A MANUAL FOR THE USE OF SCHOOLS AND COMMUNITIES IN THE CONSTRUCTION OF PRIMARY SCHOOL BUILDINGS

Draft.

CONSTRUCTING NEW PRIMARY SCHOOL BUILDINGS

A. INTRODUCTION

In the past, the construction of primary schools has been the responsibility of local government and has been carried out by local building contractors supervised by the Ministry of Works. This process has however resulted in many cases in poor quality construction.

A number of recent primary school construction projects have therefore used school committees and/or communities to manage or carry out the construction of primary school buildings.

As government increasingly transfers the responsibility for managing primary schools to school committees and communities this method of constructing primary school buildings is becoming increasingly common and this manual has been designed to assist both schools and communities in managing and carrying out the work.

While neither school staff nor community members can be expected to replace completely the role of the building contractor, there are usually some members of the community who are either skilled artisans, building foremen, builders or engineers who will be able to assist the school committee or community in carrying out the work.

This manual makes proposals for a standard primary school classroom unit. This unit can be combined to form a variety of standard buildings and that can be simply and economically constructed using locally available materials and that if built properly, should have a long and useful life.

The manual also sets out the main steps necessary to construct the building through a set of simple instructions and illustrations.

These steps, instructions and illustrations are relevant not only to this particular classroom unit but to most primary schools that will be constructed in the country not matter what the design and should be useful to everyone concerned with the construction of new facilities for primary schools.

Two separate manuals give guidance to school committees and communities on renovating existing primary schools and on maintaining primary school buildings after they have been built. All three manuals should be read together.

B. DESIGN OF PRIMARY SCHOOL BUILDINGS

A cost-effective design for a primary school classroom building has been prepared that should be relatively simple for schools and communities to construct (see illustration of new classroom design).

While it is similar to traditional designs, it has been modified to both ease construction and to prevent a number of failures that have commonly occurred in previous designs.

These modifications include:

- Lowering the top ring beam to top of window and door frame height in order that it can act as a lintel as well as a ring beam and thus prevent cracking of the wall over.

- Constructing the veranda columns and beams of timber instead of reinforced concrete and thus simplifying construction and avoiding the problems commonly found when using concrete in these areas.

- Increasing the roof overhang at the rear of the buildings in order to give increased protection from the sun and rain.

- Increasing the size of all reinforced concrete columns and beams (apart from the ground beam to the verandas) to 20 x 20 cm reinforced with 4 No. 10mm diameter reinforcing bars. This will make it easier to pour the concrete, get adequate cover to the reinforcement and get better quality concrete overall.

The standard classroom can be combined in a number of different ways in order to fulfil the specific needs of individual schools.

Two variations of the standard classroom building are illustrated: one with three classrooms and toilets at the end and one with three classrooms and an office at the end. (see illustrations of the classroom buildings and detailed drawings attached in Annex 1).

To assist school committees and communities in constructing these classroom units, a list of materials required for a standard classroom, a three classroom and toilet building and a three classroom and office building are attached in Annex 2.

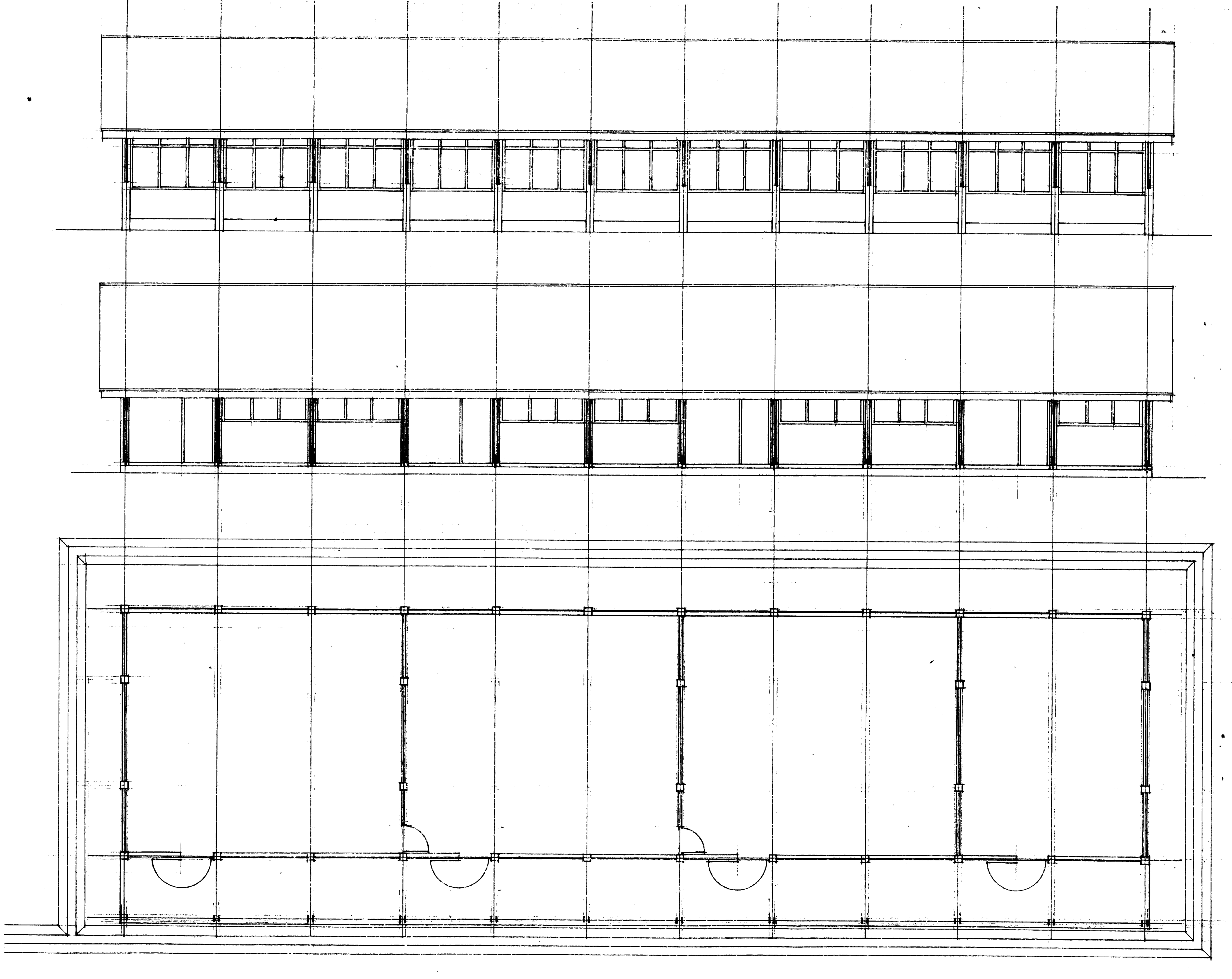
A number of different materials can be used for constructing the buildings and these include:

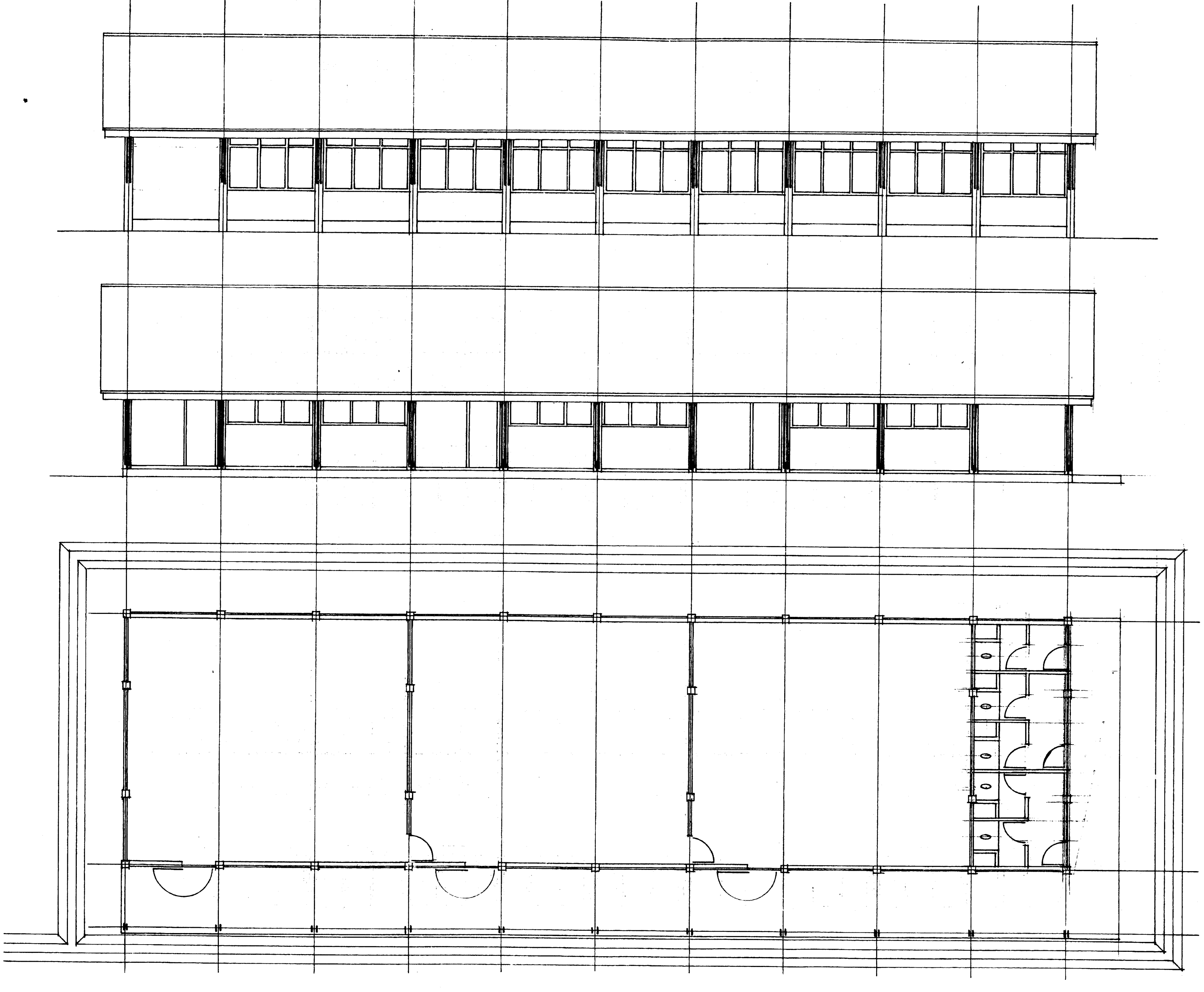
- Brick or concrete blocks for walls.

- Clay roof tiles, corrugated steel roof sheets or corrugated fibre-cement roof sheets for roofs.

- Concrete or glazed ceramic tiles or a concrete slab for floors.

This manual illustrates the construction of a typical classroom building using brick or blocks for walls and corrugated steel roof sheets or clay tiles for roofing but other materials can be substituted depending on their local availability without affecting the basic methodology.





C. CONSTRUCTING THE BUILDINGS

1: SELECTING THE SITE

A site for a new primary school should have:

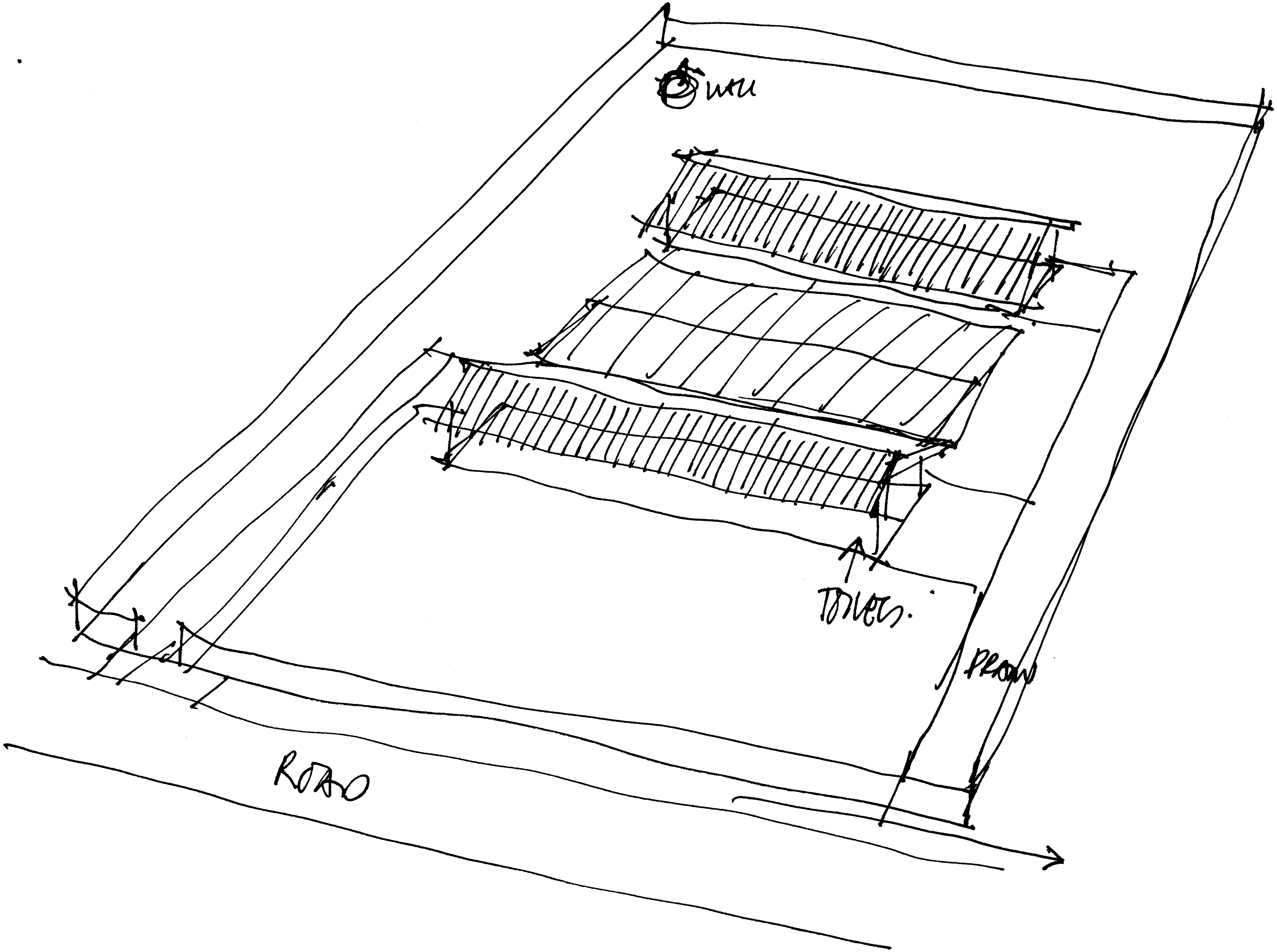
- A minimum area of 3,000m² with adequate space for the school buildings, for a playing area and for any future extensions that may be required.
- Easy access by foot for the majority of the children who will be attending the school.
- Easy access to a safe water supply.

The site should be:

- Level and not liable to flooding.
- Situated well away from roads carrying traffic.
- Well drained with good, uniform soil conditions and not marshy or rocky in order to avoid the need for special, expensive foundations.

A good site for constructing a new primary school will therefore be large enough to construct two 3-classroom buildings with space for a playing area and possible future expansion; set on the outskirts of a village and well back from any main road.

The site will have firm ground capable of supporting the buildings; a large flat area for the buildings and a playing field and good natural drainage.



WALL
TOILETS.
PRAM
ROAD

2: LAYING OUT THE SITE

When laying out the buildings on the site the following simple rules should be followed:

- Orient all buildings so that the windows face north-south (i.e. with the line of the roof ridge running east-west) to reduce the amount of sunlight entering the classrooms.

