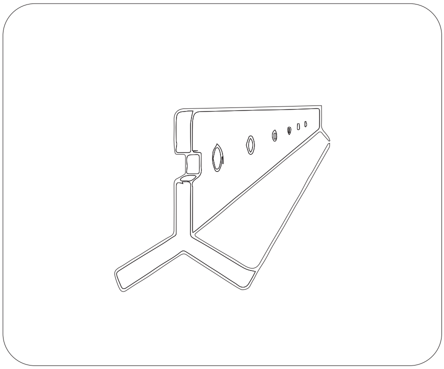
BUILDER'S LINE
Used for setting-out. A typical product is "GRUNT Fluro Builders Line 100m" as the fluorescent colour maximises the line's visibility.



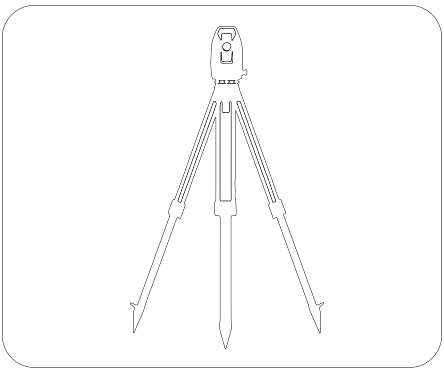
LAYOUT SQUARE
Used for setting-out and achieving perpendicular angles at step B.2.



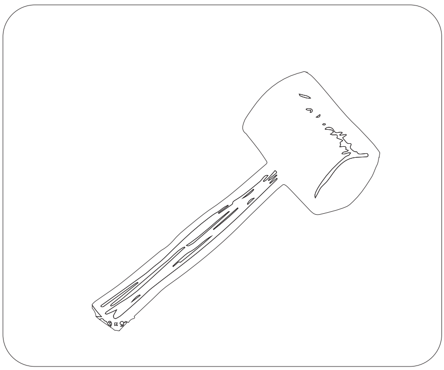
PENCIL & RULER
Used throughout the construction process, especially during steps B.4 and B.5 Formwork Design and Manufacture.



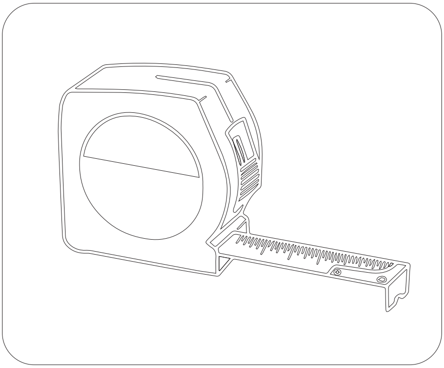
STAR PICKETT
Used to create "hurdles" when setting-out at step B.2. Ensure that safety caps are attached at all times. A typical product is Whites Ultrapost 60mm.



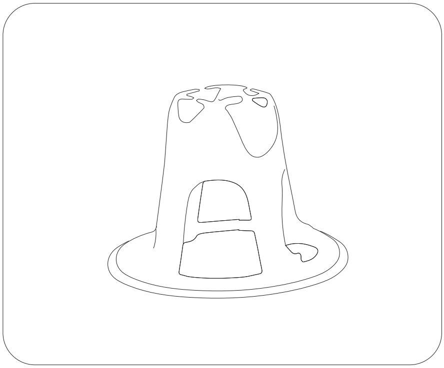
THEODOLITE / DUMPY LEVEL
Use for setting out and checking levels and locating the steel cast-in at step B.8.



MALLET
Used at step B.9 during the concrete pour to "vibrate" the concrete and minimise air bubbles.

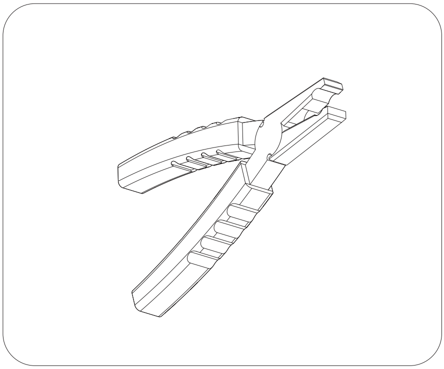


TAPE MEASURE
Used throughout the construction process to measure small distances (< 10m)

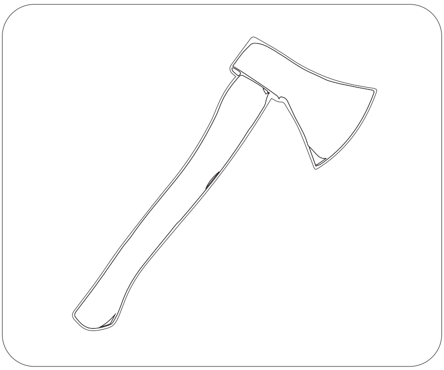


BAR CHAIRS
Used to support the reinforcement cage. A typical product is Whites 24954 65 mm Bar Chairs.

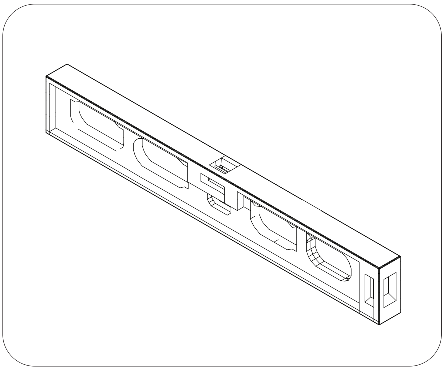
HAMMER
Used during B.2 Site Measurement to create the hurdles, B.5 Formwork Manufacture to drive nails in when creating the formwork, B.9 Concrete Pour to vibrate concrete.



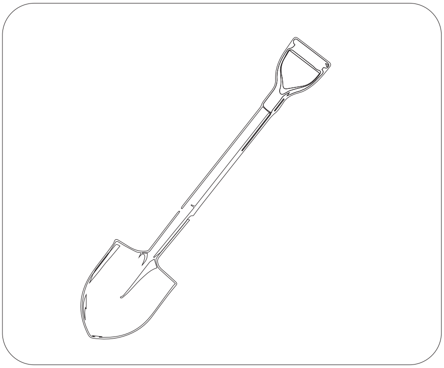
PLYER
Used during B.7 Reinforcement to twist and cut the galvanised tie wires.



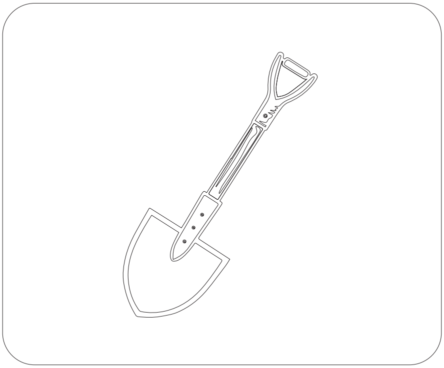
AXE
May be required during B.1 Site Preparation for cutting roots when digging trenches.



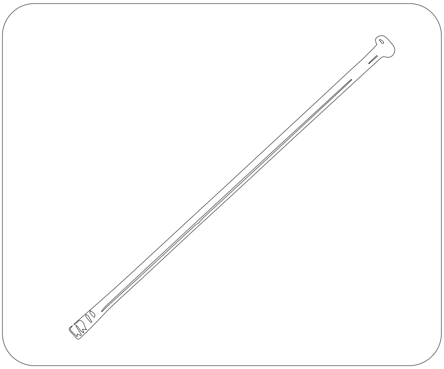
SPIRIT LEVEL
Used throughout the construction process to check levels are straight (e.g. B.5 Formwork Manufacture, B.6 Formwork Placement, and B.8 Locating Cast-in).



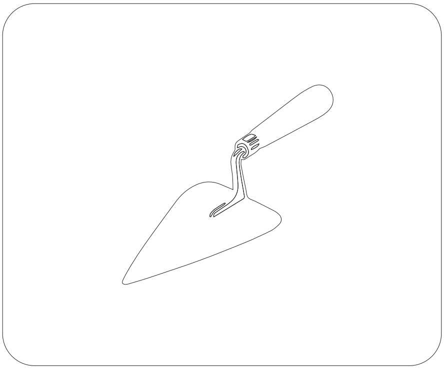
SHOVEL
Used for scooping dirt from the footing holes in steps B.3 Foundations and B.6 Formwork Placement, and filling dirt during B.9 Concrete Pour.



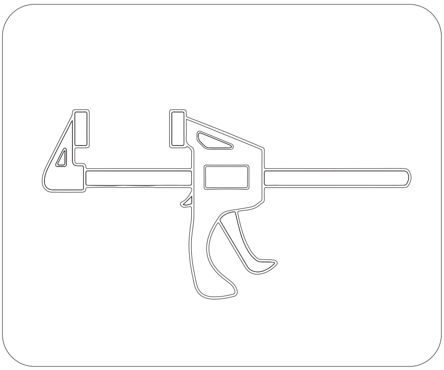
SPADE
Used for digging the footing holes in steps B.3 Foundations and B.6 Formwork Placement.



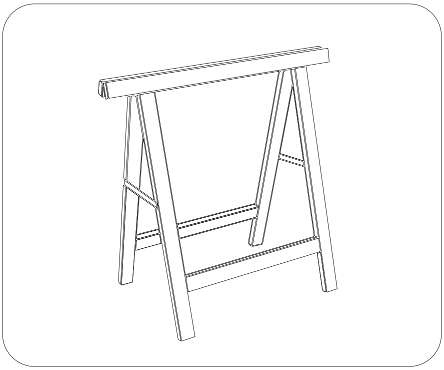
CROW BAR
A heavy iron bar used for breaking the earth when excavating the footing holes in step B.3 Foundations.



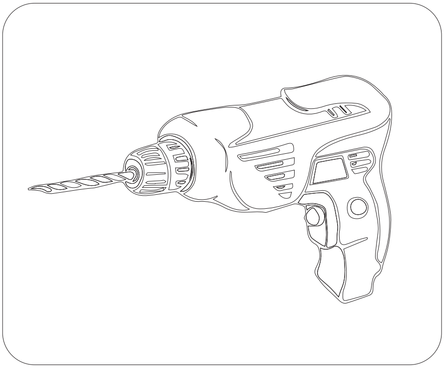
TROWEL
Used for smoothing and shaping the top of the concrete during B.9 Concrete Finishes.



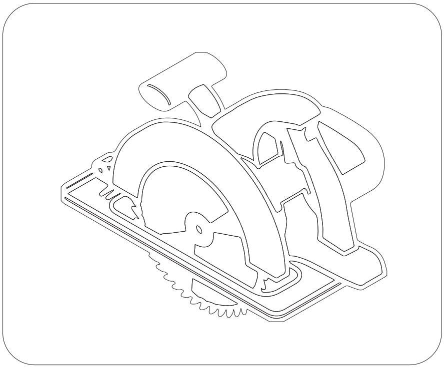
CLAMPS
Used to align and secure materials during B.5 Formwork manufacture and B.6 Formwork placement.



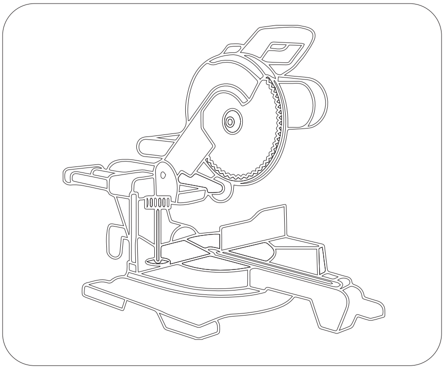
TRESTLE (x 2)
Assembled when cutting materials during B.5 Formwork Manufacture.



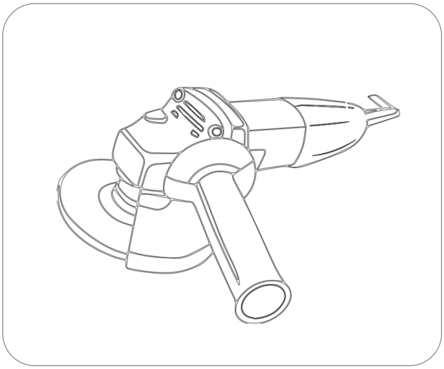
BATTERY OPERATED DRILL
Used to drive screws into timber during B.2 Site Measurement, B.5 Formwork Manufacture, and B.8 Locating Cast-in.



CIRCULAR SAW
Used to cut Formply during B.5 Formwork Manufacture.



DROP SAW
Used for cutting MGP10 Untreated Pine during B.5 Formwork Manufacture.



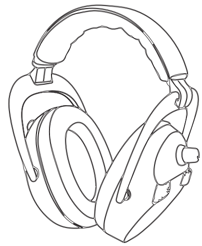
ANGLE GRINDER
Used for cutting the reinforcement cage in B.7 Re-inforcement and the bottom of the steel plate in B.8 Locating Cast-in.

Use of the angle grinder use to cut the bottom plate of the Quad footing.

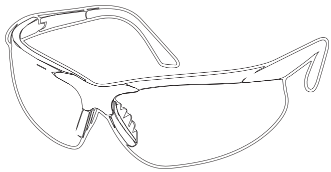
A.6 SAFETY

The following Personal Protective Equipment (PPE) is recommended on site.

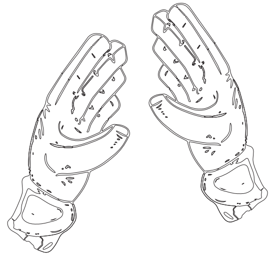
WORK BOOTS
Foot protection, must be worn on site at all times.



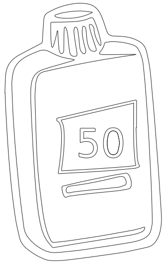
EAR MUFFS
Ear protection, wear during operation of power tools.



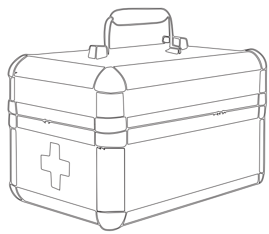
SAFETY GLASSES
Eye protection, wear during operation of power tools.



GLOVES
Hand protection, wear as required during the operation of power tools, manual labor (e.g. digging), or handling of abrasive materials (e.g. concrete).



SUN PROTECTION
Sun screen, broad-brimmed hat, and long-sleeved clothing is recommended.



FIRST AID KIT
Keep a fully-stocked first aid kit on site at all times.

Digging the footing holes at Site 1.

B. CONSTRUCTION PROCESS

B.1 FORMWORK DESIGN

MATERIALS:

- NA

TOOLS:

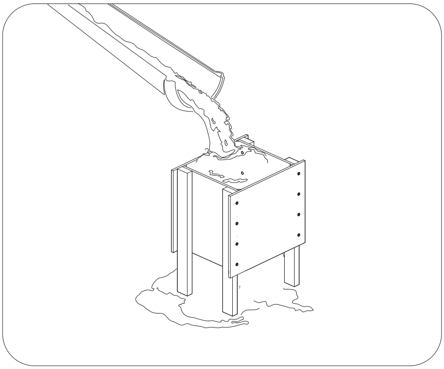
1 X RULER & PENCIL

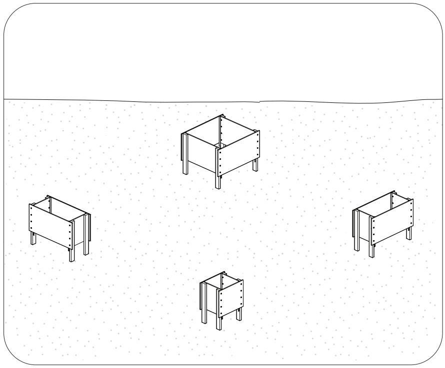
1 X PAPER, NOTEBOOK OR WHITEBOARD

1 X TAPE MEASURE

FIXINGS:

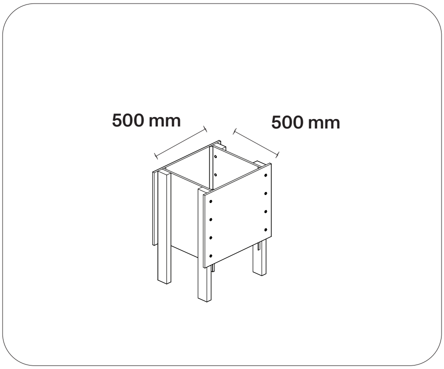
- NA

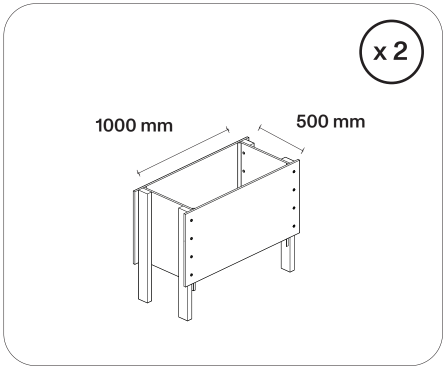




1 Formwork is a temporary or permanent mould into which concrete or similar materials are poured. For the footings at Cummeragunja, the formwork is a mould for the concrete to set in.

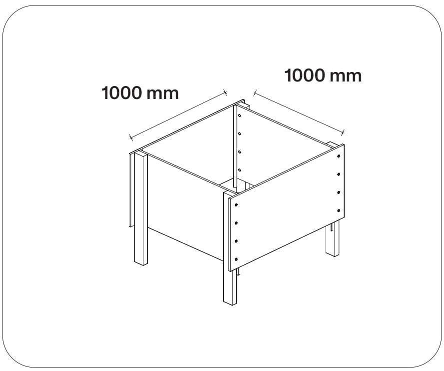
2 Formwork was designed for each of the four footings: Single, Double (x2), and Quad.

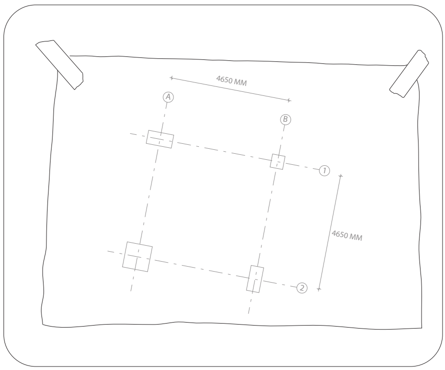




3 The Single concrete footing (500×500mm) was the smallest and sized to accommodate a single, vertical steel plate.

4 The Double concrete footing (500×1000mm) was twice the size of the single footing and sized to accommodate two steel plated on a diagonal.





5 The Quad" concrete footing (1000×1000mm) was the largest and sized to accommodate four steel plates.

6 Plan formwork with rough sketches, measurements, and a cut list.

B.2 FORMWORK MANUFACTURING

MATERIALS:

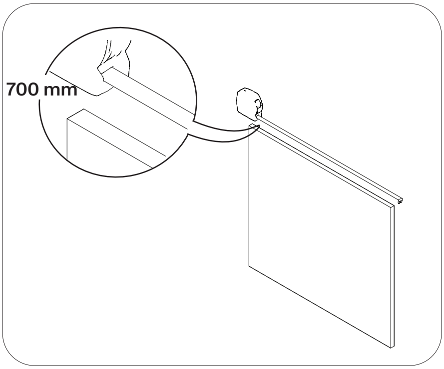
- 2 X FORMPLY (16 MM) CUT TO 500 X 700 MM
- 2 X FORMPLY (16 MM) CUT TO 500 X 500 MM
- 4 X UNTREATED PINE (90 X 45 MM) CUT TO 800 MM
- 4 X TRIMOULD (25 MM) CUT TO 675 MM

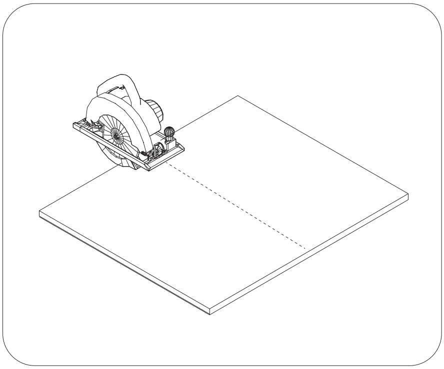
TOOLS:

- 1 X HAMMER
- 1 X RULER & PENCIL
- 1 X TAPE MEASURE
- 1 X SPIRIT LEVEL
- 4 X TRESTLES
- 2 X QUICK GRIPS
- 1 X CIRCULAR SAW
- 1 X ELECTRIC DROP SAW
- 1 X ELECTRIC DRILL

FIXINGS:

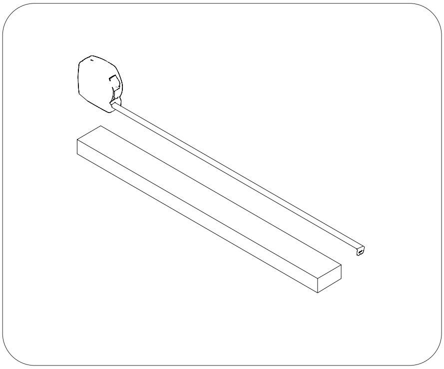
- 10 X FLATHEAD NAILS
- 16 X TEK SCREWS 50 MM
- 16 X BATTEN SCREWS 50 MM

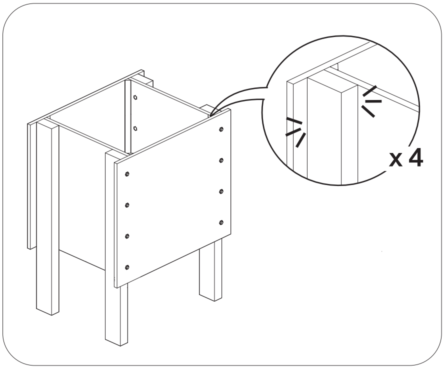




1 First measure the Formply as per the cut list. As mentioned in Part A, Formply is a structural plywood suitably strong for the concrete formwork.

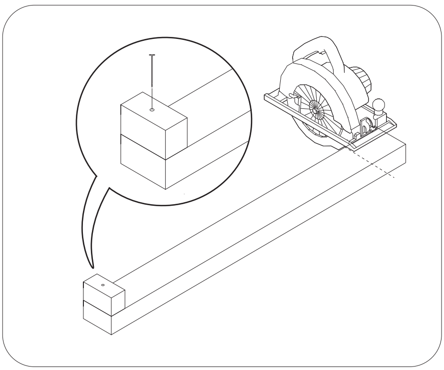
2 Cut the pieces of Formply with a circular saw. Ensure that PPE is worn at all times.