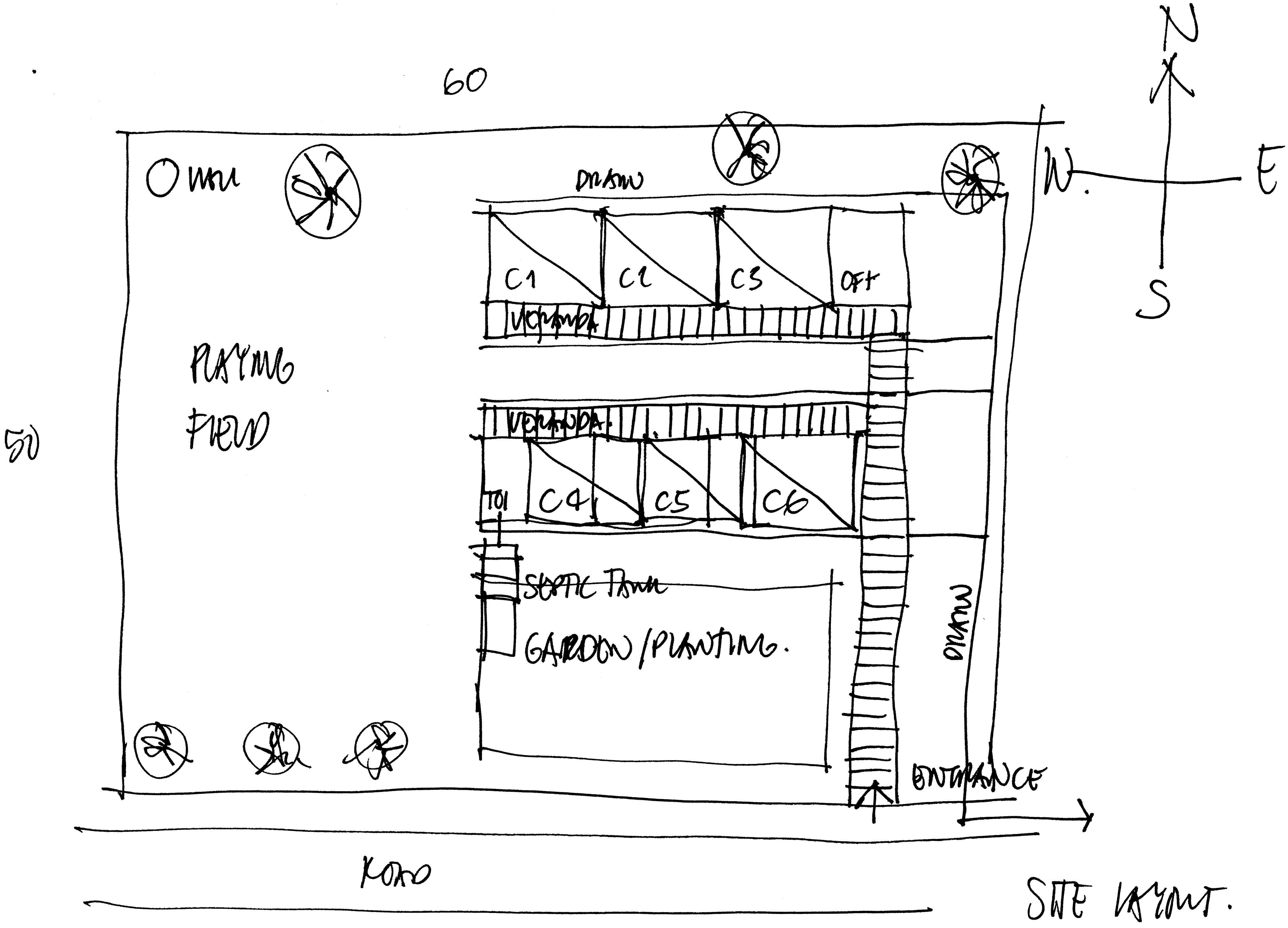
- Place classroom buildings at the rear of the site with playing fields, gardens, etc at the front to give privacy and keep classrooms away from the source of any noise such as roads.

- Situate any well used to supply drinking water to the school at least 15 metres and preferably 30 metres away from the septic tank and soakaway serving the school toilets.

- Pay attention to the contours of the site and do not place the buildings in a hollow where water will collect or on soft wet ground. It should be possible to run storm drains away from the buildings to dispose of storm water and water from roofs.

- Do not place classroom buildings too close together so as to avoid noise from one building interrupting teaching in another building. A minimum distance of 20 metres should be adequate.

- Do not place buildings too close to trees whose roots could damage foundations or whose branches could damage roofs. As many trees as possible should be kept however to provide shade on the site.


N
W
E
S
60
50
DRAIN
C1
C2
C3
OFF
VERANDA
PLAYING
FIELD
VERANDA
TOI
C4
C5
C6
SEPTIC TANK
GARDEN/PLANTING.
DRAIN
ENTRANCE
ROAD

SITE LAYOUT.

3: PREPARING THE SITE

Clear the whole site of shrubs and vegetation in order that the buildings can be positioned and set out.

Retain any large trees that are well away from the buildings in order to provide shaded areas on the site.

Orient the buildings to face north-south. This is best done using a compass but if this is not available the person supervising the construction should stand on the site with his arms outstretched and with his left hand pointing to where the sun rises and his right hand pointing to where the sun sets. He will then be facing south and the veranda of the buildings should face in this direction. The roof overhangs will then keep the sun off the windows for most of the day.

Position the buildings on the site and drive pegs in to mark the corners of each of the buildings. The building must be square and when positioning the corners use a large steel square or a 3-4-5 triangle.

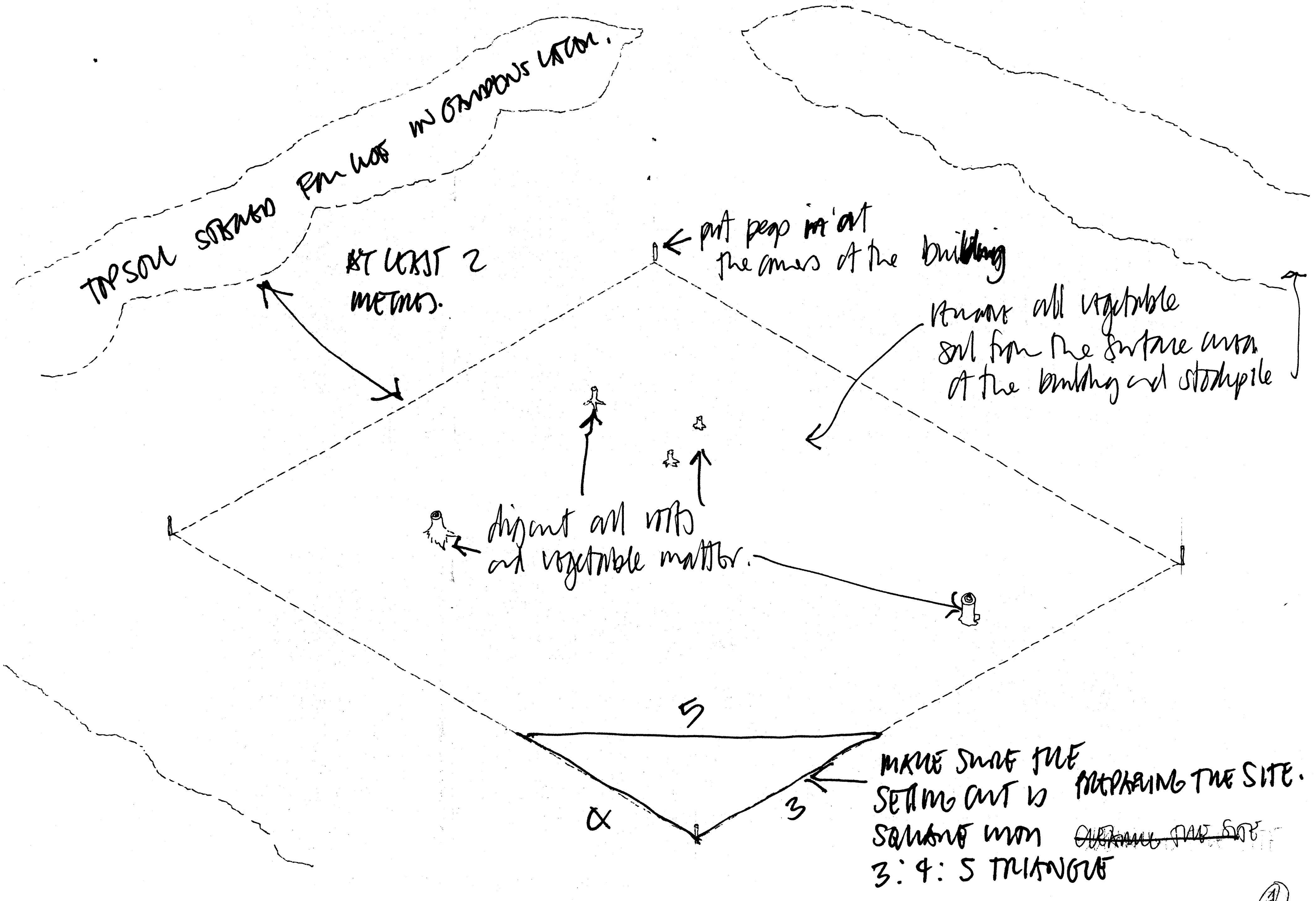
The space to be occupied by each building together with an area all round at least 2 metres wide should then be stripped of all top soil and vegetable matter and the soil stockpiled for future use in a situation where it will not interfere with the work. The area around the building will be required as workspace during construction.

It is very important that all roots and vegetable matter within the area of the building are dug out and removed. Any roots that are left will eventually rot and cause subsidence of floors or even of foundations and the cost of remedial work will then be very high.

Any termite nests that are found must also be dug out and destroyed.

Remember:

- **Orient all buildings north/south if possible**
- **Clear all top soil and vegetable matter from the building area**
- **Dig out and remove all roots**
- **Destroy any termite nests**


TOPSOIL STORED FOR USE IN GARDENS LATER.
AT LEAST 2 METRES.
put pegs in at the corners of the building
remove all vegetable soil from the surface area of the building and stockpile
dig out all roots and vegetable matter.
5
3
MAKE SURE THE SETTING OUT IS SQUARE USING 3:4:5 TRIANGLE
PREPARING THE SITE.

4: SETTING OUT THE BUILDINGS/1

Having cleared the site and established the position of the buildings, the buildings must be set out.

Wooden profiles are erected at the corners of the building and about 1 metre outside the area of the building. The profiles consist of vertical posts driven into the ground with horizontal boards approximately 1.5 metres long nailed to the outside of the posts at the top.

The positions of the outside corners of the building are marked on the top of the horizontal boards of the profiles using a long tape. The corner positions are marked and nails are driven in at the marks.

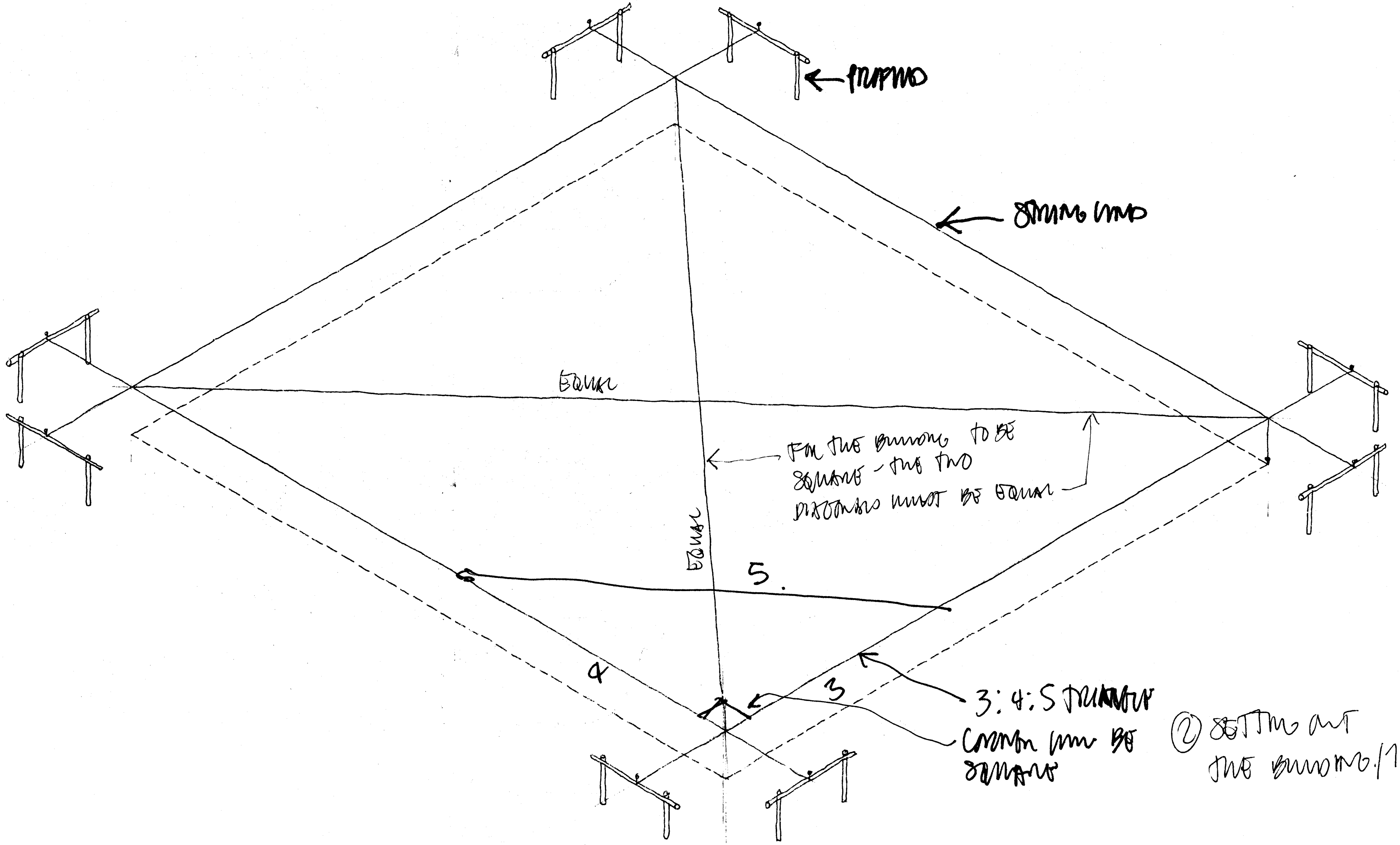
Before proceeding with the rest of the setting out it is very important that the outline of the building is checked for square. The simplest way to do this is to check the diagonals. If the building is to be square the diagonals must be equal. If when checked, the diagonals are not equal then the marks for the corner positions must be adjusted until the diagonals are equal and the outline of the building is square.

Nails can then be driven in to mark the outline of the end walls and foundations and the remaining profiles can then be fixed in a similar manner to the corner ones.

Profiles are required for all intermediate walls, columns and foundations. The profiles must be in line and level. If the ground slopes then the profiles must be levelled and stepped down from the adjacent ones. Opposite profiles must be levelled across the building.

Remember:

- **All profiles must be in line and level with the profile opposite**
- **The setting out must be accurate**
- **The setting out must be checked for square**



② SETTING OUT THE BUILDING/1

5: SETTING OUT THE BUILDINGS/2

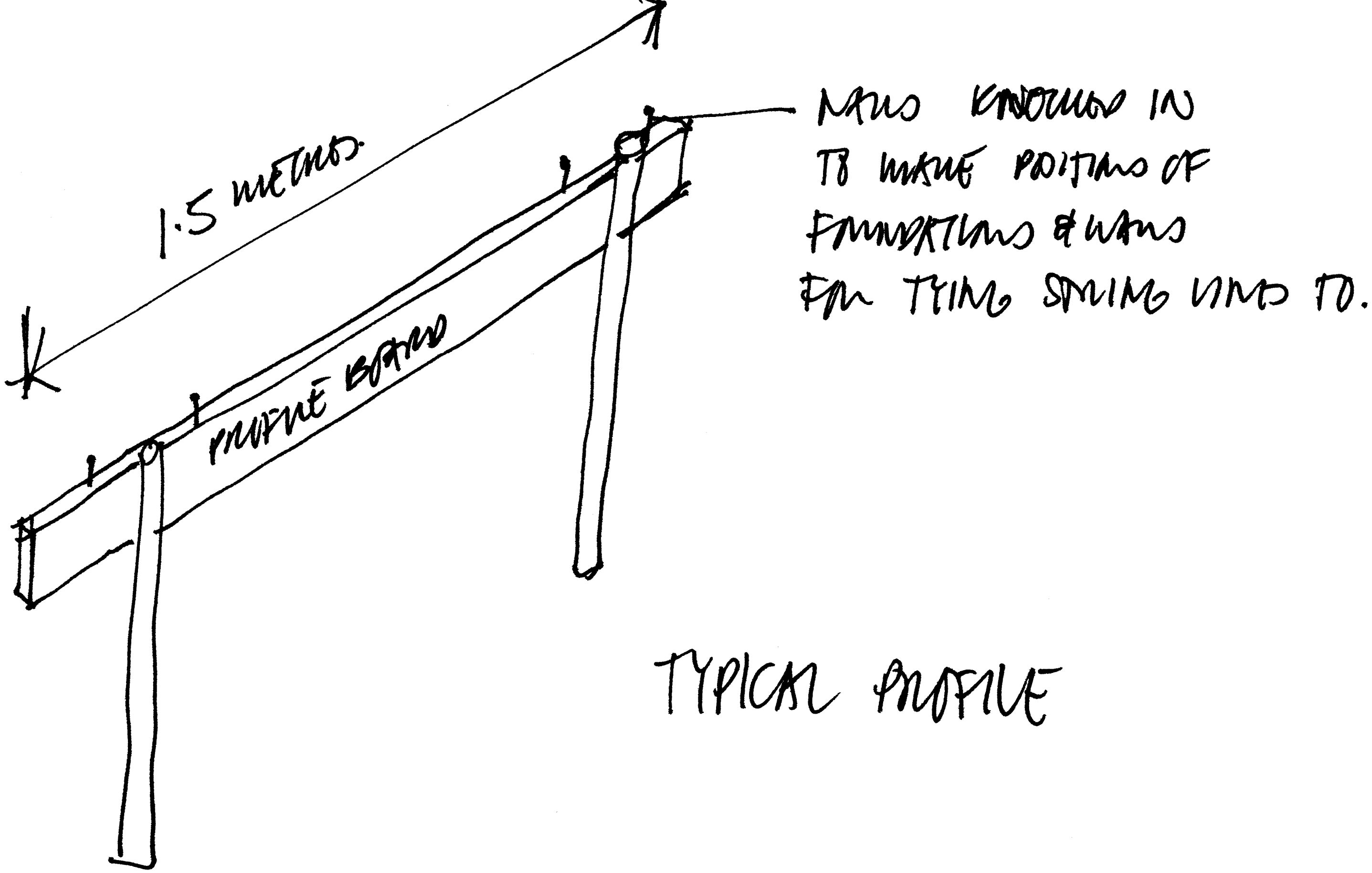
Mark the position of all foundations, walls and columns on the profiles, starting at the corners and using a long tape and nails driven in to mark the positions of the outside face of each foundation, wall and column on the top of the profile boards.