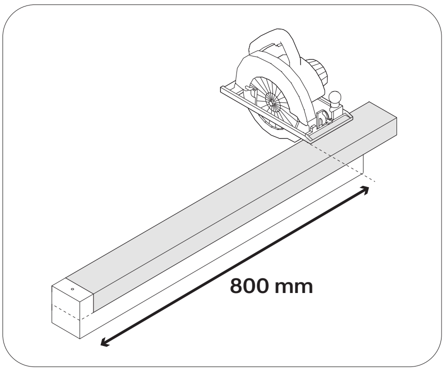




3 Next, measure the four lengths of studwork (MGP10 Untreated Pine 90×45mm) to be cut with the drop saw.

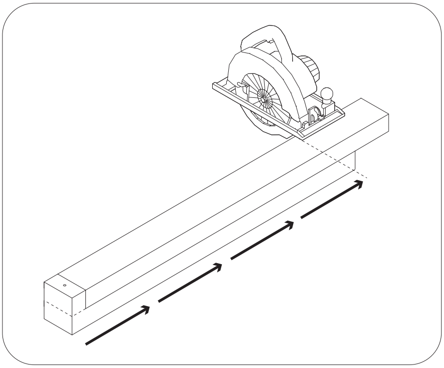
4 The Untreated Pine studs act as a brace to help the formwork stay straight during the concrete pour.





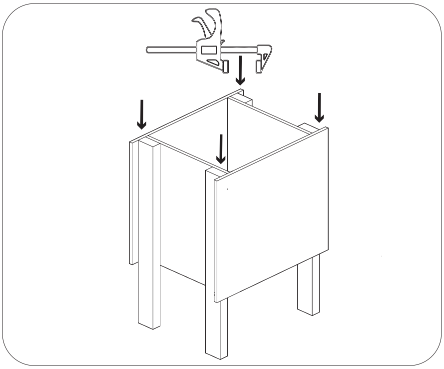
5 To increase efficiency when cutting similar length timbers, a jig can be made wherein the length required to cut is measured and a piece of timber is secured perpendicularly by nailing it to the frame.

6 When cutting the Untreated Pine, an 800mm jig was established and the Pine was cut accordingly .

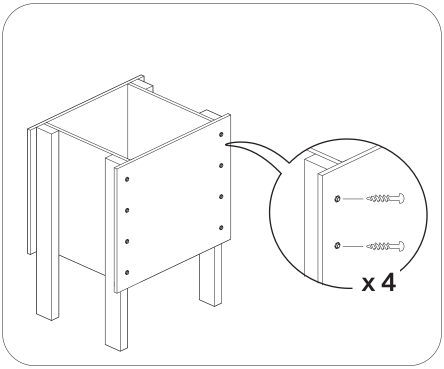


7 Cut long pieces first as this allows room for error and prevents new timbers needing to be cut when mistakes are made.

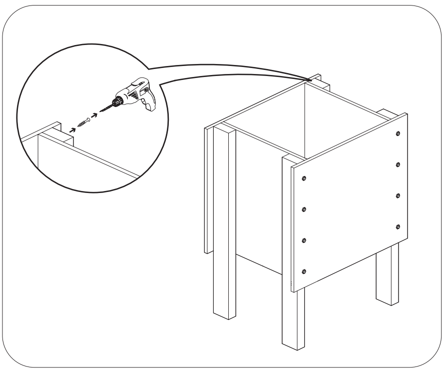
8 David highlighted the importance of double-checking measurements and undercutting after we first cut the pine to 820mm and then cut it down to 800mm using the jig.



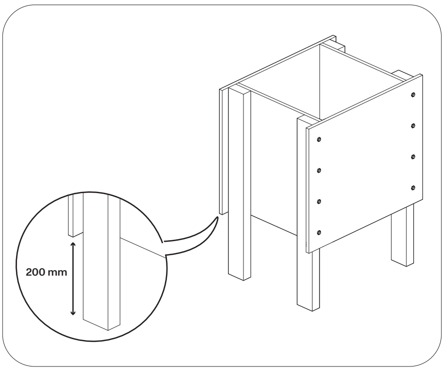
9 Next use "Quick Grips" to clamp the stud to the ply and establish the correct alignment.



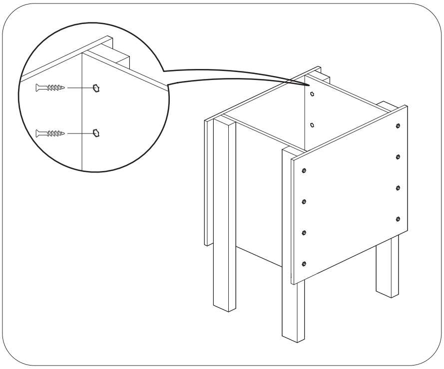
10 First, use the drill to fix 4 × 50mm Tek screws to the outside of the Formply to each MGP10 Untreated Pine stud.



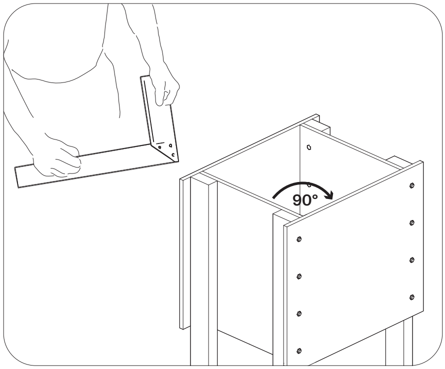
11 The top of the stud should be flush with formwork. Note that if a mistake is made, simply put the drill in reverse to remove the screw.



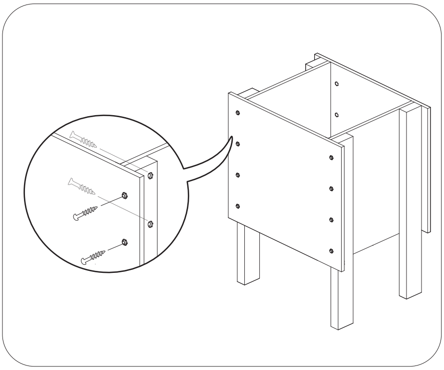
12 The bottom of the Pine stud should sit 200mm below the bottom of the formwork.



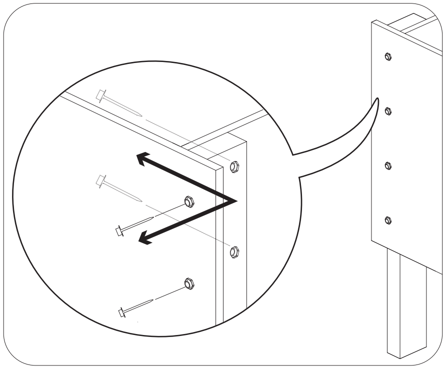
13 Next, use the drill to internally fix 4 × 50mm Batten screws to each MGP10 Untreated Pine stud.



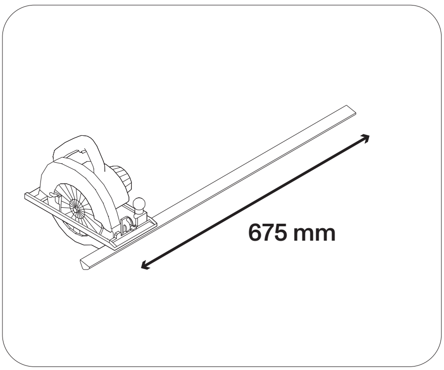
14 A set square is used to confirm the Formwork is at right angles.



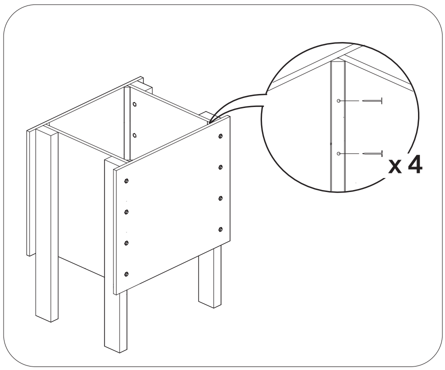
15 The use of multiple nails in opposite directions triangulates the force at this connection.



16 This means that instead of sheer forces being born in one nail, axial forces are born in two which have better resistance.

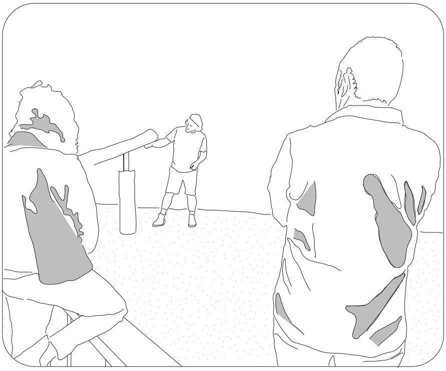


17 Finally, create the formwork's chamfered edge by cutting 4 × 675mm Trimould lengths with the drop saw.



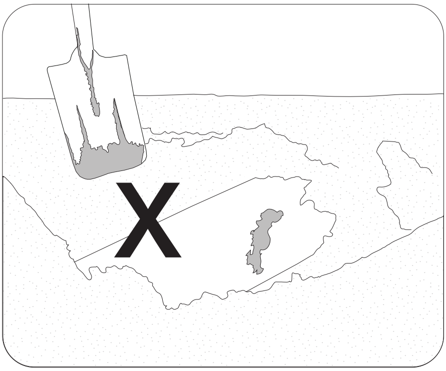
18 Nail the Trimould to the inside corners of the formwork, ensuring the nails are flush with the Trimould surface.

B.3 SITE PREPARATION

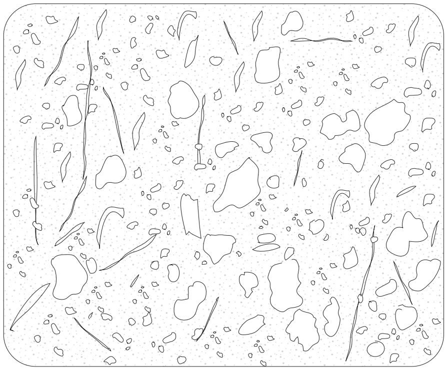


1 Consult with community leaders to agree upon the site and design of the structure.

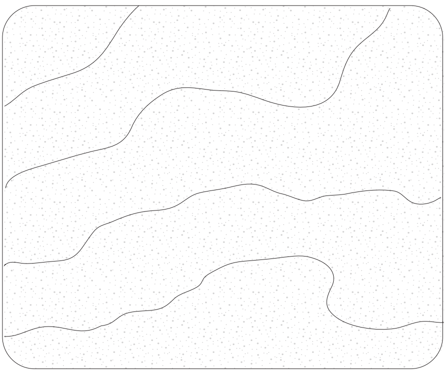
2 Once a general site has been agreed upon, select an area clear of trees, roots, and stumps.



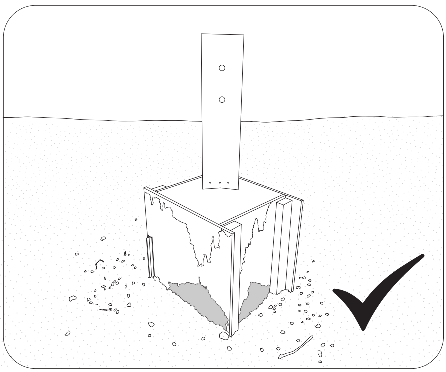
3 Check for existing water, gas, and sewerage lines as digging in these areas should be avoided.



4 Consider the type of soil on-site. The soil by the river in Cummeragunja is clay-based. Clay is fine-grained and expands or contracts according to presence or lack of water.



5 Alternatively, sand is coarse-grained and free draining. A Geotechnical engineer would typically provide an assessment of the soil before building goes ahead.



6 As will be discussed later, the use of isolated pad footings is an appropriate structural approach to the foundations in this soil.

B.4 SITE MEASUREMENT

MATERIALS:

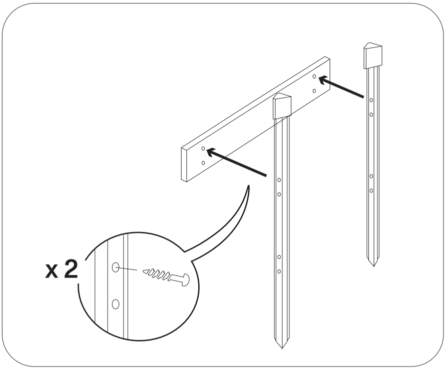
- 2 X MGP10 UNTREATED PINE TIMBER FRAMING (120 X 35 MM) CUT TO 700 MM
- 2 X MGP10 UNTREATED PINE TIMBER FRAMING (120 X 35 MM) CUT TO 700 MM

TOOLS:

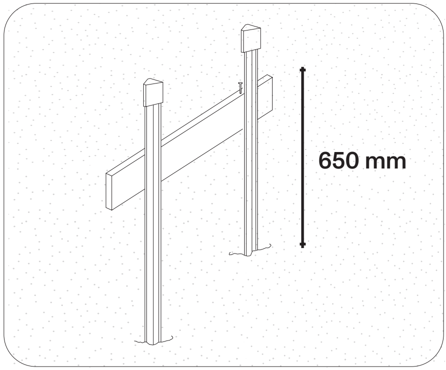
- 1 X HAMMER (CLAW HAMMER)
- 8 X STAR PICKETS (WITH SAFETY CAPS)
- 1 X BUILDERS LINE (100 METER ROLL)
- 1 X LAYOUT SQUARE
- 1 X TAPE MEASURER
- 1 X SPIRIT LEVEL
- 1 X THEODOLITE

FIXINGS:

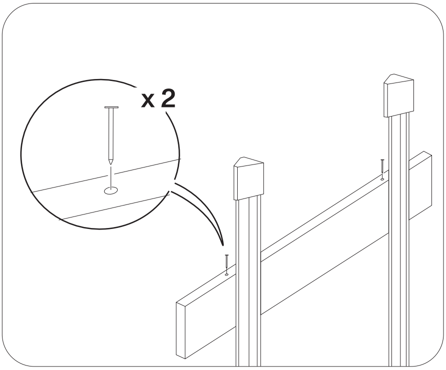
- 8 X FLATHEAD NAILS
- 8 X TEK SCREWS



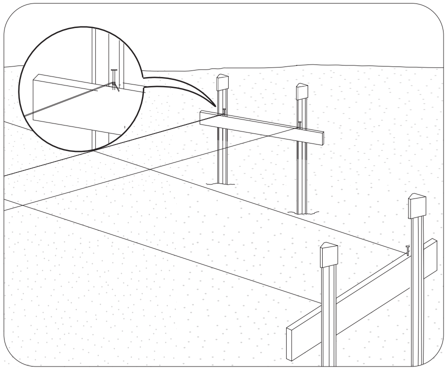
1 Construct hurdles at the edge of each footing from 90×45mm MGP10 Untreated Pine by drilling 2 x Tek screws into 2 x Star Pickets with safety caps.



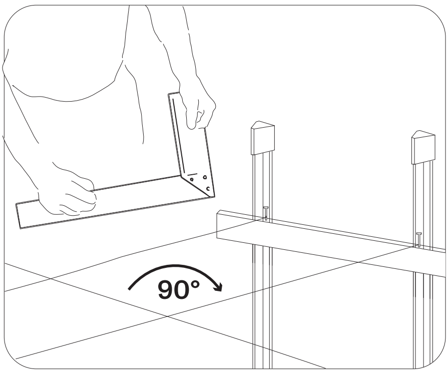
2 Set the top of the hurdles to 650mm above ground. Confirm this using a tape measure.



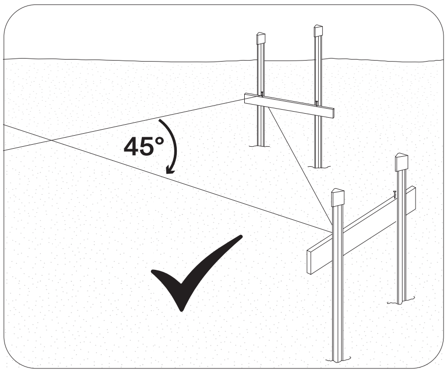
3 Set out a grid establishing the outer edges of the footing holes to be dug by nailing “pegs” to the top of the hurdles in line with the inner lines of the formwork.



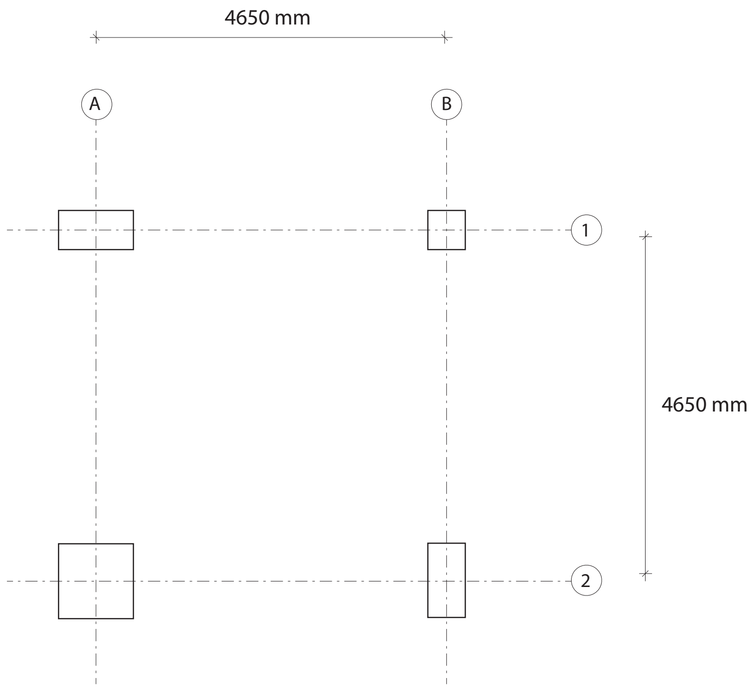
4 Run the first string line around a peg and repeat the process for each hurdles until the grid is complete.



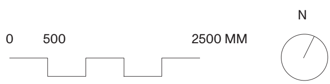
5 A layout square is used to ensure the grid is at 90°.



6 Diagonal strings can also be run to confirm the grid is at right angles. Finally, a tape measure and/or theodolite can be used to double check the placement of strings.



Site Set Out 1:100 @ A5



B.5 FOUNDATIONS

MATERIALS:

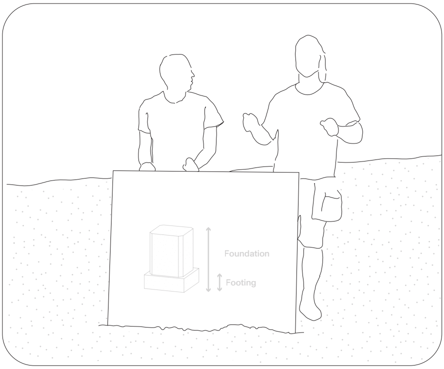
- NA

TOOLS (PER FOOTING):

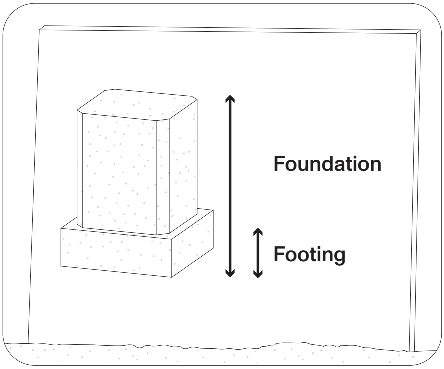
- 1 X CROW BAR
- 1 X SPADE
- 1 X SHOVEL
- 1 X SPIRIT LEVEL
- 1 X TAPE MEASURER

FIXINGS:

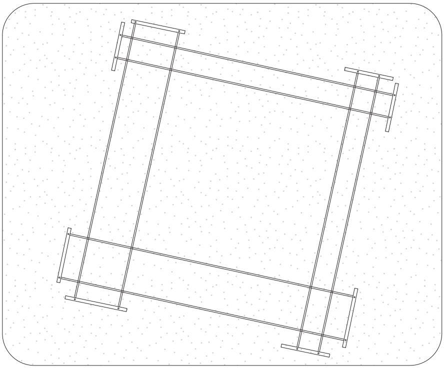
- NA



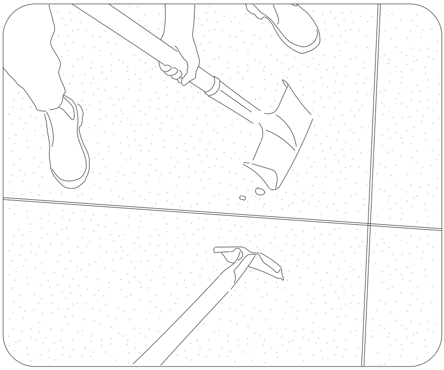
1 Before starting work on footing construction it is important to note the difference between a foundation and a footing.



2 A footing is the bottom part of a foundation that supports the structure. As perforated steel will be used for the Pavilion roof, we are able to have smaller foundations as there will be less lift.

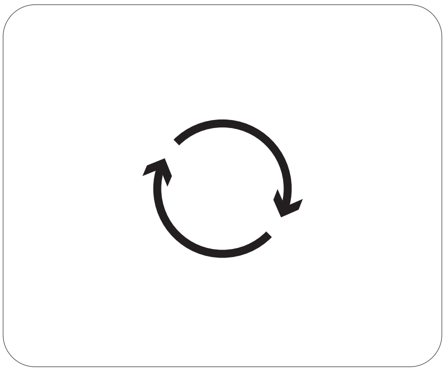


3 Once the site has been correctly measured you are ready to start excavating the footing holes!



4 Excavation can be completed via manual labor with shovels, spades, and crow bars. Start at the inside corner of the string and dig until the footing holes are 400mm deep for the formwork to sit in.

5 Note that it is better to over- rather than under-dig the footing holes as the holes can be filled-in later after placing the formwork.



6 If the client decides to move the site (as occurred in Cummeragunja) fill-in the old trenches, and repeat steps 3-5 at the new site. Adjust the footing depth to 200mm accordingly.