Tie builders' line to the nails marking the outside of all foundations and mark the outline of the foundations on the ground.

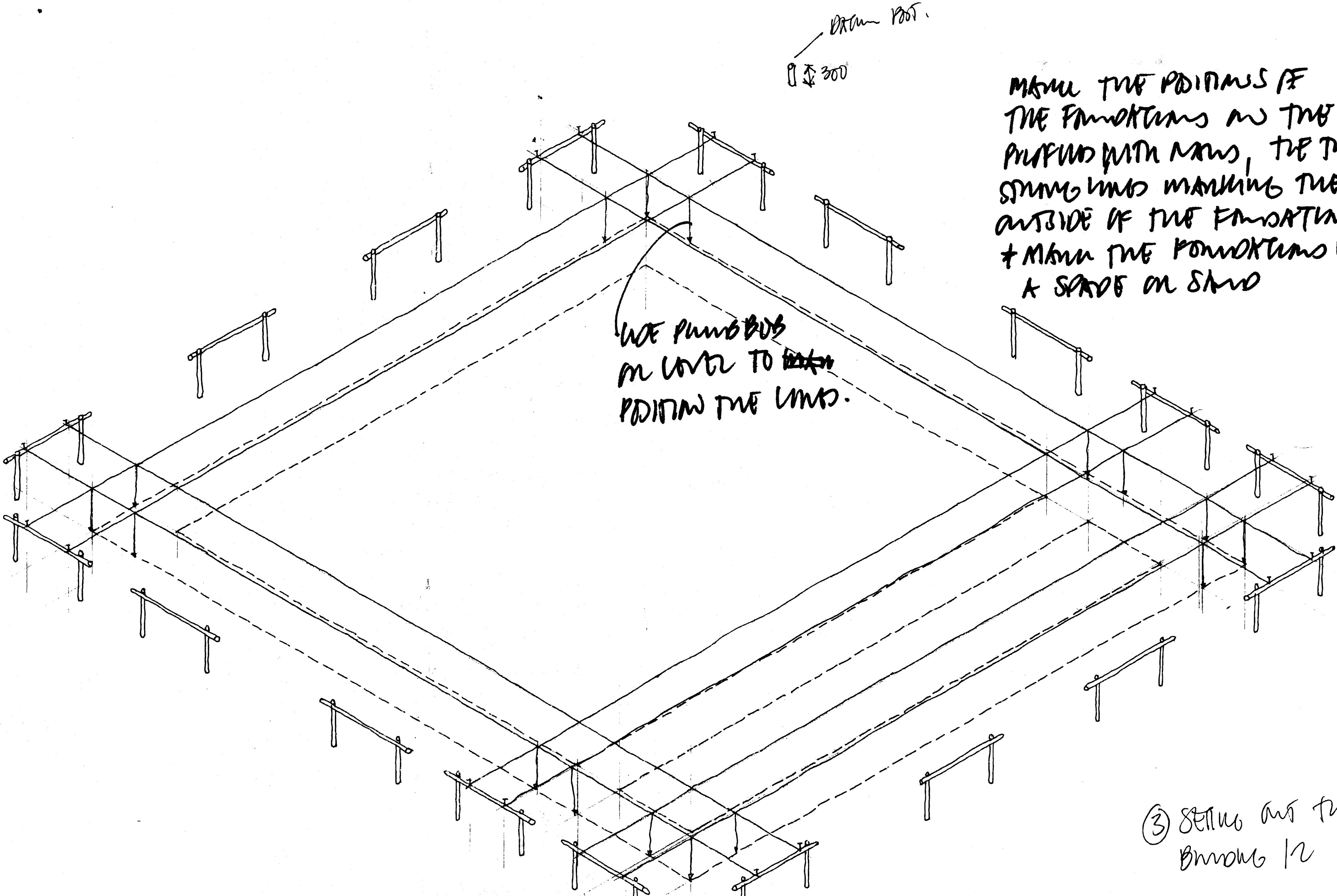
To do this the corners of the foundations must be marked with a plumb bob hung from the point where the lines intersect at the corner or with a vertical level and the lines of the foundations are then marked on the ground with a line of sand or by cutting with a spade.

When the profiles are complete, the floor level of the building must be established. This should be at least 30cm above the highest ground level (higher if the site is very wet). Knock a 50 x 50 cm post into the ground at the highest end of the building outside the profiles until the top is 30 cm above ground level. This will be the datum point, the level of the finished floor.

When the lines of the foundations have been marked on the ground, remove the builder's lines so that they do not get in the way of the work. If the nails are left in the profile boards and the lines can always be put back if it is necessary to check the lines of the foundations.



TYPICAL PROFILE



MARK THE POSITIONS OF THE FOUNDATIONS ON THE PROFILES WITH NAILS, TIE THE STRING LINES MARKING THE OUTSIDE OF THE FOUNDATIONS + MARK THE FOUNDATIONS WITH A SPADE OR SAND

③ SETTING OUT THE BUILDING 1/2

6: EXCAVATING THE FOUNDATIONS

Foundations are generally constructed of large stones set in sand/cement mortar (mix: 1 of cement to 4 of sand measured by volume). The stone foundation is set on a layer of large stones laid on a bed of sand (see sketch).

On sites with soft or unstable soil or pockets of made-up ground or sites that are very wet, the buildings will have to have special foundations and the design of these is beyond the scope of this manual. A properly qualified engineer should be consulted who will design the foundations for the buildings. These might be reinforced concrete foundations for the columns, concrete or ironwood piles, a reinforced concrete raft, etc depending on the individual site circumstances.

The foundation trenches for normal foundations are 65 cm wide and the bottom of the trenches must at least 110 cm below finished floor level (marked by the timber datum peg). The sides of the foundation trenches must be cut straight and square and the bottom should be level.

If the site slopes then the bottom of the foundations should be stepped, each step being horizontal and level. Use a water level to establish the levels of the bottom of the foundation trenches.

If there is a very steep slope on the site, the building might have to be separated into two parts with floors at different levels in order that the foundations do not become too high. The height of the top of the foundations above the ground should not exceed 120 cm at the highest end.

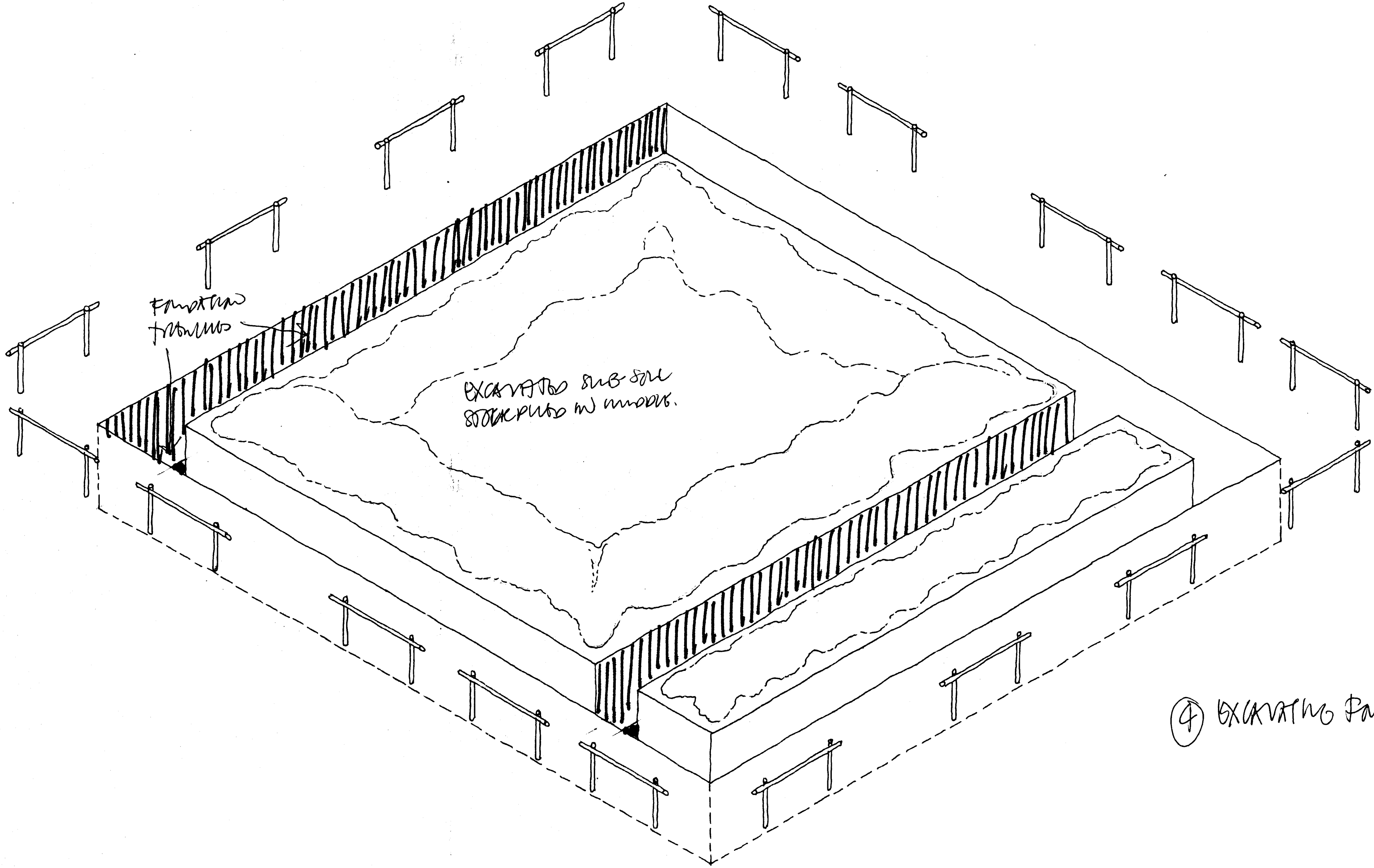
Excavate the trenches until firm soil is reached even if this means excavating below the 110 cm depth. Foundations must always be built on firm ground and inadequate excavation of foundation trenches and the construction of foundations on soft ground is a common cause of foundation failure resulting in settlement of walls and columns.

The bottom of the trenches should be left undisturbed, smooth and free of debris. If it rains before the foundations are constructed, remove any standing water, silt and other rubbish.

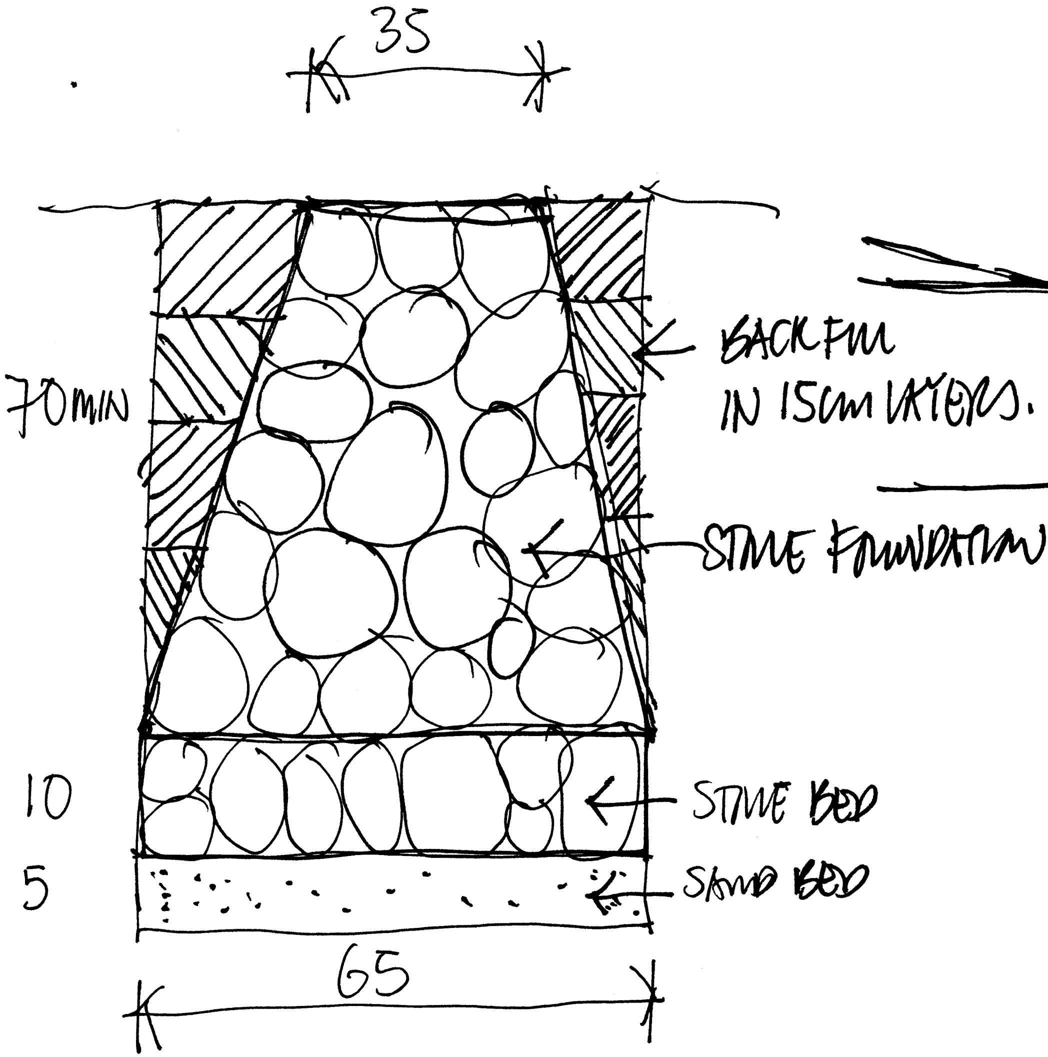
Stockpile the excavated material from the trenches inside the trench line for use later in backfilling around the foundations and under the floor.

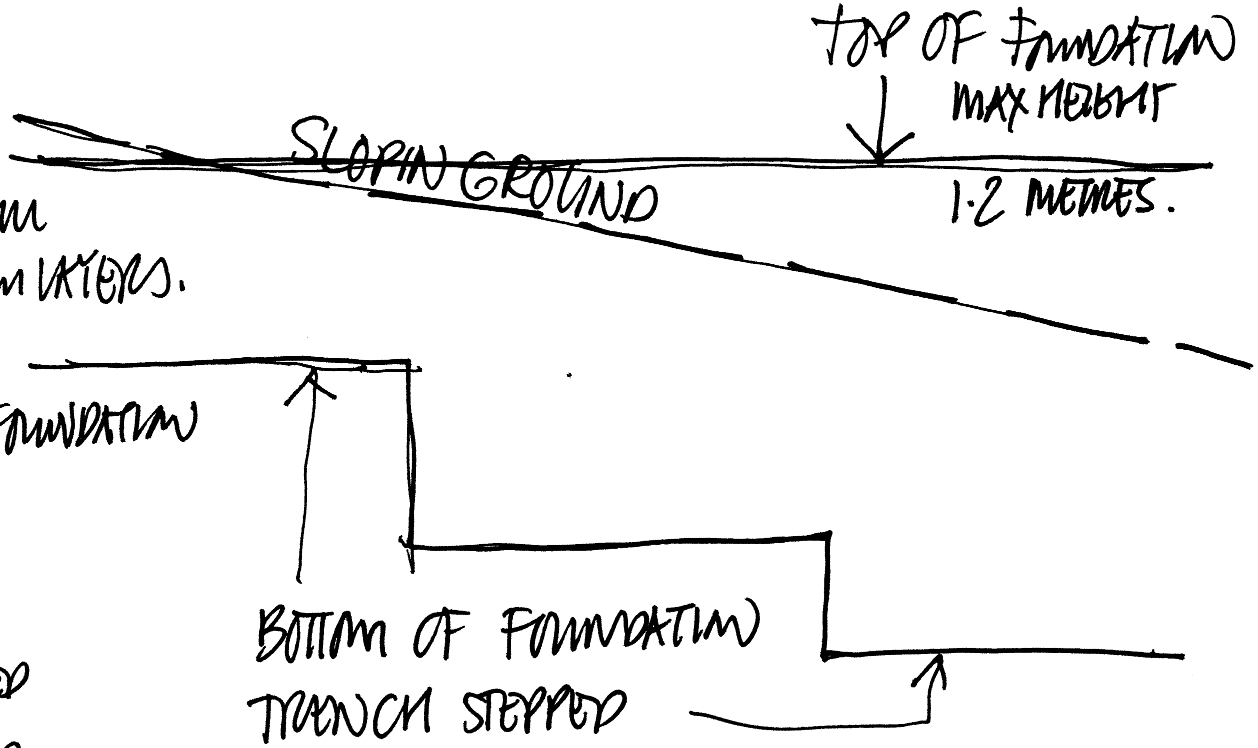
Remember:

- **The bottom of the foundations must sit on firm ground**
- **Get expert advice on the foundations if the soil is very wet or soft**



(4) EXCAVATING FOUNDATIONS.