B.6 FORMWORK PLACEMENT

MATERIALS:

- NA

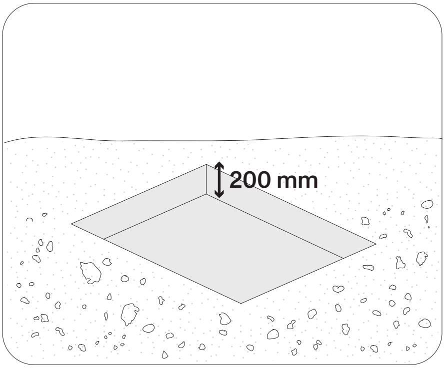
TOOLS:

1 X SPIRIT LEVEL

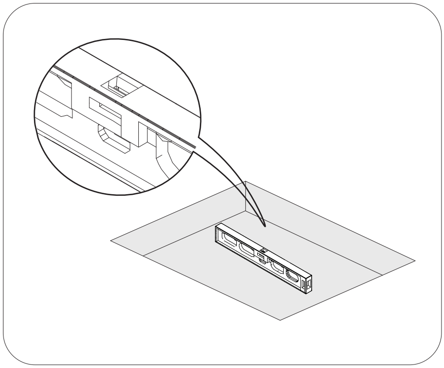
1 X THEODOLITE

FIXINGS:

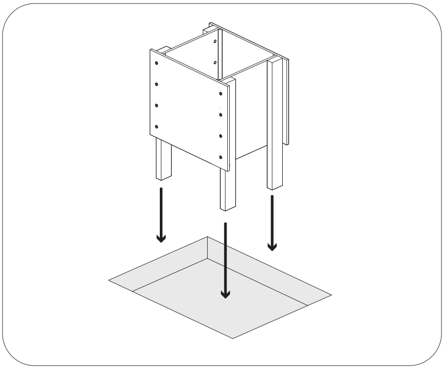
- NA



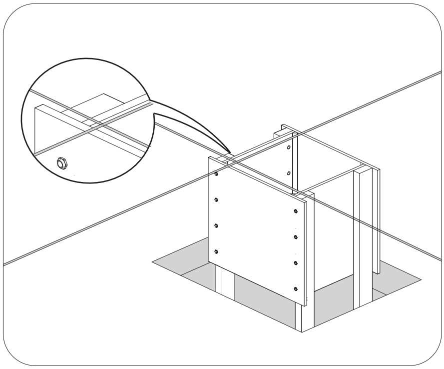
1 Ensure the sides of the footing holes are flush and the bottoms are level and compact.



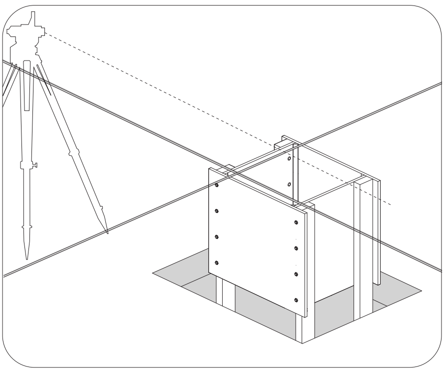
2 A spirit level can be used to confirm their flatness.



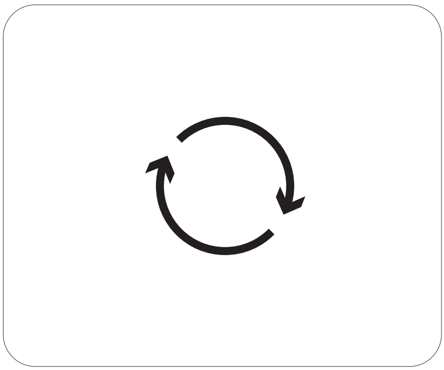
3 Lower the formwork into the footing hole.



4 Ensure the (outer/inner) edges of the formwork is flush with the string lines.



5 Use the theodolite and the spirit levels to ensure the formwork is exactly level.



Repeat steps 1-4 as necessary.

6

B.7 REINFORCEMENT

MATERIALS:

3 X REOMESH SHEET (7MM BAR) CUT TO 400 X 400 MM

4 X REOMESH SHEET (7MM BAR) CUT TO 400 X 650 MM

TOOLS:

1 X ANGLE GRINDER

1 X PLYERS

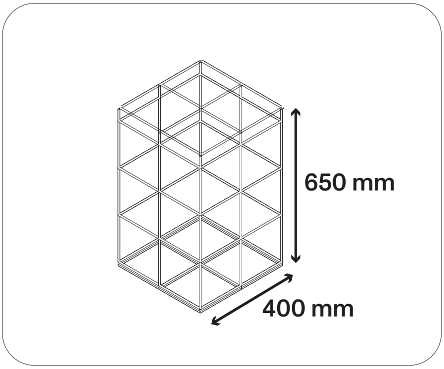
4 X BAR CHAIRS

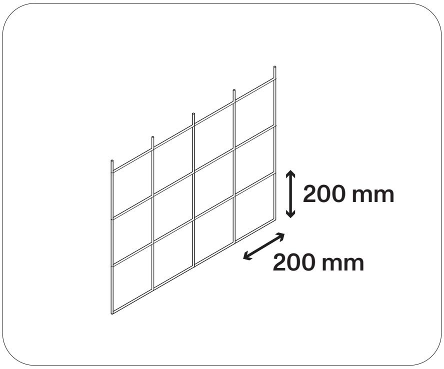
1 X TAPE MEASURE

1 X SPIRIT LEVEL

FIXINGS:

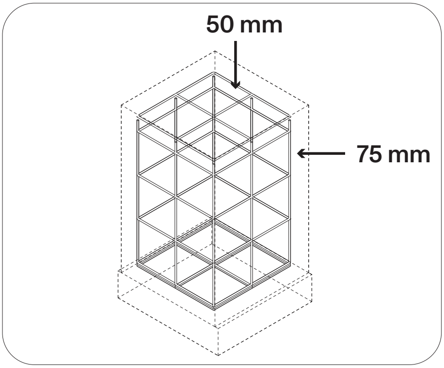
10 X TIE WIRE

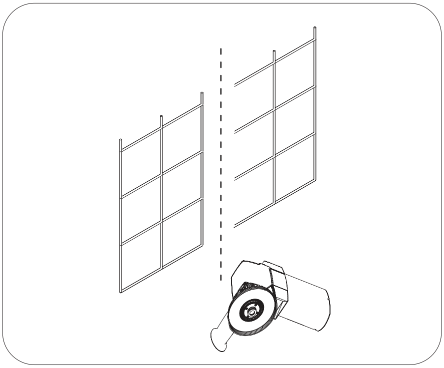




1 The reinforcement cage was constructed from Reomesh sheet with 7mm bars.

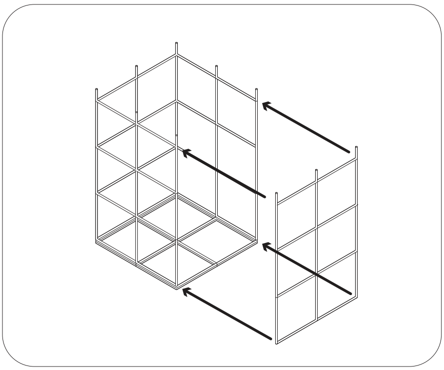
2 First plan the cuts of the Reomesh sheets based on the footing size. Measure in sections (200mm blocks) to conserve materials.

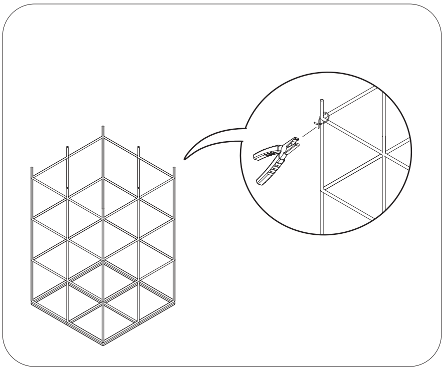




3 The reomesh will be placed 50mm from top and sides, 75mm from the bottom of the footing to prevent rust as concrete becomes waterproof at 30mm.

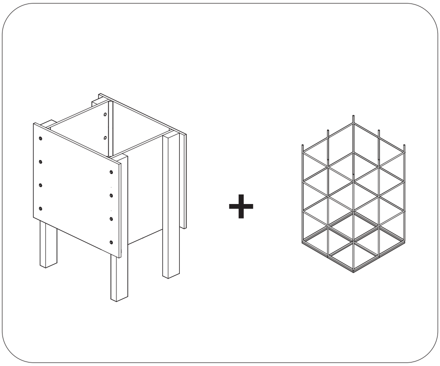
4 Cut the Reomesh sheet with an angle grinder. When using the angle grinder, always cut away from your body, and do not cut near dry vegetation or wear flammable materials that can ignite from the sparks.



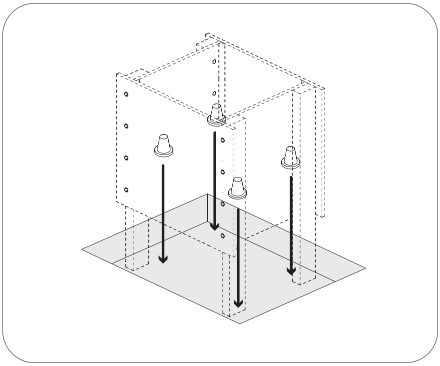


5 Assemble the reomesh into a cube with a double sheet at the bottom. Initially leave off the top off the cage, as it will be fixed around the steel beam after it's placed.

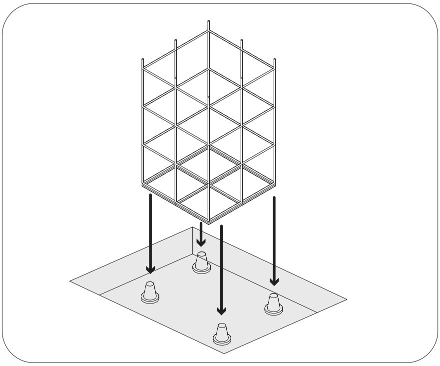
6 Fix the sections together in the corners with tie wire, twist the wire with the pliers and cut off the excess wire.



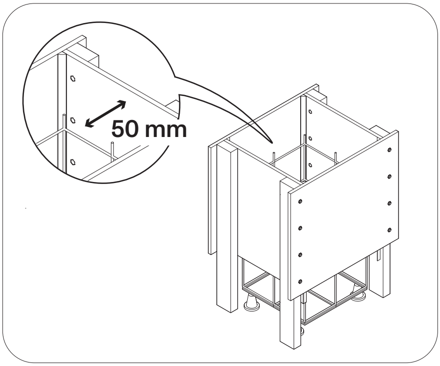
7 Now that you have completed the reinforcement cage, it can be carefully placed inside the formwork!



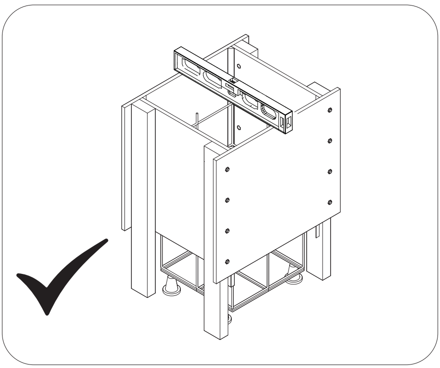
8 Place 75mm bar chairs on ground inside the footing hole.



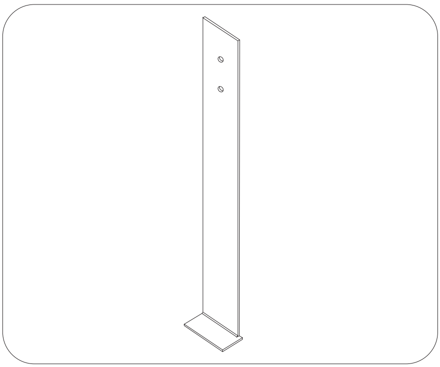
9 Lower the reinforcement cage on top so that the bottom of the cage sitting in the groove of the “saddle”.



10 Use a tape measure to check the cage is 50mm from the sides and 75mm from the edges of the formwork.



11 A spirit level can again be used to confirm the cage’s flatness.



12 You are now ready to locate the cast-in steel plate!

B.8 LOCATING CAST-IN

MATERIALS:

2 X MGP10 UNTREATED PINE (120 X 35 MM)

2 X MGP10 UNTREATED PINE (OFFCUTS)

TOOLS:

1 X PENCIL & RULER

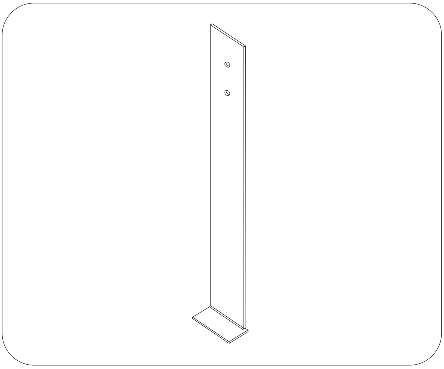
1 X TAPE MEASURE

1 X QUICK GRIPS

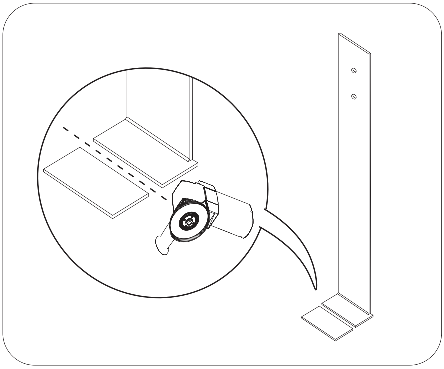
2 X STAR PICKET WITH SAFETY CAP

FIXINGS:

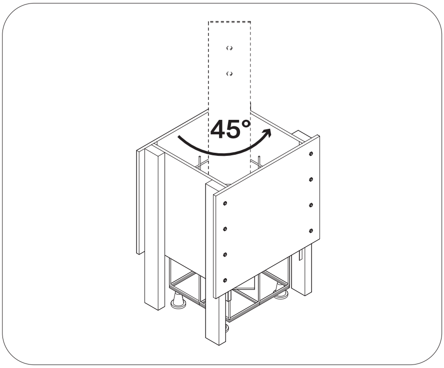
6 X TEK SCREW 50MM



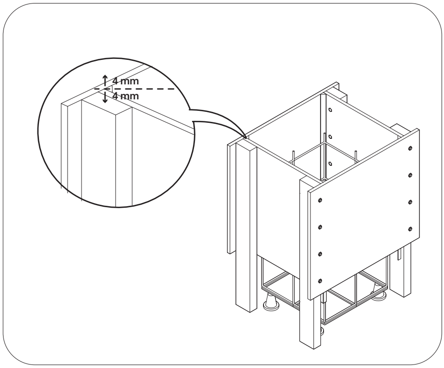
1 Carefully check the steel plate and make any final modifications as required.



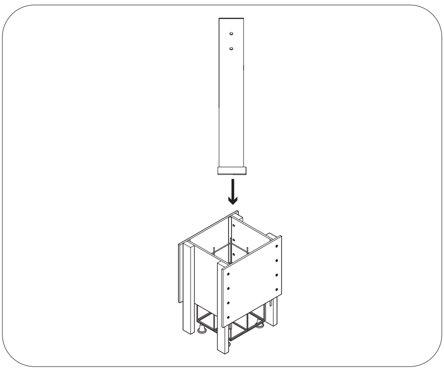
2 An angle grinder was used to cut off excess metal on the bottom.



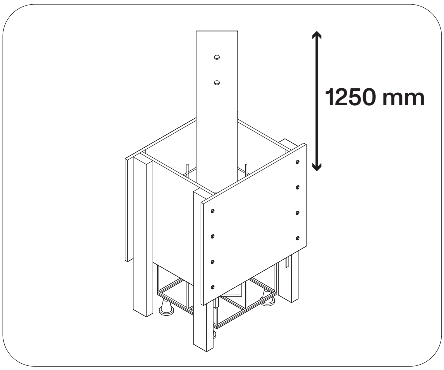
3 First choose the orientation of the steel plate; either on a diagonal at 45 ° or straight in each direction.



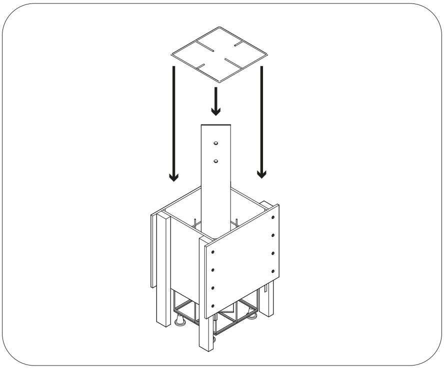
4 Next identify the center line of the steel plate on the formwork. Mark the center point of where the 8mm steel plate will be located and 4mm either side.



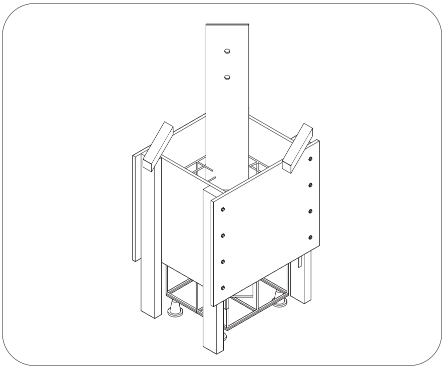
5 Carefully lower the 8mm steel plate into the formwork, aligning the plate with the measurements taken in step 4.



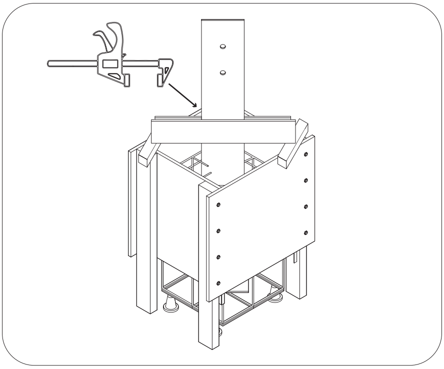
6 Ensure that the steel plate height is 1250 mm above the top of the formwork.



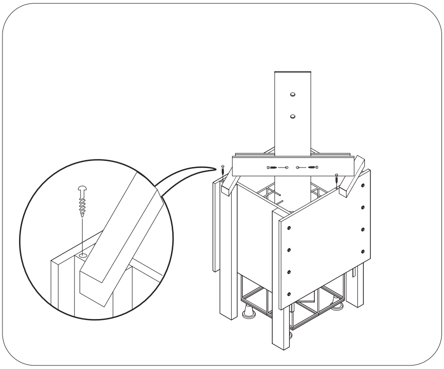
7 Place the top piece of the reinforcement cage over the 8mm steel plate and fix it in place with tie wires.



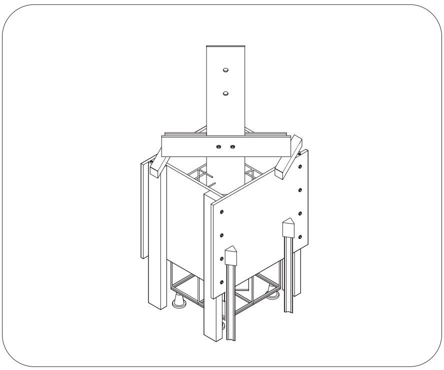
8 Finally, brace the cast-in by placing two timber offcuts diagonally across two corners of the formwork



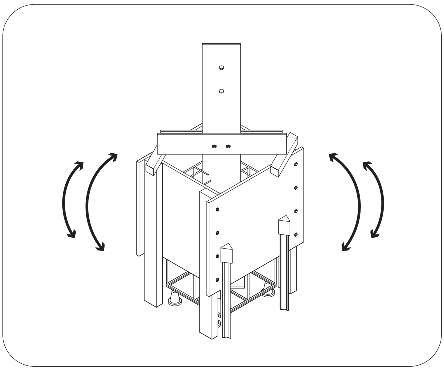
9 Then clamp two pieces of MGP10 (120×35mm) to either side of the steel plate.



10 Fix the MGP10 to the steel plate using Tek screws.



11 Drive two star pickets with safety caps into the ground on either side of the formwork.



12 The star pickets will help to prevent bowing of the formwork during the concrete pour.

B.9 CONCRETE POUR

MATERIALS:

3 X 25 MPA CONCRETE (APPROX 0.27 M^3)

4 X DIRT

TOOLS:

1 X SHOVEL

1 X CROW BAR

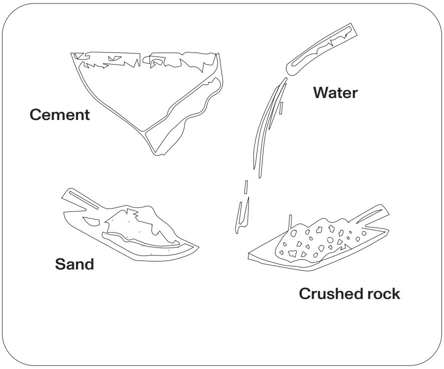
1 X HAMMER

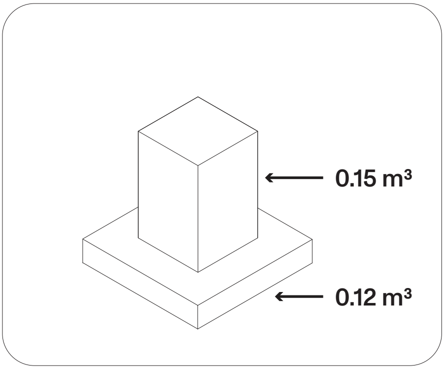
1X MALLET

1X SPIRIT LEVEL

FIXINGS:

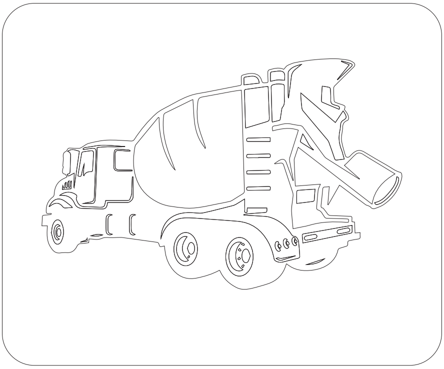
-

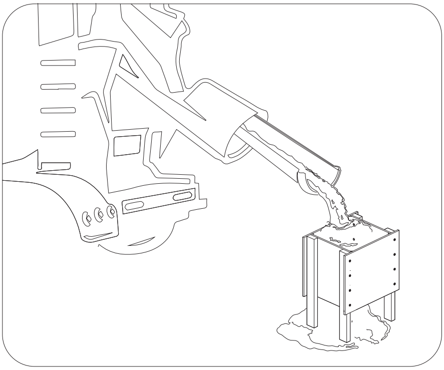




1 Concrete is an ideal material for the footings owing to its high strength, being composed of sand, cement, crushed rock and water (which acts as the active ingredient).