FOUNDATION DETAILS

7: MIXING MORTAR

Before moving on to the construction of the foundations, for which mortar will be required, it is necessary to set out some guidelines on the mixing of mortar by hand, which will be the most common method at primary schools.

Mortar will be required for building foundations, building walls, for screed, for laying tiles and for plastering the walls.

There are some common problems associated with mixing mortar by hand: 1) the materials are not mixed enough dry before the water is added and 2) too much water is used in the mix.

Mortar for foundations and for laying bricks or blocks should be mixed in the ratio of 1 of cement to 4 of sand.

Mortar to be used for plastering walls should be mixed in the same ration or lime can be added which makes it easier to use. The ratio should then be 1 of cement, 1 of lime and 3 of sand.

Mortar for screed or laying tiles should be in the ratio of 1 of cement to 3 of sand.

The materials should be measured by volume preferably using a specially made box which should be big enough to take exactly one bag of cement or by using buckets. The measurements should be exact.

All sand should be clean and sand for mortar for laying bricks or blocks and for plastering should be and fine and soft and sand for mortar for laying tiles or for screeds should be coarse and sharp; sea sand should not be used unless it is thoroughly washed.

Mix the mortar on a clean platform and not on the ground. The platform should be made of cement/sand screed and should be big enough to take as much mortar as can easily be mixed by hand at one time.

Mix only enough mortar that can be mixed easily at one time by hand and can be used in less than one hour. Mix all materials thoroughly dry before any water is added until an even grey colour is achieved.

When an even colour is achieved, add water slowly and in small quantities mixing thoroughly all the time. To achieve maximum strength use as little water as necessary to achieve a workable mix. Very wet mortar will be very weak concrete! Never add more water later to improve the workability!

All materials containing cement require a curing period to reach their maximum strength and during this period (at least a week) they should be kept damp.

Remember:

- **Always mix materials on a clean platform**
- **Always measure materials accurately and by volume**
- **Always mix materials thoroughly dry before adding any water**
- **Use as little water as necessary to achieve a workable mix**

8: CONSTRUCTING THE FOUNDATIONS

When the foundation trenches have been excavated, put a layer of well consolidated coarse sand 5 cm deep in the bottom of the foundation trench and on this put a layer of large, clean stones approximately 10 cm deep set in cement/sand mortar (1:4 mix). Lay the sand and stone layers across the full width of the foundation trench.

When the initial layer of stone has set the foundation can be constructed. All foundations are 65 cm wide at the bottom and reduce to 35 cm at the top. The foundations should be at least 70 cm deep and deeper if the site slopes and the foundations have to be stepped.

To simplify construction, the ground beam is the same width as the column and there is no need therefore to increase the foundation in size under the columns.

The foundation is constructed of large stones set one on another with broken joints (i.e. the vertical joints between stones should not go up through more than one course of stone) and set in cement/sand mortar (1:4 mix).

Use a fine, clean sand for mortar and as little water as possible to give a workable mix. Very wet mortar will be very weak mortar!

Mix the mortar on a clean platform as described above and mix only enough mortar that can be used at any one time and in less than one hour. Do not keep mortar for use later or for more than one hour and do not add more water to make it workable; this will make it very weak!

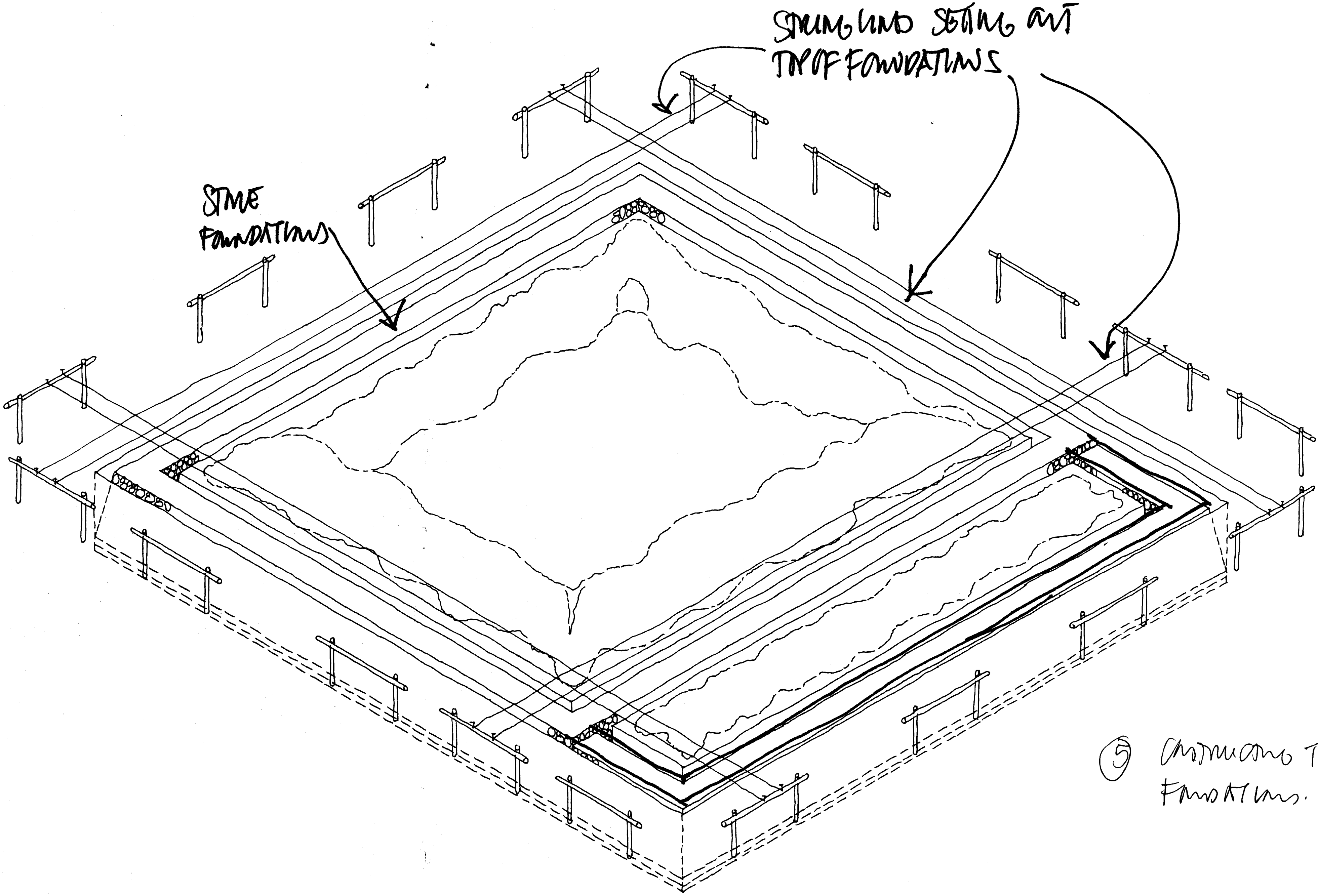
When the foundations are complete, level the top with a bed of mortar using a water level.

Leave the foundations to cure for a week and then back-fill the trenches on either side of the foundations. Remove any water lying in the trenches before starting the back-filling and use the material that has been dug out of the trench and stock-piled for this purpose.

Lay the back-fill in 15cm deep layers on both sides of the foundation (do not fill one side only; back-fill both together or the foundations might be damaged) and thoroughly compact each layer before the next layer is placed. Any material left over can be used later for back-filling under the floor.

Remember:

- **Always use clean sand and stone**
- **Lay the foundation stones with broken joints**
- **Leave the foundations to cure for a week before back-filling**
- **Back-fill in equal layers on both sides of the foundation**



(5) CONSTRUCTING THE FOUNDATIONS.

9: MIXING CONCRETE

Before moving on to the construction of the ground beams, for which concrete will be required, it is necessary to set out some guidelines on the mixing of concrete by hand which will be the most common method at primary schools.

Two types of concrete will be required for primary school buildings: 1) mass concrete or concrete with no reinforcement and 2) reinforced concrete or concrete reinforced with steel bars.

There are some common problems associated with mixing concrete by hand: 1) the materials are usually not mixed enough dry before the water is added; 2) too much water is used in the mix; 3) the concrete is not very well compacted when it is put into the formwork because vibrators are not available.

Various measures have been taken in the designs used in this manual to counter-act these problems: 1) the strength of the mixes has been increased and 2) the size of columns and beams has been increased so that it is easier to pour and compact the concrete and get the required cover to the reinforcement.

Mass concrete should be mixed in the following ratio: 1 of cement, 2 of sand and 4 of aggregate.

Reinforced concrete should be mixed in the following ratio: 1 of cement, 1½ of sand and 3 of aggregate.

The materials should be measured by volume preferably using a specially made box which should be big enough to take exactly one bag of cement. If a wheel barrow is used for measuring, empty a bag of cement into it, level it and mark the top of the cement all round. Use this mark for measuring the sand and aggregate.

Cement should be fresh, Portland cement and should not be lumpy or hard. Any hard or lumpy cement should not be used. Cement should be stored off the ground and under cover.

Sand should be clean, coarse and sharp (not fine, soft sand) and sea sand should not be used unless it is thoroughly washed.

Aggregate should be either crushed rock ('split') or river stone. All aggregate should be clean and should be an average size of 20mm and a maximum size of 25mm.

Mix concrete by hand on a clean platform and not on the ground. The platform should be made of cement/sand screed and should be big enough to take as much concrete as can easily be mixed by hand at one time.

Mix only enough concrete that can be mixed easily at one time by hand and can be used in less than one hour. Mix all materials thoroughly dry before any water is added until an even grey colour is achieved. The materials should be completely turned over and mixed at least three times before any water is added.

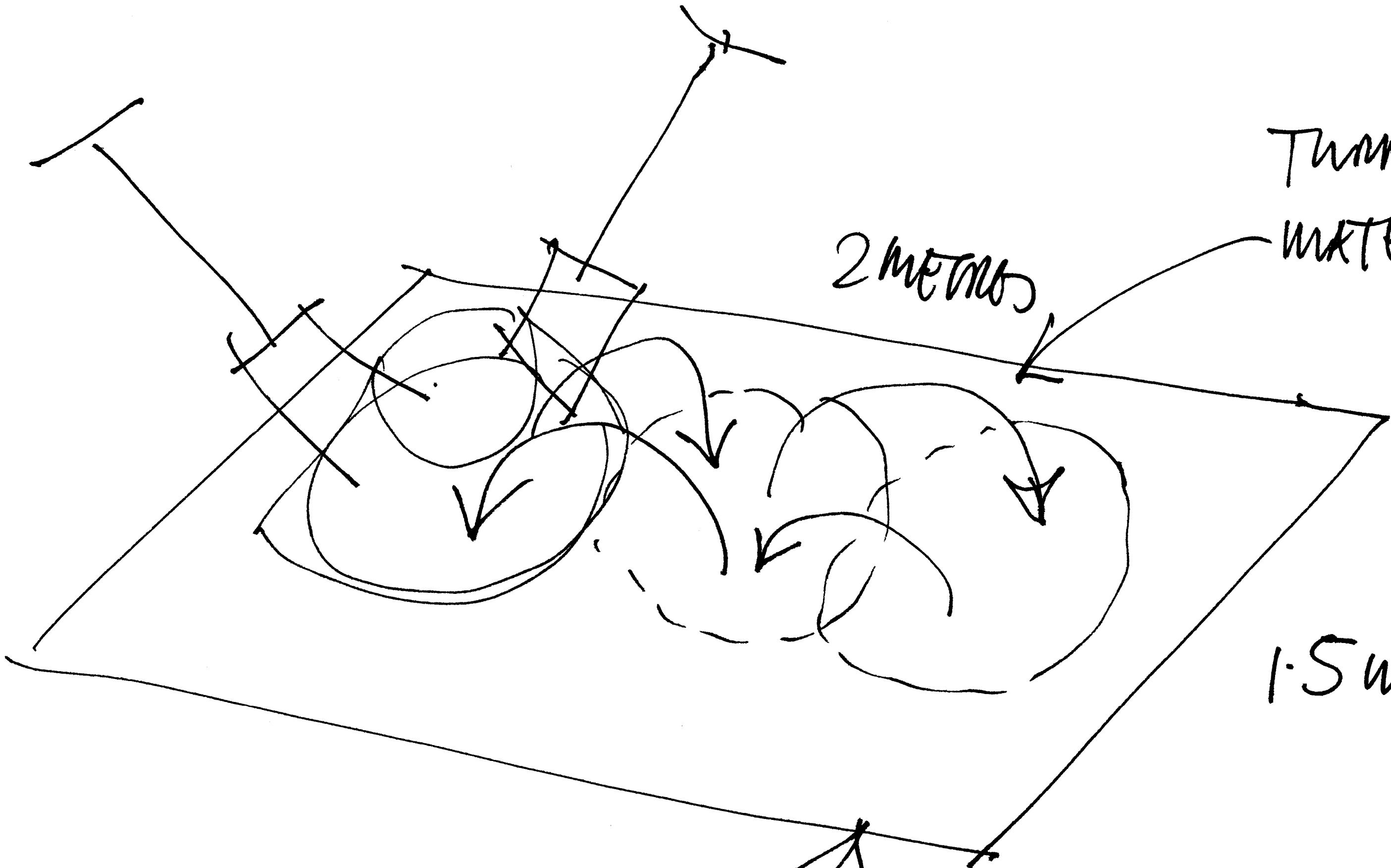
When an even colour is achieved, add water slowly and in small quantities mixing thoroughly all the time and mix all materials with the water and do not leave any to mix later. Again the materials should be completely turned over and mixed at least three times before use. To achieve maximum strength use only enough water as necessary to achieve a workable mix. Very wet concrete will be very weak concrete!

When the concrete is poured into the formwork, tamp it thoroughly using a length of 12mm reinforcing rod to make sure that no air pockets are left in the concrete that will reduce its strength.

Concrete becomes stronger as it gets older through a process of curing and it must be kept damp for as long as possible. Leave the shuttering on the beams and columns for at least 7 days to conserve moisture in the concrete and thus allow it to cure. Cover any exposed surfaces such as the top of beams with cement bags and keep them wet to assist the curing. Concrete that dries out quickly will not be very strong!

Remember:

- **Use only fresh cement that has no lumps**
- **Use only coarse, clean sand and clean aggregate**
- **Always mix the materials on a clean platform**
- **Always measure the materials accurately**
- **Make sure that all the materials are thoroughly mixed both dry and wet**
- **Never use too much water in the mix**
- **Keep the concrete protected and damp for at least 7 days in order to cure properly**



MIXING CONCRETE

10: CHOOSING & USING REINFORCEMENT

Before moving on to the construction of the ground beam, where reinforced concrete will be required, it is necessary to set out some guidelines for the size and type of reinforcement that will be used in all of the reinforced concrete in the building.

There are many sizes and types of reinforcement available in Indonesia. There are for instance a number of different sizes that are called '12mm Ø' bars available from building materials suppliers and these range in actual size from 8mm Ø to 12mm Ø.

To avoid any confusion and to ensure that the reinforcement is of an adequate size for the job it has to do, the same size of reinforcement has been specified for the main bars in all reinforced concrete columns and beams in the building. This is 10mm Ø reinforcement or what is quite often called 'local standard' 12mm Ø!

On no account should any reinforcement that is smaller than this be used and if any smaller sizes are delivered to site they should be rejected.

All column and beam sizes have been standardised at 20 x 20cm with 4No 10mm Ø bars and all the column and beam reinforcement 'cages' will be the same size: 15 x 15cm externally which will allow for 25mm of concrete cover to all sides of the reinforcement (see sketch).