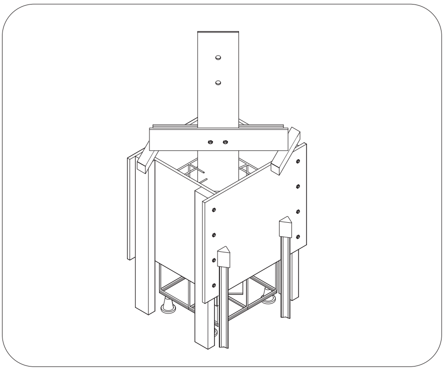
2 Calculate the approximate volume of concrete required. The amount of concrete necessary to, for example, resist lift in heavy wind, was determined by the structural engineers.

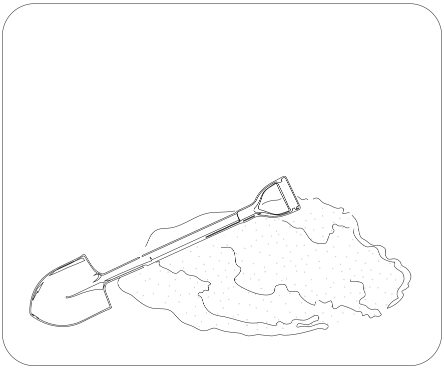




3 A professional concrete mixer was brought to site

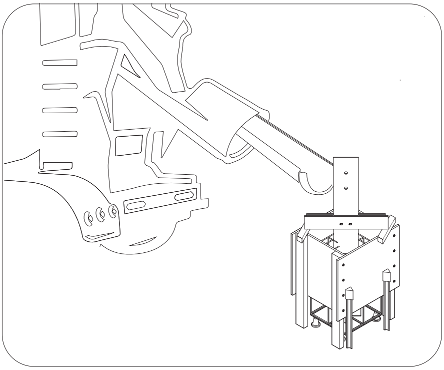
4 This saved time and labor, but incurred greater transportation and rental costs than if concrete had been mixed on site.

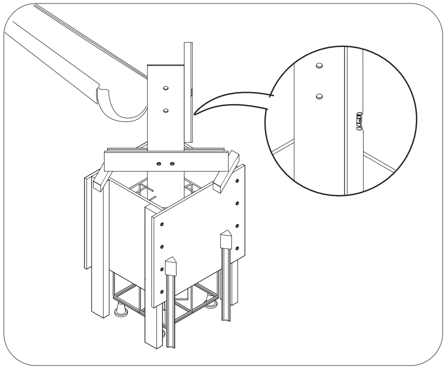




5 Check all formwork and complete any last minute reinforcements before the pour.

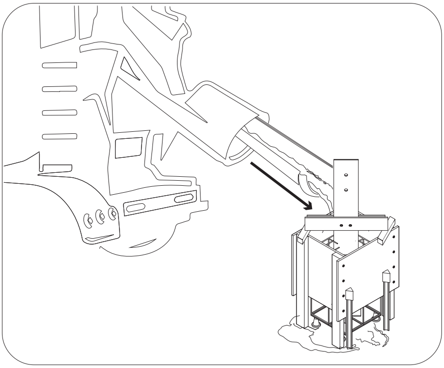
6 Have piles of dirt and shovels at the ready to fill -in the edges of the footings during the concrete pour.

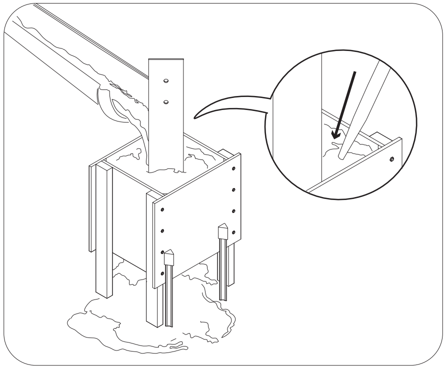




7 When you are ready, guide the concrete truck's chute to the formwork.

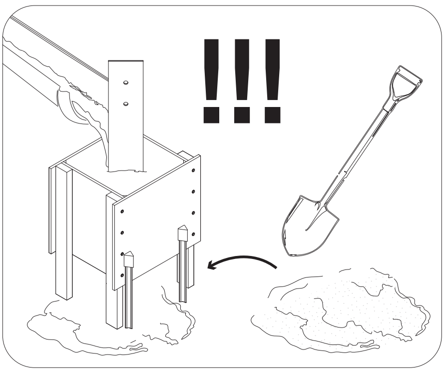
8 Confirm the cast-in is straight using a spirit level. Hold the spirit level to the steel plate during the concrete pour, correcting the plate's alignment if disturbed by the concrete.

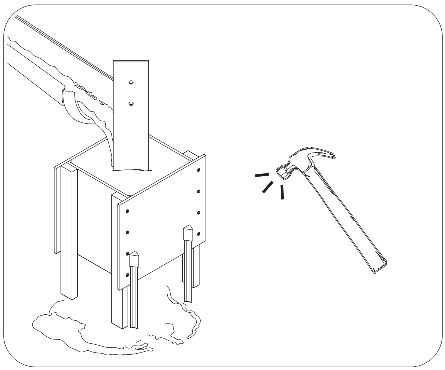




9 Start pouring the concrete, pausing if necessary to allow the concrete to settle.

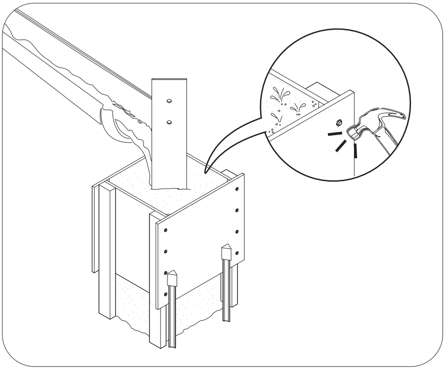
10 Use a crow-bar to push the concrete through the formwork and ensure that it is evenly distributed.



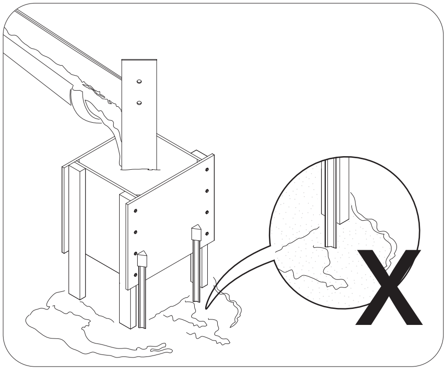


11 Once excess concrete emerges from the bottom of the formwork, shovel soil around the base to prevent excess leaking.

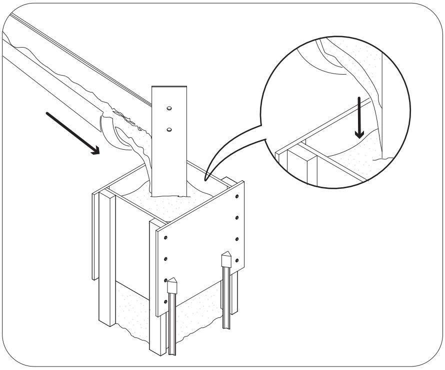
12 Once poured, use a hammer or mallet to knock on the side of the formwork.



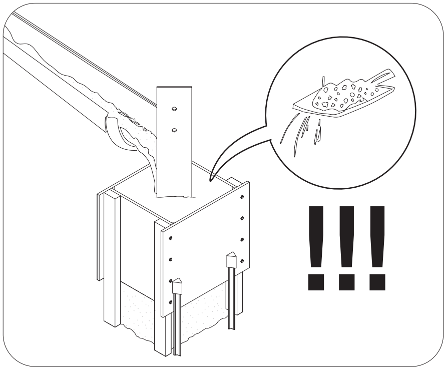
13 “Vibrating” the concrete in this way reduces the change of air pockets forming in the footing which compromise the concrete’s strength.



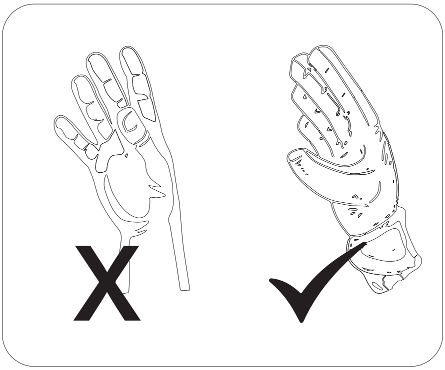
14 Be careful not to vibrate the concrete too much as this will cause further leakage out of the bottom of the footing.



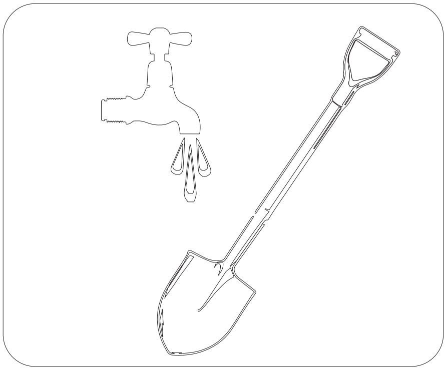
15 The concrete level will drops as it settles inside the formwork and air bubbles dissipate. Top it up accordingly.



16 If the concrete needs to be stronger then the mix can be amended by adding more cement.



17 Note that concrete is very corrosive to touch. Wear gloves when handling it and take care not to touch wet concrete with bare hands.



18 Finally, carefully wash shovels, crow bars and any other tools that came into contact with the concrete or cement as once set the concrete is near impossible to remove!

B.10 CONCRETE FINISHES

MATERIALS:

-

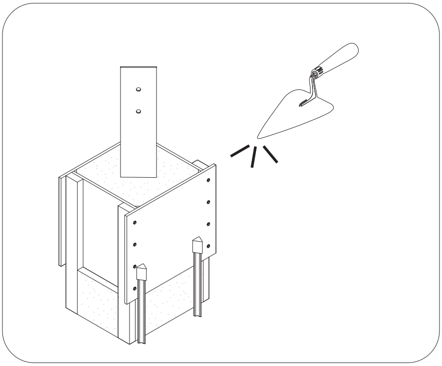
TOOLS:

1 X TROWEL

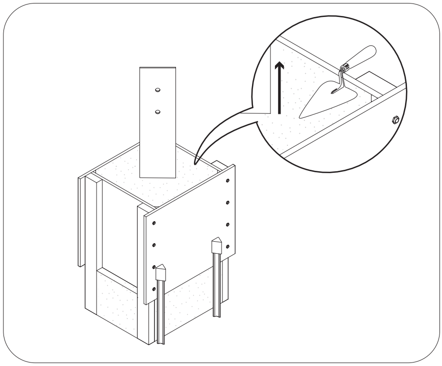
1X ELECTRIC DRILL

FIXINGS:

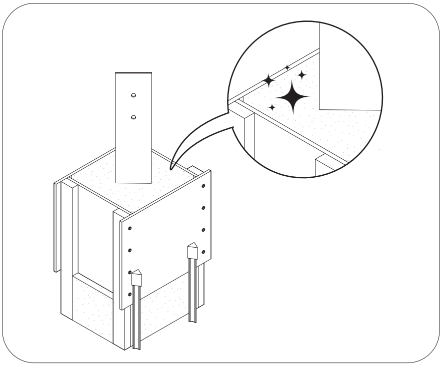
-



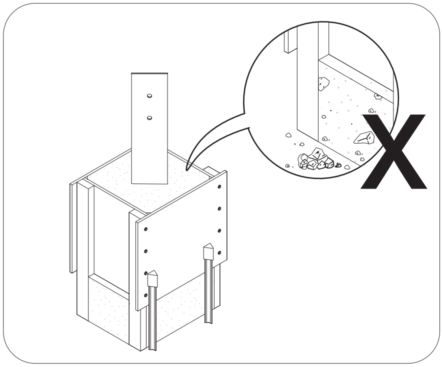
1 In the final stages, use a trowel to smooth the top of the concrete.