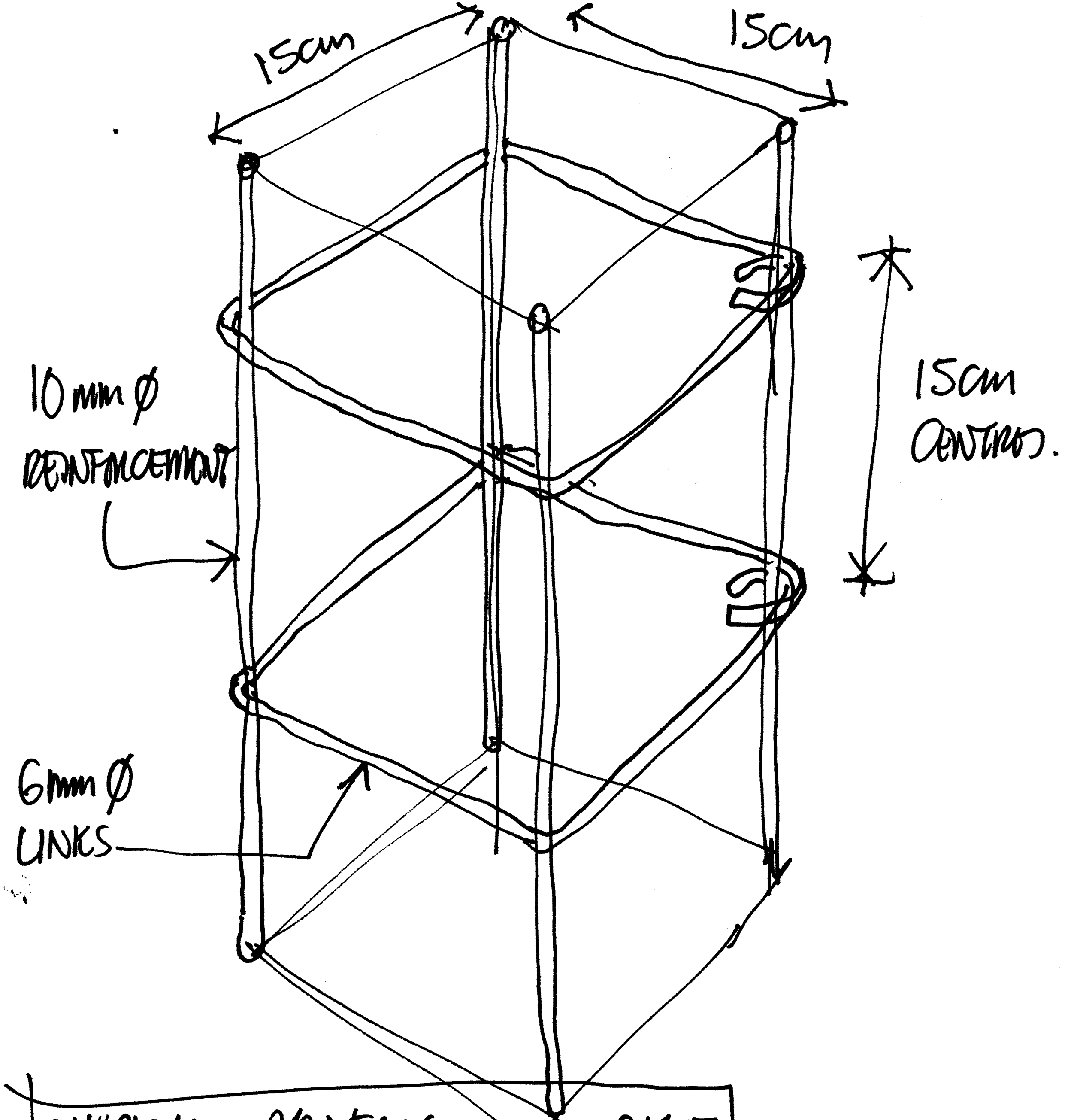
The 4No reinforcing bars in the columns and beams are held together with 'links' and these links will all be of 6mm Ø bars set at 15cm centres.

Where lengths of reinforcement have to be joined, they must overlap for at least 40cm. Bend the ends of all bars back to assist bonding with the concrete (see sketch).

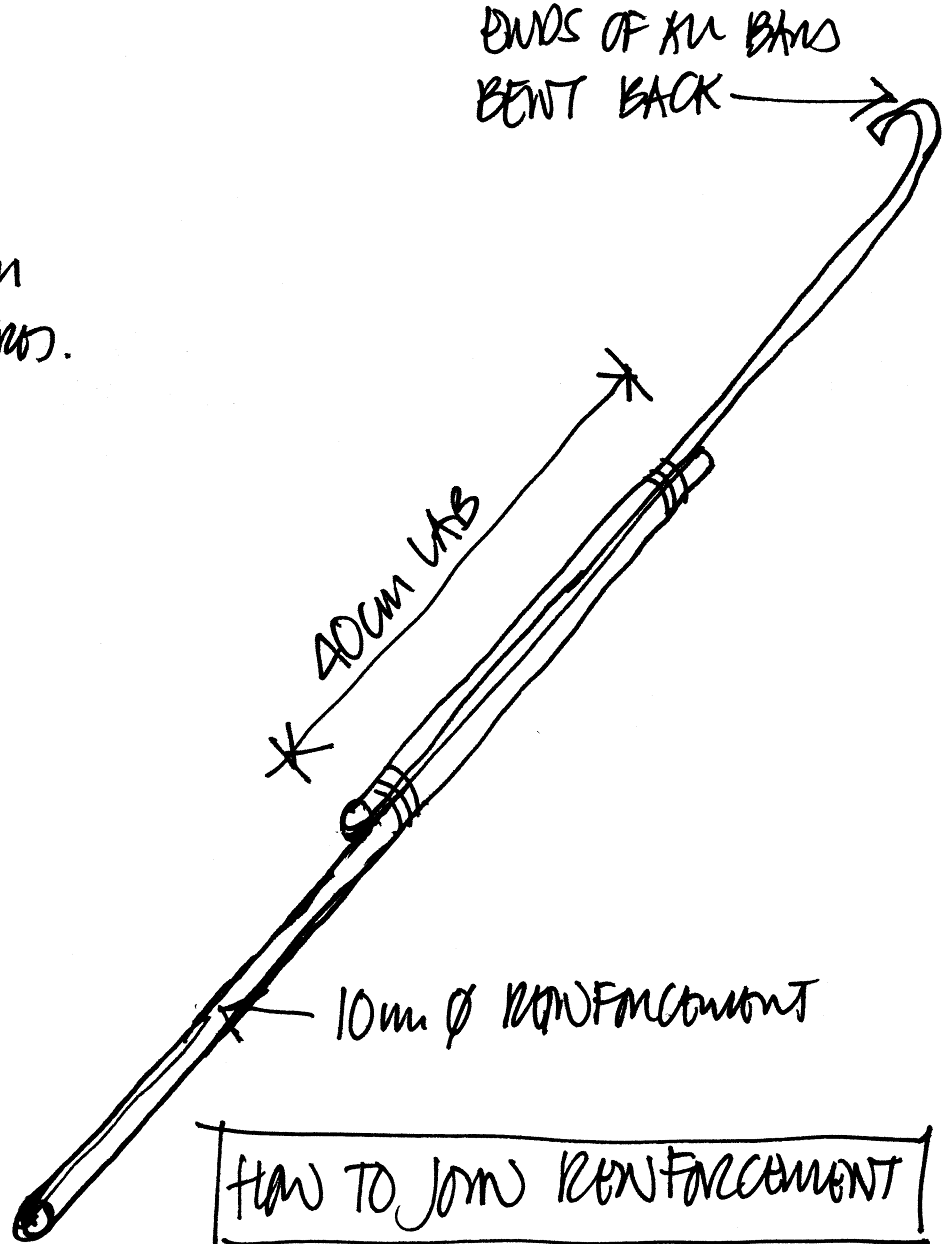
In order to achieve the 25mm concrete cover that is required over all reinforcement, make spacers of a mixture of sand and cement (1:3 mix) with wire ties cast in (see sketch) and cut up into 40 x 40mm squares. These spacers can then be wired to the outside of the reinforcing bars when they are put in the formwork and will hold the bars 25mm away from the formwork to give the required cover of concrete.

Remember:

- **Use only the correct size of reinforcement**
- **Put links at a maximum spacing of 15cm**
- **Where reinforcement has to be joined, it must be lapped for at least 40cm**
- **Hook the ends of all reinforcement to improve the bond**
- **Ensure that there is 25mm cover of concrete to all reinforcement**



TYPICAL REINFORCEMENT CAGE FOR ~~FOUNDATIONS~~ COLUMNS & BEAMS.



HOW TO JOIN REINFORCEMENT

REINFORCEMENT DETAILS

11: CONSTRUCTING THE GROUND BEAM

Leave the stone foundations for at least a week before the ground beam, which sits on top of the foundations, is cast.

The ground beam is constructed of concrete (1:1½:3 mix) reinforced with 4No 10mmØ bars. The overall size is 20 cm high x 20 cm wide around the building. The ground beam to the veranda however is 20cm wide x 15cm high to enable a step up from the veranda to the classroom and stop any water getting into the classroom.

Check the top of the foundations to ensure that they are level and then construct the shuttering for the ground beam. The shuttering is made of timber and the internal size is 20 cm high x 20 cm wide. Make sure that the shuttering is straight and level and that it is adequately braced so that when the concrete is poured, the shuttering does not move (see sketch). The shuttering is built in the centre of the top of the foundation.

When the shuttering is complete, the reinforcement can be put in position. A cage of 10mm Ø reinforcement (outside size 15 cm high x 15 cm wide with links of 6mmØ at 15 cm centres) is made up in lengths to suit the shuttering. Use spacers of cement 25mm deep to keep the reinforcement 25mm away from the shuttering and from the bottom of the beam and thus give adequate concrete cover to the reinforcement.

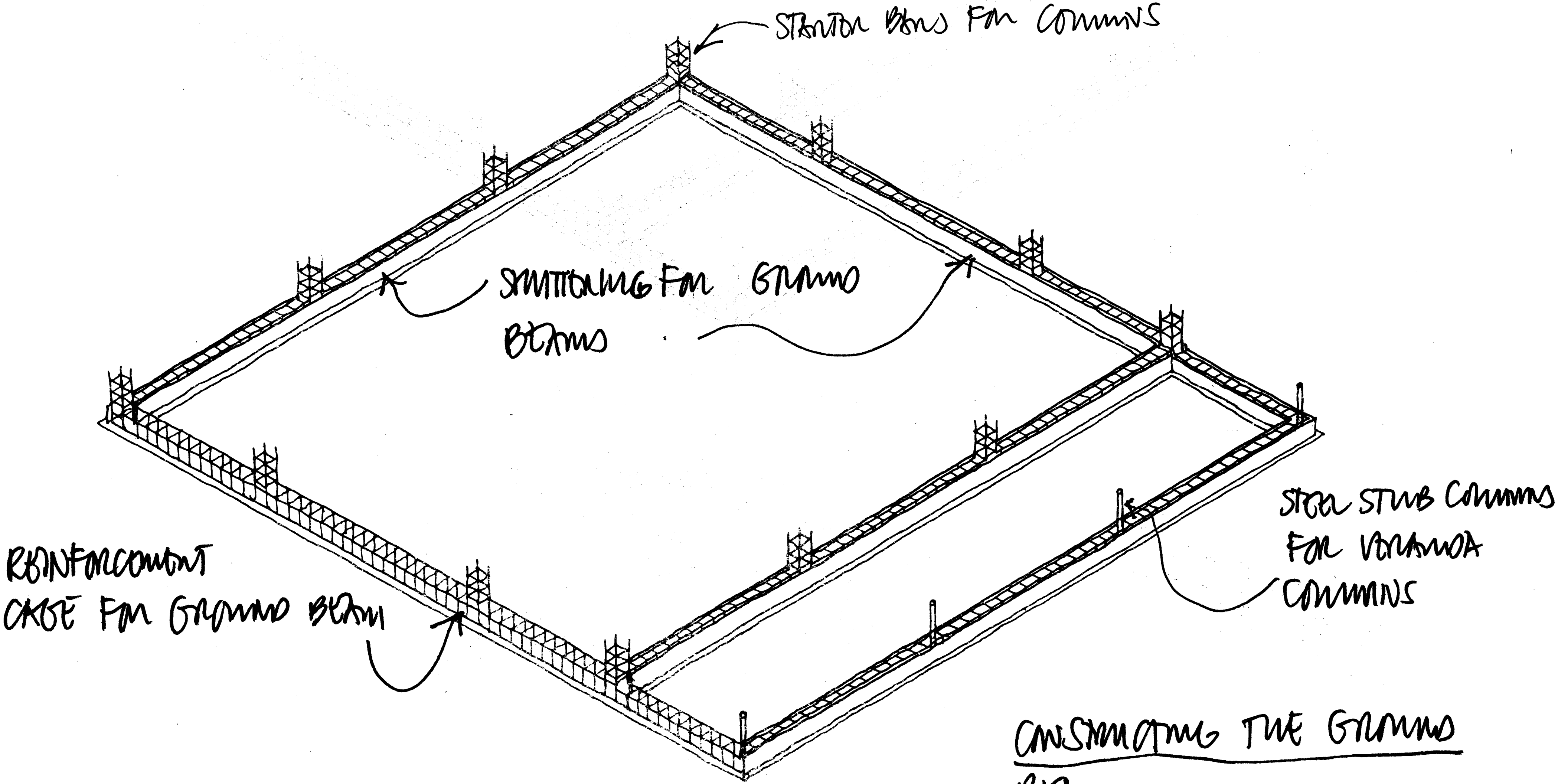
Before pouring the concrete for the ground beam, fix starter bars for the concrete columns. The starter bars are the same size as the concrete ground beam reinforcement (ie 10mmØ) and stand 40cm above the top of the ground beam. The bars are bent at right-angles at the bottom and must lap the bottom bars of the ground beam by at least 40cm and be tied to the ground beam bars. The overall size of the starter bar cage is 15 x 15 cm with links of 6mmØ at 15 cm centres (see sketch).

Before pouring the concrete for the veranda ground beam, steel supports need to be built into the beam at the front of the veranda to support the timber columns that will support the ends of the roof trusses and rafters.

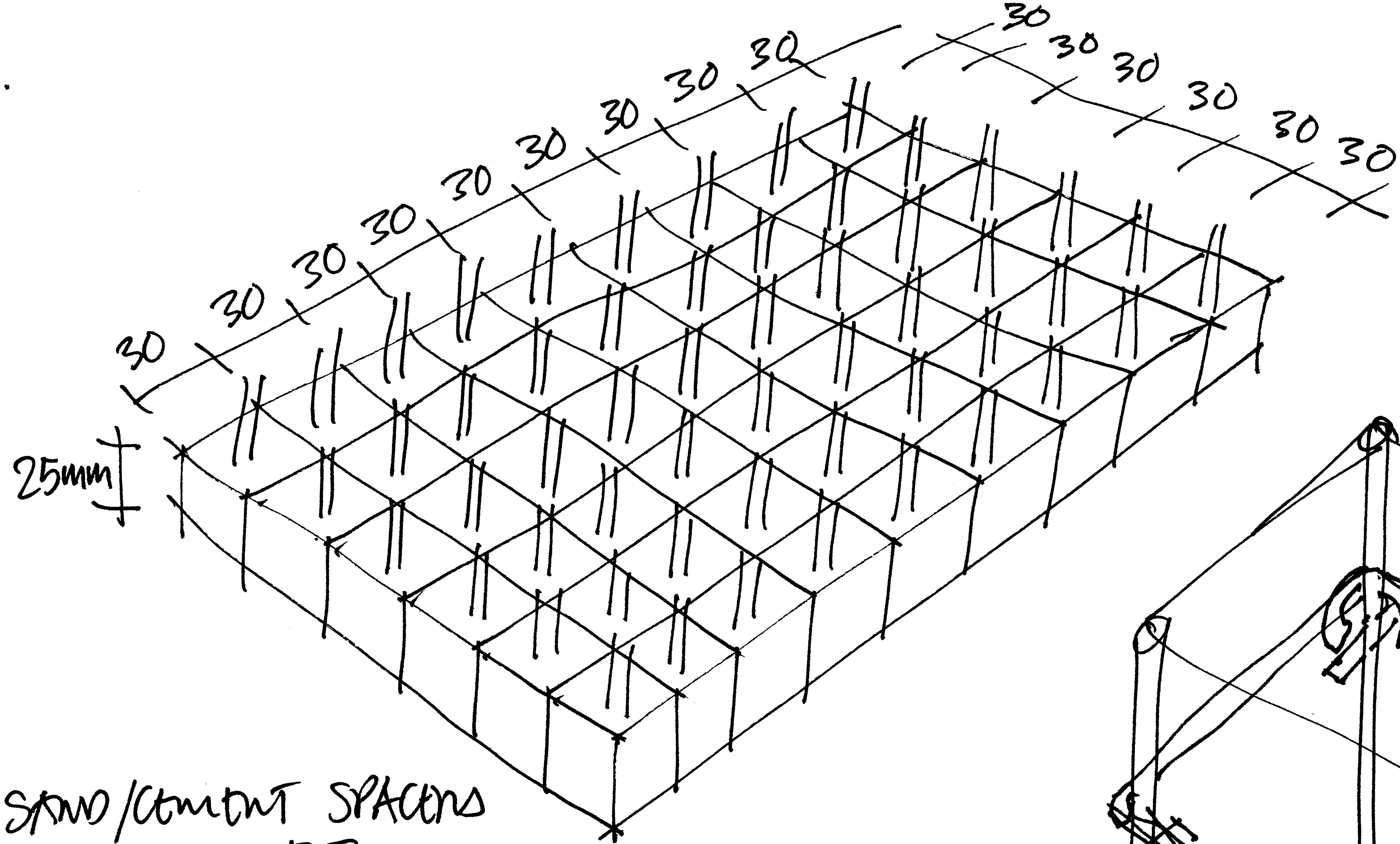
These supports can be made of either 50mm diameter steel pipe or 50 x 50mm steel RHS. The supports should be 60cm long with either a steel plate or two lengths of 10mm reinforcement welded to the bottom (see sketch). The supports should be positioned and braced before the concrete for the ground beam is poured.