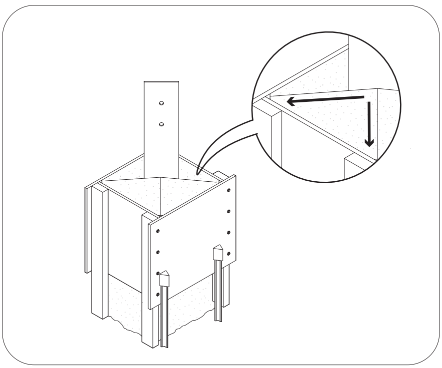
2 Troweling on top of the concrete bring the cement up and helps to harden.



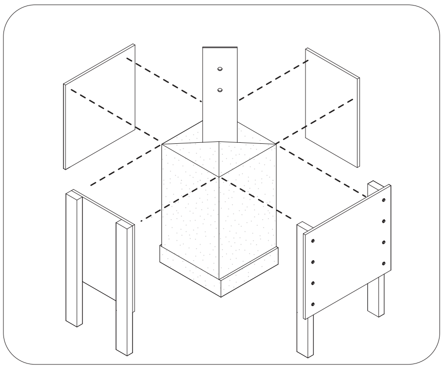
3 The footings at Cummeragunja were troweled until a glaze was achieved on top.



4 Troweling was also necessary to avoid a rough surface where pieces can easily break off.



5 When troweling, slope the concrete down towards the edges, thereby creating a subtle pyramid to drain water.



6 After the concrete has dried (the amount of time this takes will vary), carefully disassemble and remove the formwork from the footing.

C. PROJECT REFLECTION

OVERALL

Building the footings at Cummeragunja was a rich learning journey. As someone with no construction experience prior to this subject, having to learn, document, and reflect upon, construction methods has been highly valuable. The seemingly simple task of building the Pavilion's footings has illuminated the complexity of construction processes, as well as the detailed planning, skills, and organisation necessary to successfully complete them.

Documenting the construction process in this journal has been particularly useful for reflecting upon the experience. The irony has been that despite the need to present this journal as a methodical, "step-by-step" construction manual, construction of the footings at Cummeragunja was a far from linear process. A variety of unexpected factors shaped the project from its inception, including engineering requirements, divergent community expectations, and even a global pandemic (which saw the completion of the footings almost 12 months after initially planned)!

This reflection focuses upon issues of cultural and environmental sustainability, and engineering concepts learned throughout the construction process. Each section of the reflection aims to highlight what worked, and where there is room for future improvement. The need to forge sustainable cultural relations when working with communities is perhaps the most critical lesson from this experience that I look forward to developing and applying in my future studies and work.

The “Single” footing team, from left to right: Frank, Yuan, Marnie, Adam, Perri, and Bronwen.

C.1 CULTURAL SUSTAINABILITY

DO:

✓ Be flexible and adaptable to change

✓ Familiarise yourself with frameworks for best practice

✓ Listen and be respectful at all times

DON'T:

X Ignore issues as they arise

X Make assumptions about what has been communicated

WORKING WITH COMMUNITY

Undoubtedly, cultural sustainability is the most important issue to reflect upon from the construction process at Cummeragunja. As David reminded us, this was a real world project and not "design tourism." Community leaders at Cummeragunja such as Uncle Col and his family were consulted on the development of the Pavilion from an early stage. This will help the completed Pavilion to be a sustainable outcome appropriate for the site and community function as rest and story-telling space. Further community engagement was sought through inviting students from the Academy of Sport, Health and Education (ASHE) partnership between The University of Melbourne, Rumbalara Football and Netball Club to the site. The students participated in construction processes and particularly learned surveying skills under the guidance of Rob.

At the same time, seeking community engagement did not mean that all community members were happy with the project or felt informed about its development. The visit from Monica to the initial site highlighted the issues that can arise when working with communities, and the adaptable and open mindset needed to sensitively respond to these issues and find appropriate solutions.

In this respect, documents such as the "National Best Practice Framework for Indigenous Cultural Competency in Australian Universities," "Working with Aboriginal People," and "Australian Indigenous Design Charter" are helpful for guiding decision-making processes and should be consulted frequently.

ECONOMIES OF CONSTRUCTION

Clear drawings, site planning, and organisation are undoubtedly essential to construction processes. Engineers advise on appropriate siting and ease of construction in order to save time, money and resources.

However, in the case of building the footings at Cummeragunja such "economies of construction" needed to be balanced with complex community needs and shifting expectations. The key example of this was undoubtedly the decision to move the site on Day 2 of construction.

Initial discussions with the community identified an appropriate site near the river bank and close to the campfire. A general consideration of orientation (inclement weather and sun position) was carried out. As the Pavilion is an open structure without walls and doors, environmental shelter is minimal and a person sitting inside the pavilion would be privy to the best site views from almost any position. The riverbank was deemed robust enough by Engineers to bear the weight of the Pavilion for the expected life-span of the structure (in particular, the Red Gum logs) and community leaders expressed an ability to move the unsealed road, if necessary.

Despite these careful consultations, resistance to the initial site meant the footings holes had to be filled-in and a new site identified and holes dug there. The change of site entailed a loss of labor and time, however, here the economics of construction had to be weighed against the importance of cultural sustainability and long-term need to force respectful cultural relationships.

A student from the ASHE program using the Theodolite/Dumpy Level.

C.2 ENVIRONMENTAL SUSTAINABILITY

DO:

- ✓ Carefully plan resources and over-cut timbers
- ✓ Use locally sourced and/or sustainable timbers
- ✓ Self-deliver materials to site where possible

DON'T:

- X Under-cut or waste materials
- X Leave externally exposed timbers untreated

A variety of environmental sustainability considerations also impacted the construction process.

WASTE MANAGEMENT

Waste is a serious issue in the construction industry. The waste generated on site at Cummeragunja consisted mostly of timber and metal offcuts (from the formwork and the reinforcement cage). Concrete mixing also generates waste of materials, however, we were not privy to this process as a professional concrete mixer was brought to site.

An initial lesson in waste management came from David during formwork design and manufacture at Melbourne University. We were instructed to cut longer lengths of the MGP10 Untreated Pine than necessary. This highlighted how when cutting timber lengths, it is better to cut lengths longer rather than shorter. Timbers that are too long can easily be cut down to size, however lengths that are cut too short may need to be discarded and new materials used.

Sometimes waste generated on site can be used for productive ends. One of the excess timber lengths of MGP10, for example, was used to create a jig. This was an clever solution that allowed correct cuts of the remaining timbers to be made efficiently.

SUSTAINABLE FORESTRY

Sustainable forestry entails utilising forest resources (e.g. timber products) without compromising the availability of these for future generations.

The use of pine timbers (such as *pinus radiata*) is a good example of using a sustainably forested timber in the construction process. Untreated pine (MGP10) was an essential component of the formwork, and an ideal timber for this application being easier and lighter (in terms of weight) to work with than hardwood, and yet strong and fast-growing.

Although not explicitly handled during the footing construction process, it is worth noting the provision of locally-sourced timber for the Pavilion posts. Using local Red Gum logs reduced the needs to fell trees specifically for the project, thereby reduced material costs and overall transportation costs for brining new logs to site. Locally-sourced and/or second-hand timbers should be used for construction processes where practicable. However, it is important to note the condition of such timbers before using them if they are already subject to degradation or warping.

Connected to this, all externally-exposed timbers must be treated to prevent rot. This is a sustainable practices that will increase the longevity of timbers in construction.

SELF-DELIVERY & PRE-FABRICATION

The self-delivery of materials to site can compliment environmental sustainability efforts. Delivery by suppliers to site raises significant additional cost as well as emissions from transportation (especially in the case of the length of travel to a relatively remote site like Cummeragunja). For the footings at Cummeragunja, a professional concrete mixer truck was brought to site. This increased costs but saved time and energy during the concrete mix and pour. All other materials, tools, and fixings were self-delivered to site from Melbourne University.

Pre-fabrication can also assist environmental sustainability efforts. Designing with standard-sized materials can help to reduce waste on site. While pre-fabrication did not appear to greatly impact the design and construction of the footings at Cummeragunja, this is a potential area of exploration for future projects.

Salvaged Red Gum logs to be used for the Pavilion's posts.

C.3 ENGINEERING CONCEPTS

DO:

✓ Consult with Structural Engineers early in the design process

✓ Employ a site Surveyor and

✓ Engage a Geotechnical Engineer to analyse soil quality

DON'T:

X Change the building site without consulting Engineers

X Hit pipes and drainage during excavation

STRUCTURAL ENGINEERING

The footings at Cummeragunja were designed in consultation with structural engineers from Arup. Their initial presentation at Melbourne University helped me to learn the role of the Structural Engineer in the design and construction processes, and how this role may differ to that of the Architect.

A variety of engineering concepts were introduced to us through the presentation to Arup. These included:

- Sheer and axial forces
- Live and dead loads (the dominant “load paths” on the Pavilions are wind and gravity)
- Designing to prevent uplift, sliding and overturning
- Ultimate limit state (ULS) and serviceability limit state (SLS)

The Engineers made recommendations for the footing design and construction in line with these concepts. A number of other factors informed their calculations, including the weight of shade structure to the supports; the soil type, the site’s proximity to water, and the drainage requirements.

BUILDABILITY

Having the Engineers from Arup on site was invaluable to understand the various construction options that exist and how solutions adapt in response.

A key example on this arose from the change in site on Day 2. The initial footing holes had to be 400mm deep, however the Engineers were able to confirm that the second footing holes could be shallower, only 200mm deep, as less depth was required further from the river bank.

The engineers also provided advice on the amount of reinforcement required to withstand the bending movement of the concrete. It is interesting to note here the “blow-out” of one of the double footings that occurred during the concrete pour. Additional bracing at the bottom of the formwork with a Star Pickett was necessary to prevent this.

Finally, the Engineers advised on moisture change in footing design. Concrete becomes waterproof at a standard distance of 70mm. In the case of the footings at Cummeragunja, 75mm was selected as the nominal distance to place the reinforcement within the concrete footing because of the footings’ contact with the earth. This distance acts as a barrier between wet and steel to protect the reinforcement from corrosion.

Other areas the Engineers advised upon included: controlling concrete cracking and ensuring that the pressure on the concrete does not exceed the concrete compressive strength; and ensuring that the pressure on the soil does not exceed the ultimate bearing capacity of the soil.

SITE SURVEY & SOIL

When selecting a site, a surveyor could be employed to create an accurate survey plan of the site and its surroundings (including natural features, trees, water, rocks, easements, topography, boundaries, roads, and so on). The surveyor can also help to identify sub-soil and surface water drains. A Geotechnical Engineer can analyse soil quality.

This may have been a worthwhile investment for the project at Cummeragunja. When digging holes for one of the four footings at the initial site, a drainage pipe was uncovered in the south-west of the building site. The footing location was initially adjusted to avoid the pipe. When the site was moved completely on Day 2 this was no longer an issue, but nonetheless highlighted the necessity of careful site planning.

The concrete truck arrives on site ahead of the concrete pour.

C.4 REFERENCES

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The concrete footings with formwork in place. Clockwise from left: Double (north), Single, Double (south), Quad.