Remember:

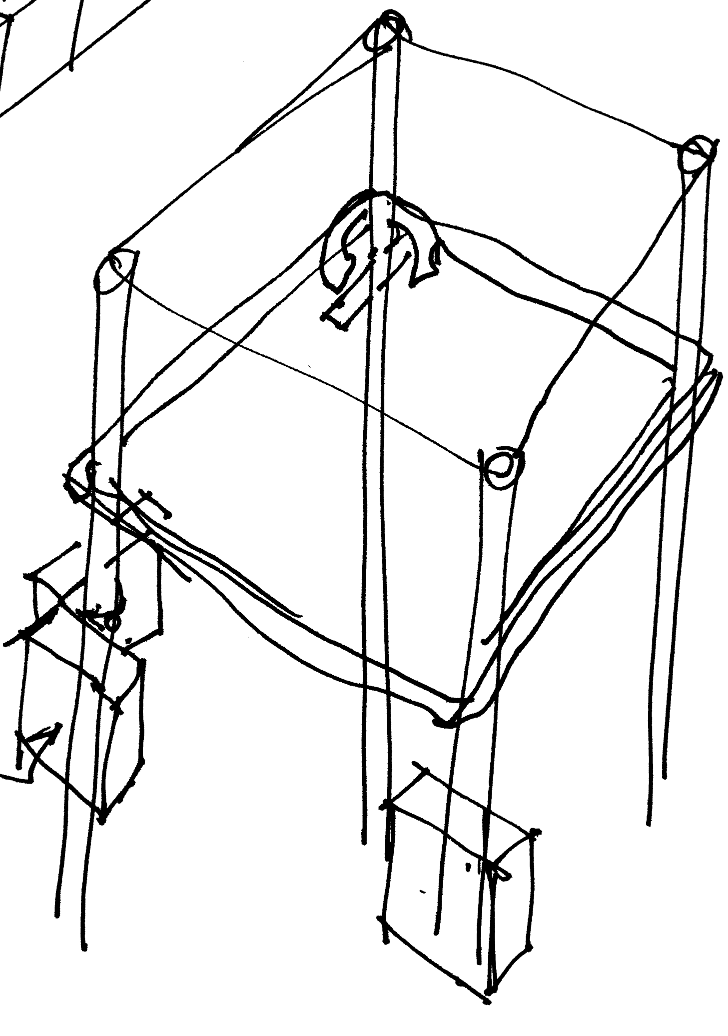
- **Check that the top of the foundations are level all round the building**
- **Make sure that the formwork is adequately braced before the concrete is poured**
- **Fix the starter bars for the columns and the steel supports for the veranda columns before the concrete is poured**



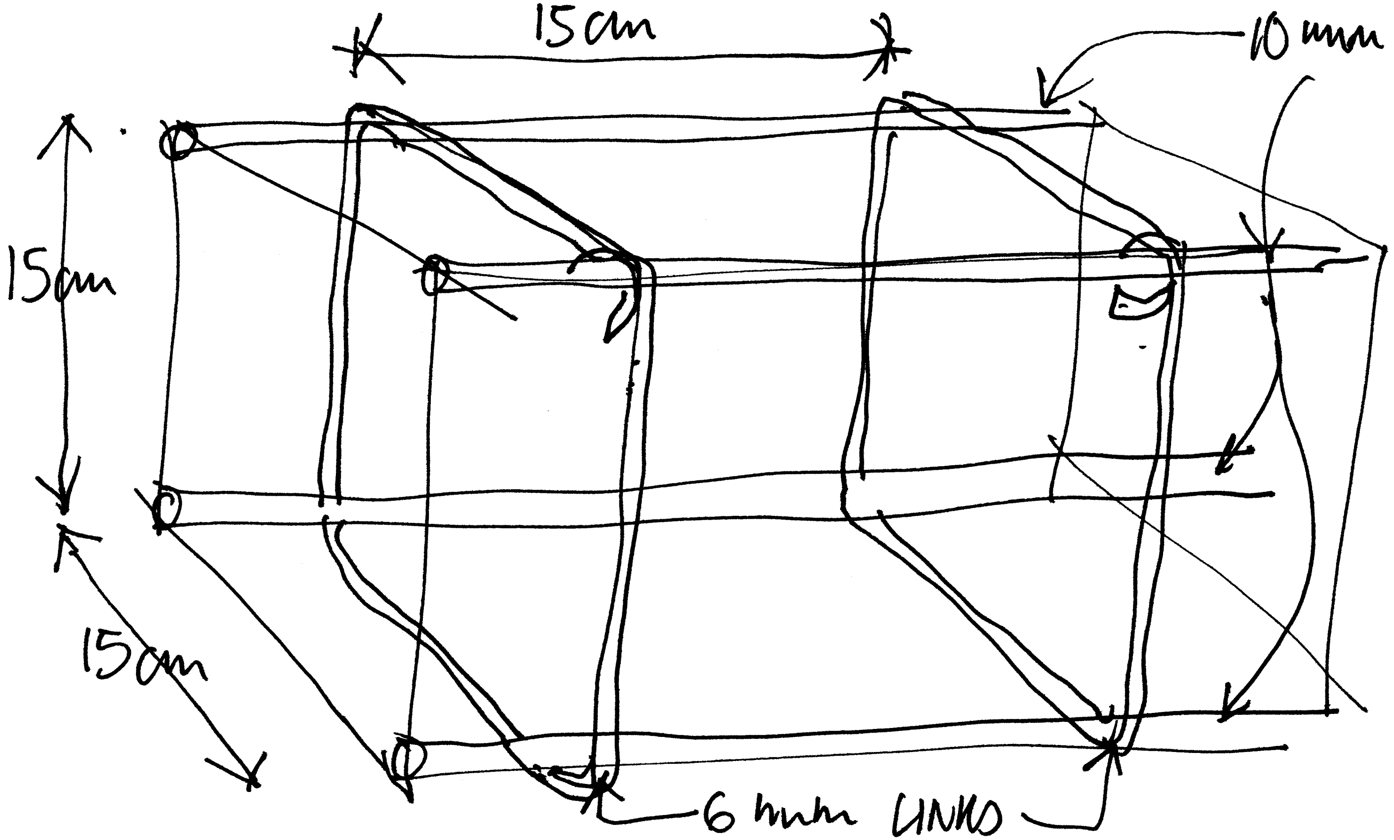
CONSTRUCTING THE GROUND BEAM



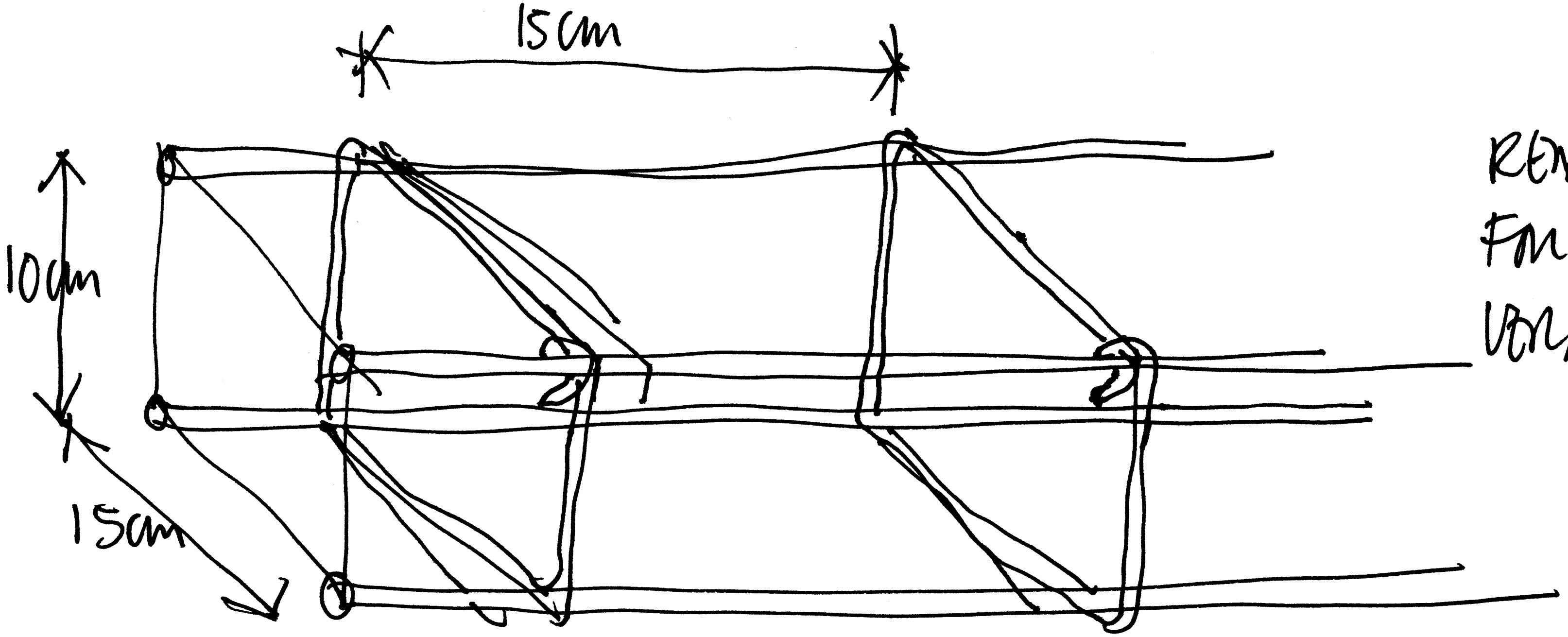
SAND/CEMENT SPACERS
WITH WIRE TIES



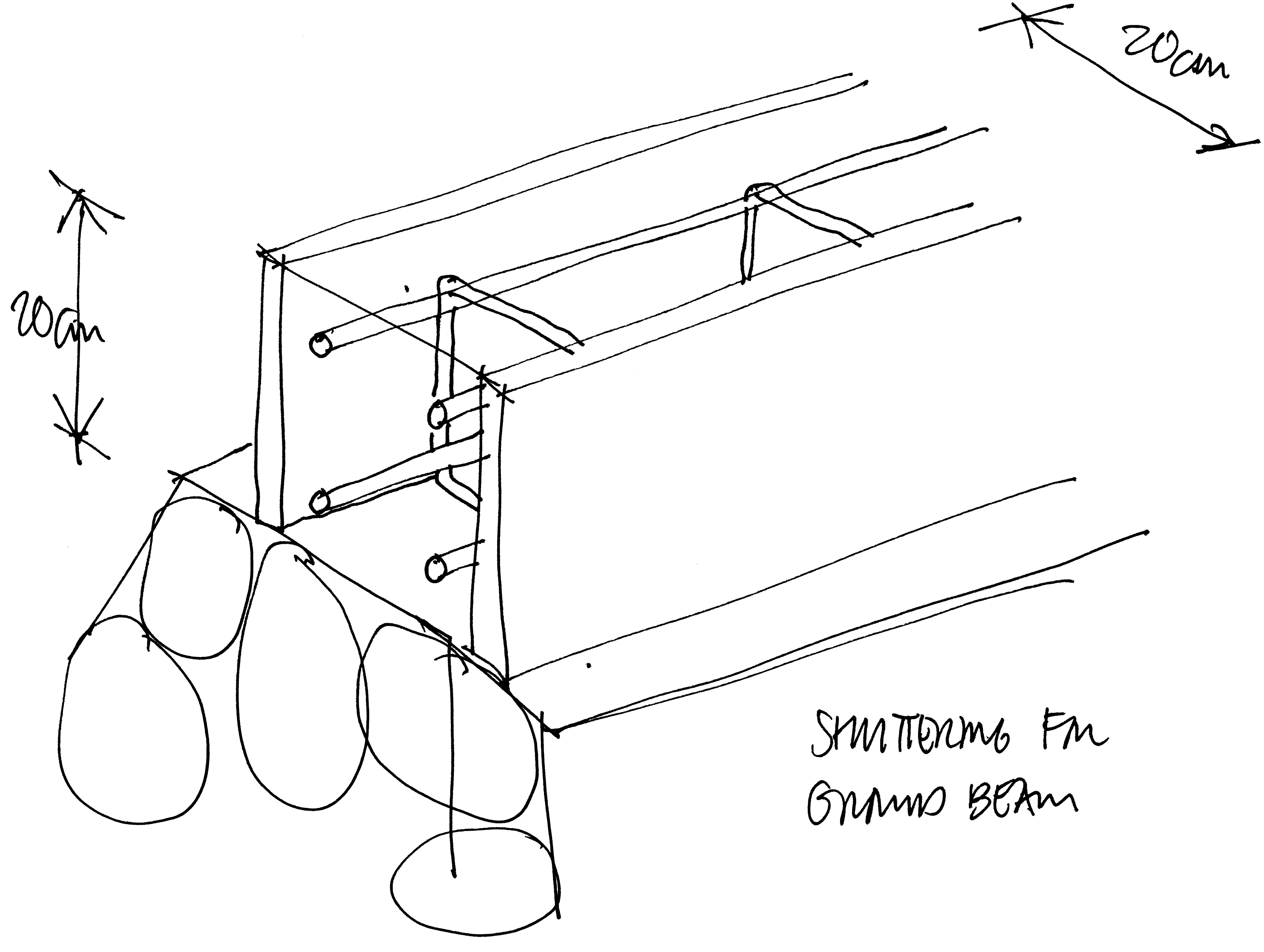
SPACERS TIED
TO RE RODS



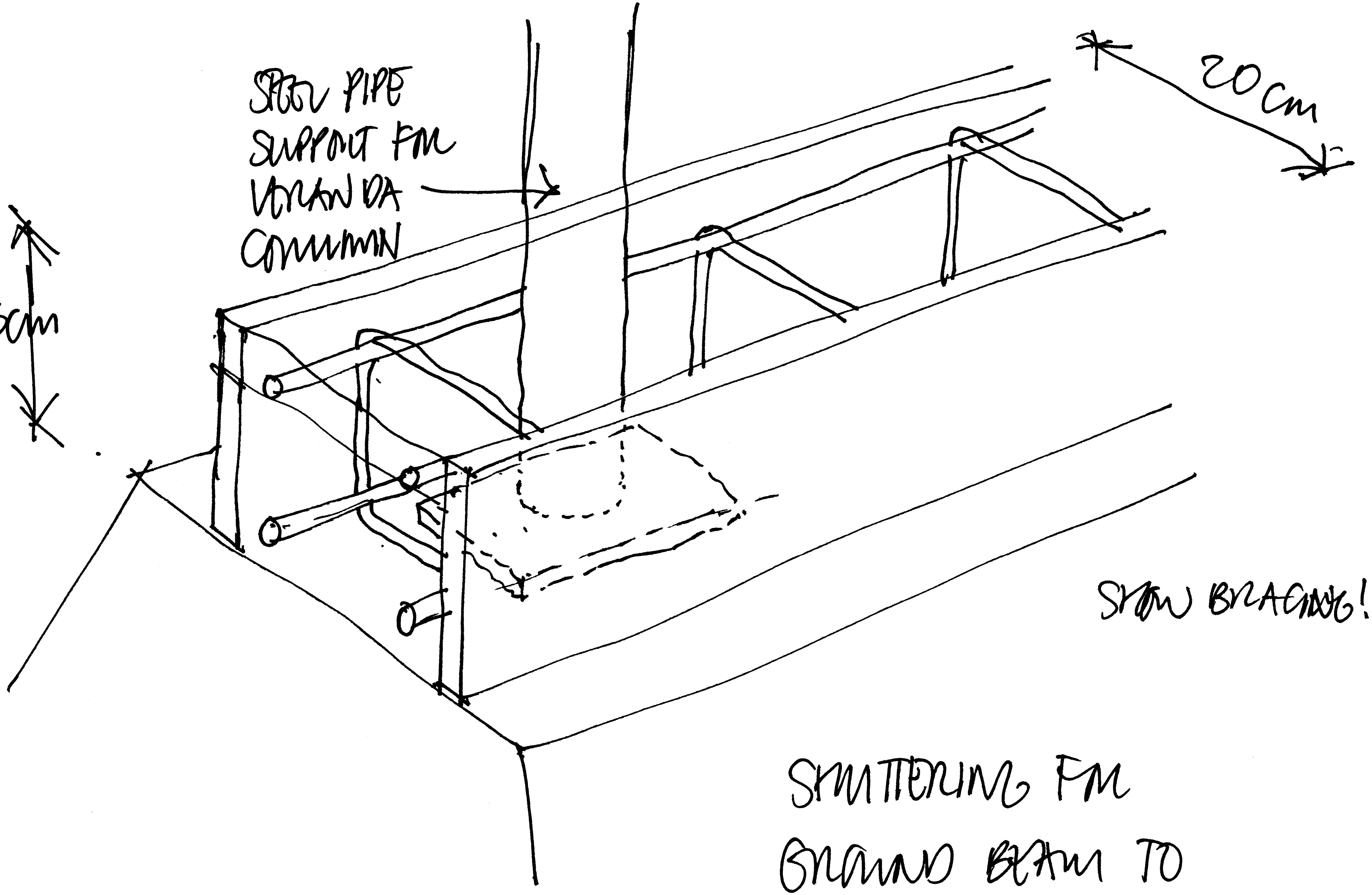
REINFORCEMENT CAGE TO GROUND BEAM & RING BEAM



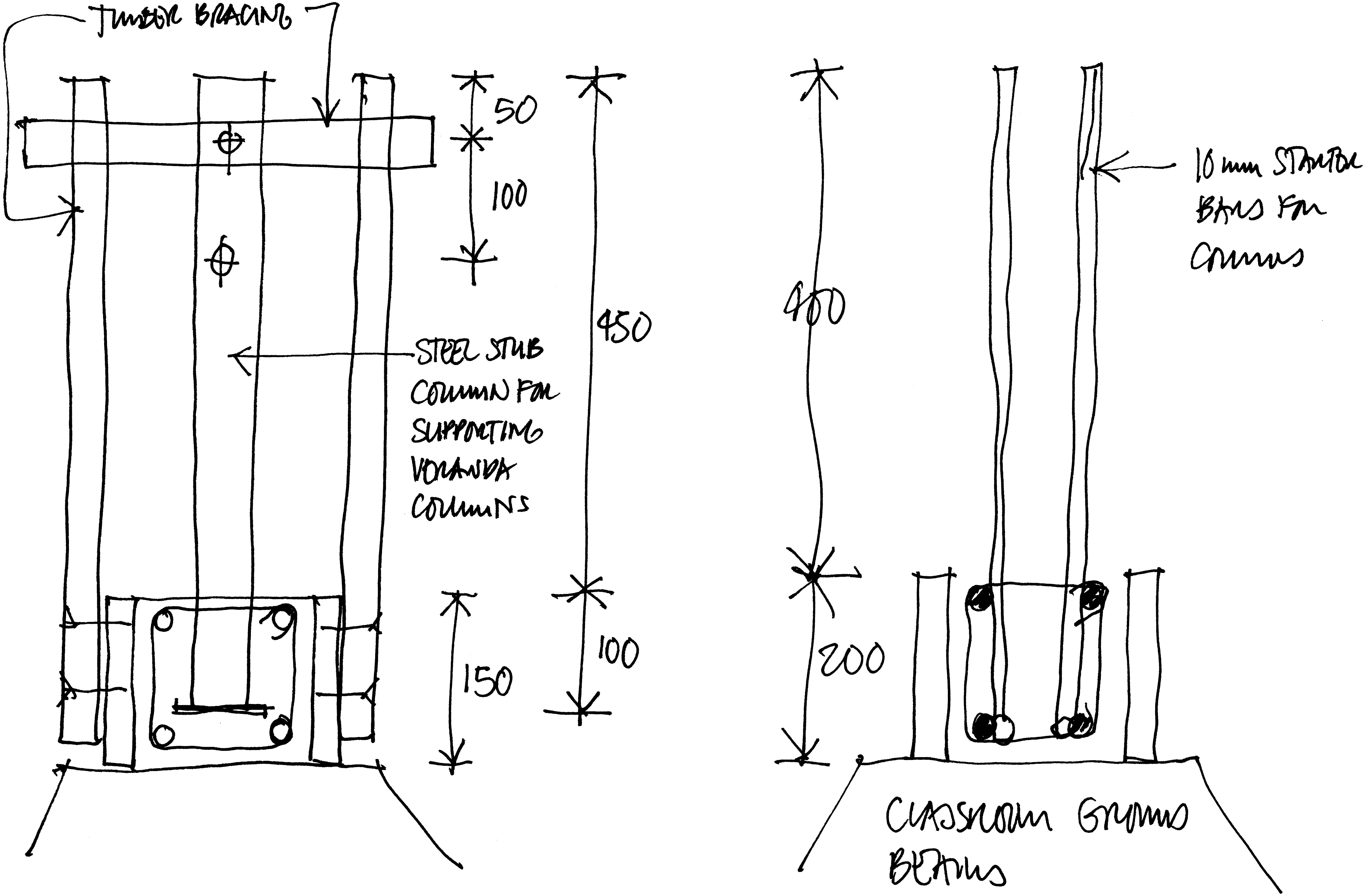
REINFORCEMENT CAGE FOR GROUNDBEAM TO VERANDAS ONLY.

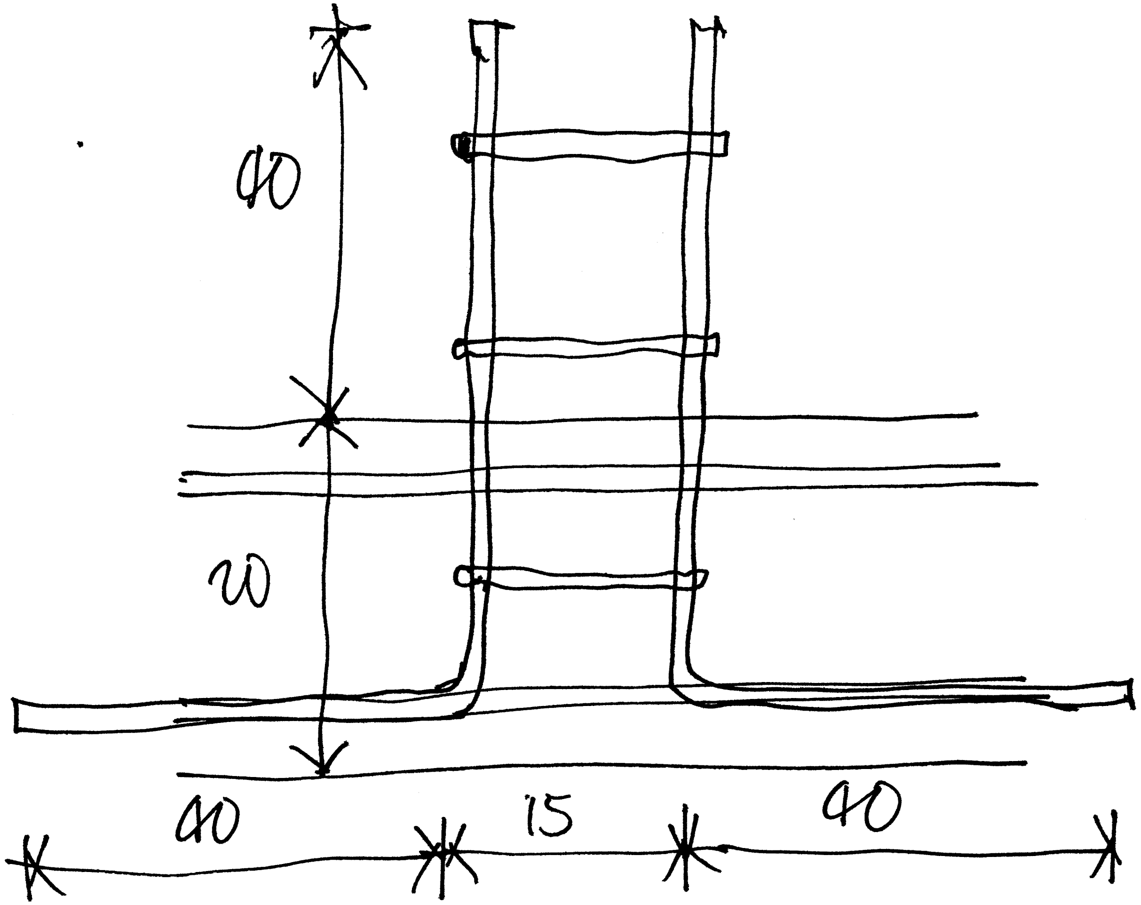


SHUTTERING FOR
GROUND BEAM



SHUTTERING FOR GROUND BEAM TO VERANDA


TIMBER BRACING
50
100
450
STEEL STUB COLUMN FOR SUPPORTING VERANDA COLUMNS
150
100
400
200
10 mm STARTER BARS FOR COLUMNS
CLASSROOM GROUND BEAMS



STARTER BARS FOR CLASSROOM COLUMNS.

12: CONSTRUCTING THE CONCRETE COLUMNS

Note: scaffolding around the building will be required from this stage onwards to enable the workers to complete the work in this stage and the work that follows.

After the ground beam has been cast, leave it to cure for at least 7 days. The reinforcement and shuttering for the concrete columns can then be fixed. All columns should be cast in timber shuttering and should not be cast into brick or block panels. In other words the columns must be cast before the brick or block walls are built.

The columns are constructed of concrete (mix: 1 cement to 1½ sand to 3 aggregate) reinforced with 4No 10mm Ø bars with 6mm Ø links at 15cm centres. The overall size of all columns is 20 x 20 cm.

The cage for the front and rear wall columns (outside size 15 x 15cm) is made up in one length up to top of column height (ie 3.05 metres above the top of the ground beam). The cage for the two columns to the cross and end walls is similar but the top of column height for these two columns is 4.15 metres. Attach spacers to the bars to ensure that there is 25mm of cover when the columns are cast.

Bend and lap the bars over the starter bars at the bottom for at least 40cm and this will give a total length for the cage for the front and rear columns of 3.05 metres including the lap (see sketch) and for the cross and end wall columns of 4.15 metres.

All columns should however have two bars extended for at least 30cm at the top to be used for fixing and holding down roof trusses and rafters by being bent over them and nailed in position (see sketch).

The fixing bolts for the cantilever brackets at the rear of the building must also be fixed at this stage. Wire one 250mm M12 steel bolts to the column reinforcement with 125mm of the bolt projecting from the face of the column (see sketch). The bolt should be 2.15 metres from the top of the ground beam. The second bolt will be fixed in the ring beam.

Once the reinforcement for the columns is fixed the shuttering for the columns can be erected.

The shuttering should be 20 x 20 cm internally and should be made up in one section up to the underside of the ring beam/lintel ie 2.65 metres high from the top of the ground beam. Check the shuttering with a plumb bob or a long level to ensure that it is vertical and then prop it and brace it securely in position to ensure that it does not move when the concrete is poured (see sketch).

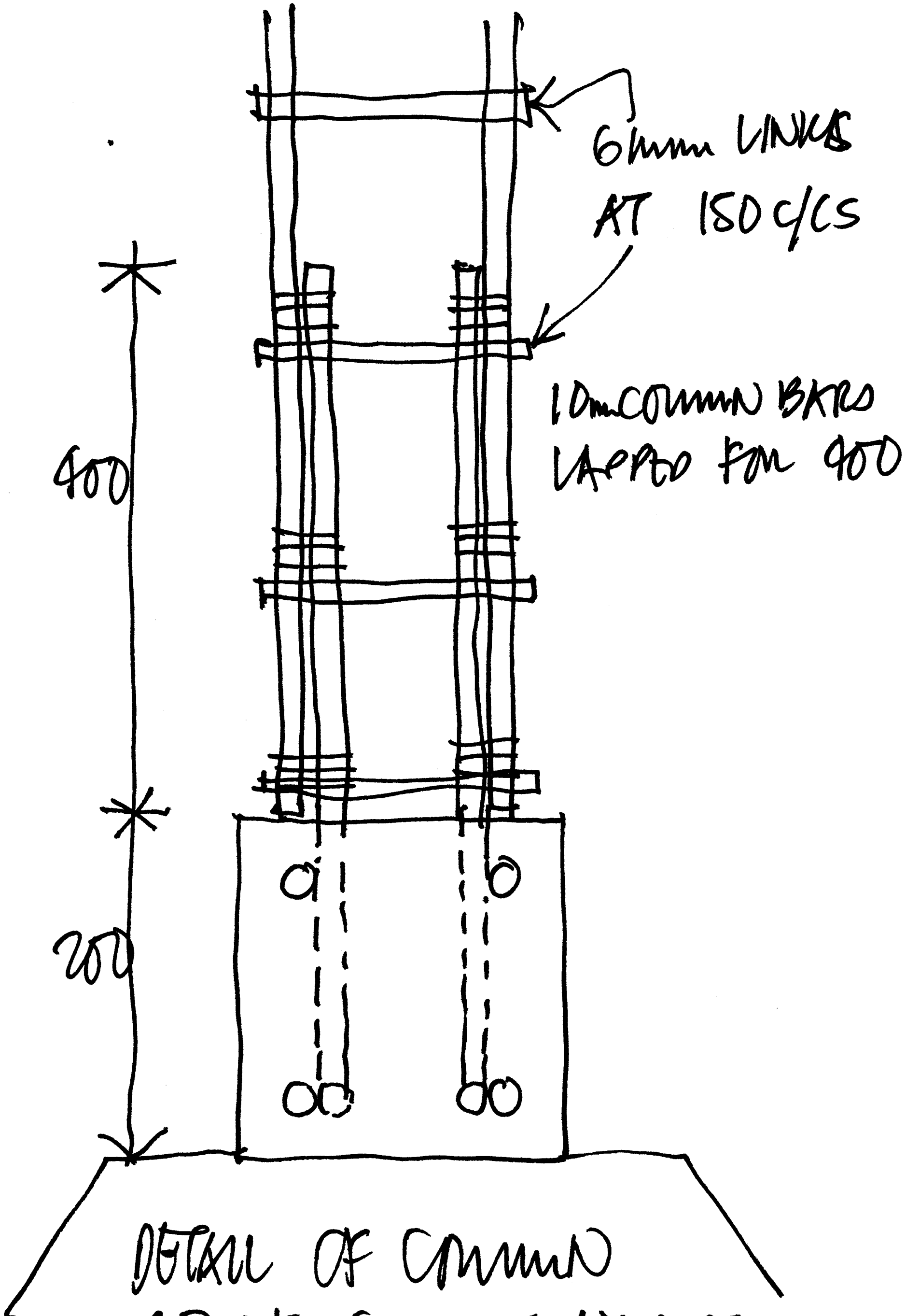
Tie bars should be built into the columns to tie the brick or block work to the columns. The tie bars are made of 10mm Ø reinforcing bars 80cm long. Drill the shuttering on either side of the columns at 40cm maximum centres (or to match the coursing of the bricks or blocks) and pass the tie bars through so that 30cm protrudes on either side before the concrete is cast (see sketch). Cast in wooden plugs into the sides of the columns for fixing door and window frames (see sketch).

The concrete for the columns can now be poured and each column should be cast in one lift. Pour the concrete very carefully and tamp it thoroughly with a 12mm steel rod as it is poured to ensure that the whole area of the formwork is filled and there are no airspaces which will weaken the column. Tapping gently on the outside of the formwork as the concrete is poured will also assist in getting rid of any air bubbles (see sketch).

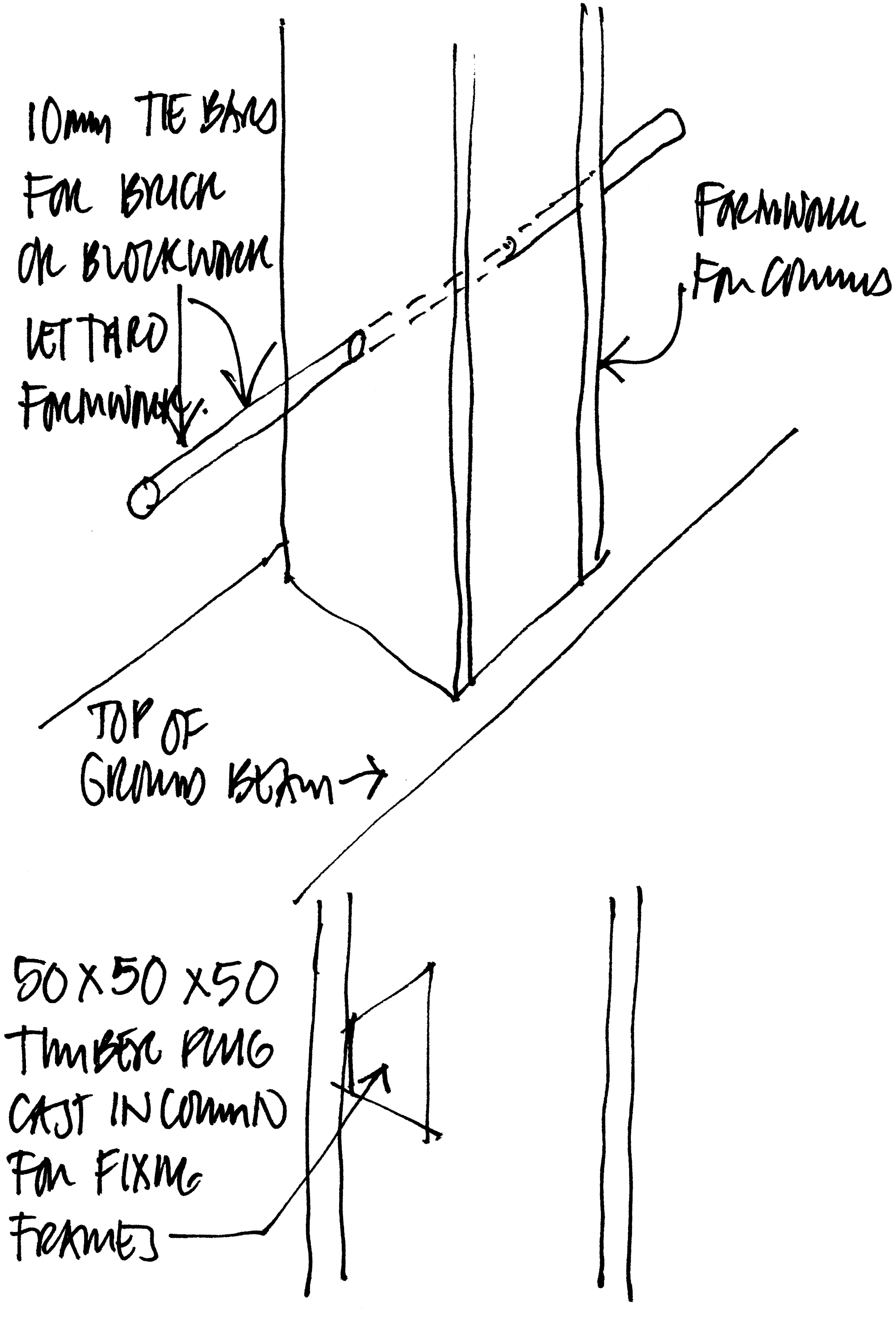
Leave the columns for at least a week before casting the ring beams/lintels and leave the formwork to the columns on for at least a week before removing it so that the concrete can cure properly.

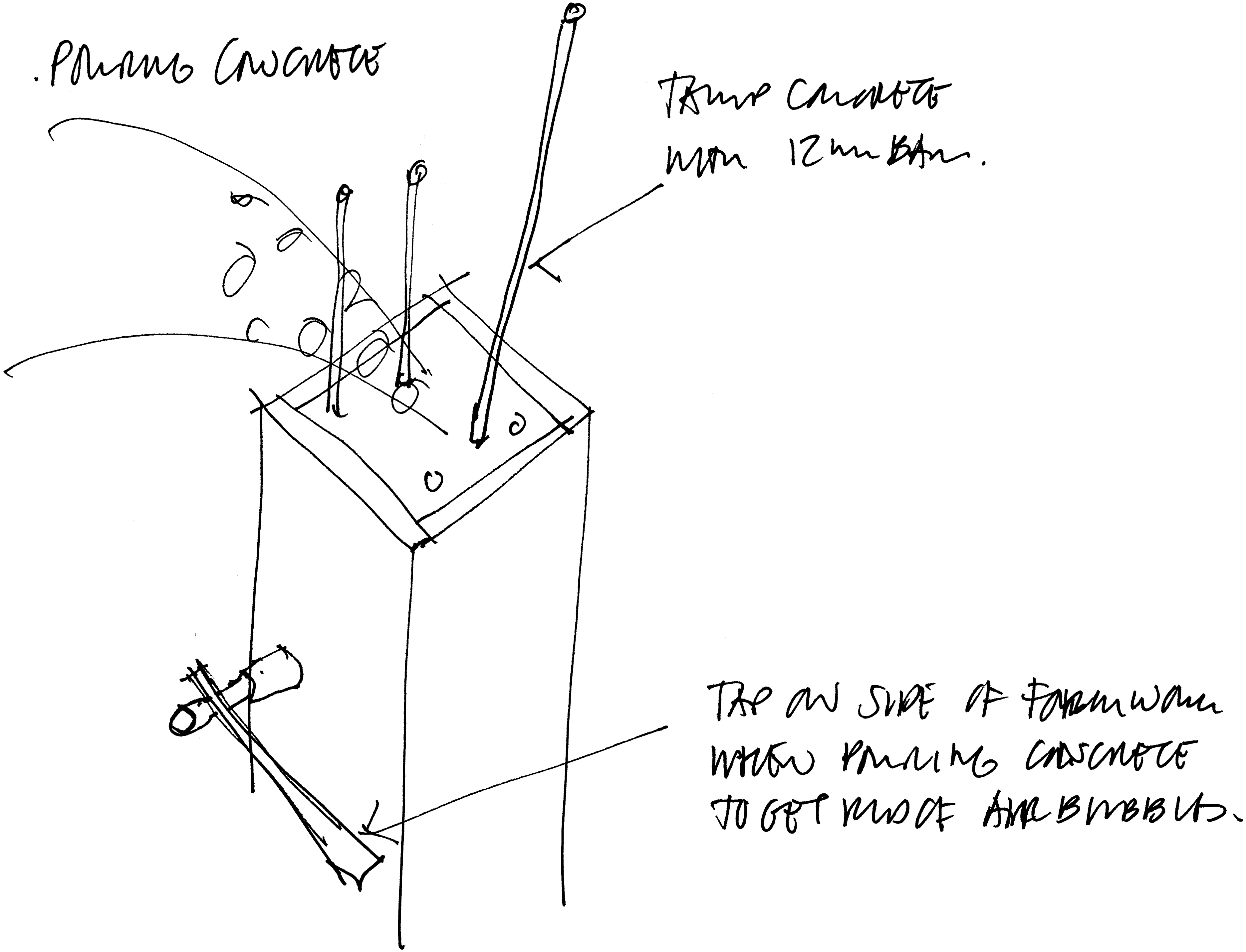
Remember: To

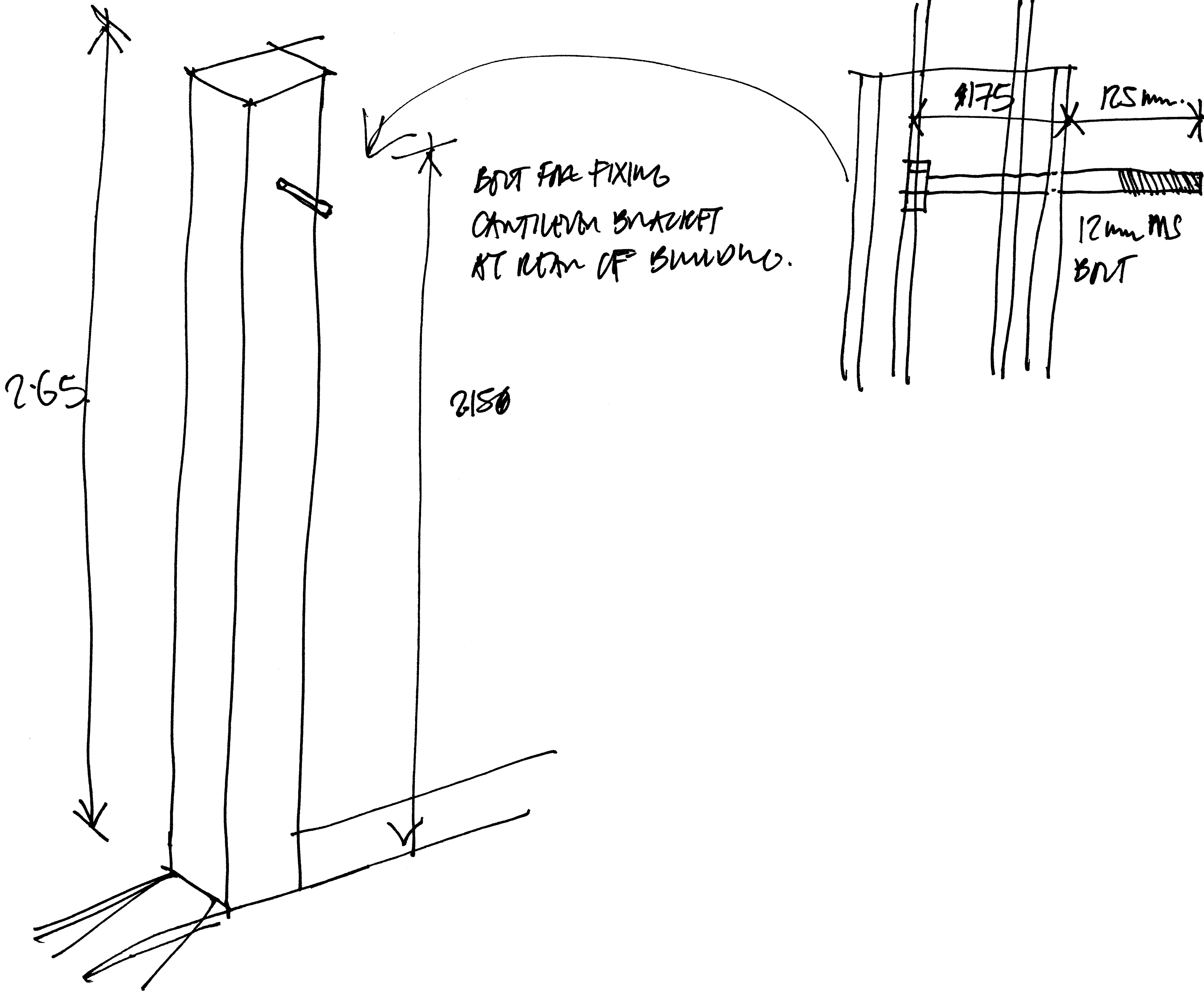
- **To erect scaffolding around the building**
- **To bend and lap the column bars over the starter bars for 40cm**
- **To extend two bars in each column by 30cm for fixing rafters and trusses**
- **To ensure that all column shuttering is plumb and adequately braced before pouring concrete**
- **To build in tie bars for brick or block work before pouring concrete**
- **To build in the fixing bolts for the cantilever brackets before pouring the concrete**
- **To tamp the concrete thoroughly as it is poured**

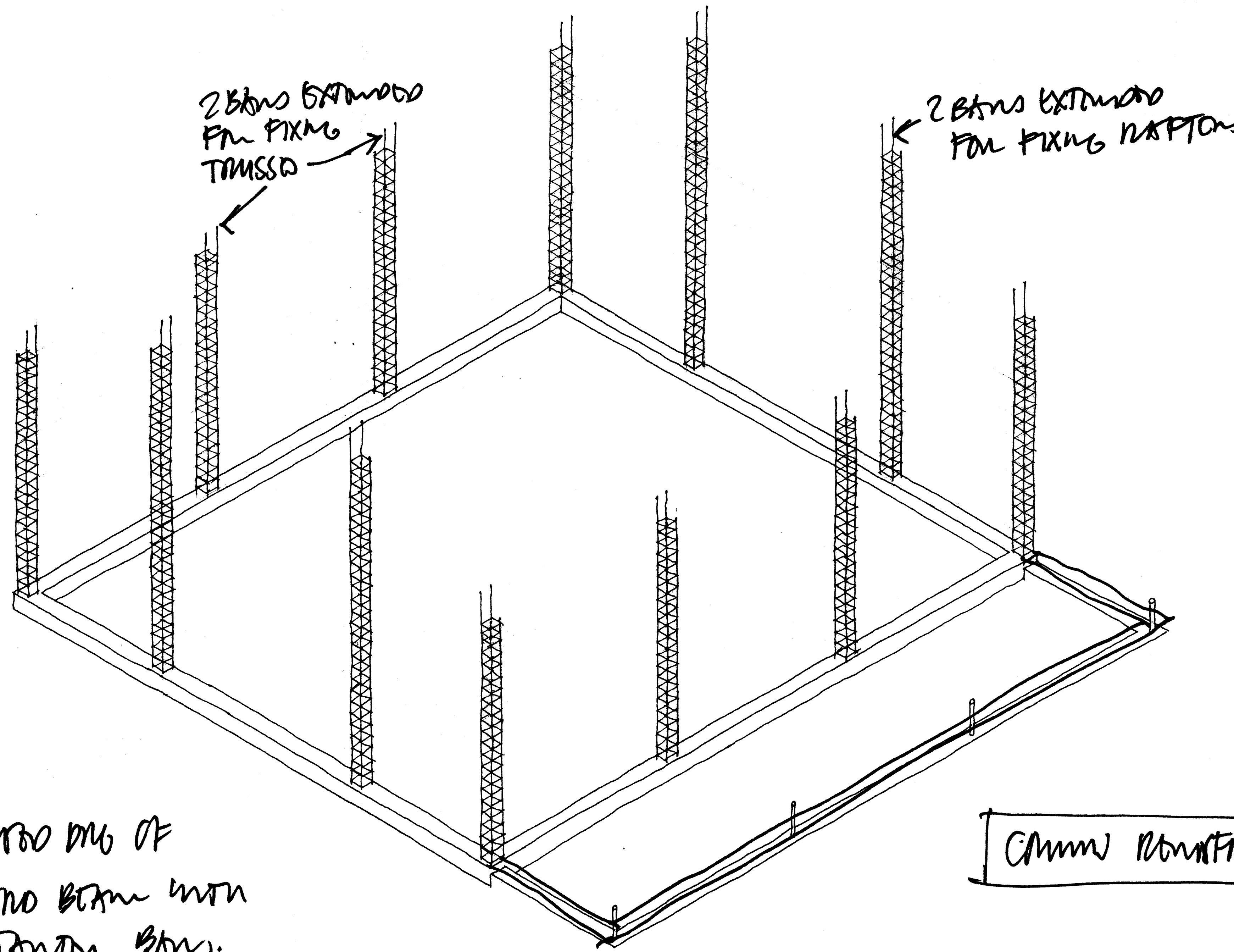


DETAIL OF COLUMN REINFORCEMENT AT BASE OF COLUMN




POURING CONCRETE
TAMP CONCRETE WITH 12mm BAR.
TAP ON SIDE OF FORMWORK WHEN POURING CONCRETE TO GET RID OF AIR BUBBLES.


2·65
2150
BOLT FOR FIXING
CANTILEVER BRACKET
AT REAR OF BUILDING.
175
125mm.
12mm MS
BOLT



ISO DWG OF GRD BEAM WITH STARTER BARS.

COLUMN REINFORCEMENT

13: CONSTRUCTING THE RING BEAMS/LINTELS

When the columns have been left to cure for a week the formwork to the columns can be removed and the formwork for the ring beams/lintels can be erected.

The ring beam/lintel is constructed of concrete (mix: 1:1½:3) reinforced with 4No 10mm Ø bars. The overall size of the ring beam/lintel is 20 cm high x 20 cm wide.

Fix the shuttering for the ring beams/lintels before making up the reinforcement cage. The shuttering is made of timber and the internal size should be 20 cm high x 20 cm wide.

The shuttering for all ring beams/lintels should span between and go around the columns (see sketch).

The shuttering must be supported below on posts sitting on the ground beam at maximum intervals of 60cm so that when the concrete is poured it does not deflect (see sketch).

Make sure that the shuttering is straight and level and adequately braced so that when the concrete is poured, the shuttering does not move (see sketch). The shuttering for all ring beams/lintels around the building must be completed before any concrete is poured so that all ring beams/lintels can be cast at one time.

Make up the cages for the ring beams/lintels (outside size 15 x 15cm with 6mmØ links at 15cm centres) in lengths to suit the column grid and the length and width of the building. Where bars have to be joined the overlap should be at least 40cm and the bars should be bent so that they form a straight line when wired together.

Return the reinforcement at all corners and junctions of walls around the corners by at least 40cm (see sketch). Bend the ends of all bars back to assist bonding (see sketch).

Pass the reinforcement for the ring beams/lintels through the reinforcement for the columns that has been previously fixed. Attach spacers to the bars to ensure that there is 25mm of cover when the beams are cast. Build in timber plugs to the bottom of the beams for use in fixing door and window frames (see sketch).

The second fixing bolt for the cantilever brackets at the rear of the building must also be fixed at this stage. Wire one 250mm M12 steel bolts to the ring beam reinforcement at the centre of the beam on the centre line of the column with 125mm of the bolt projecting from the face of the beam (see sketch).

The concrete for the ring beams/lintels can now be poured. Take great care not to move the shuttering when the concrete is being poured and tamp the concrete thoroughly during pouring to ensure that there are no air pockets. Gently tapping the sides of the formwork will also assist in getting rid of any air bubbles.

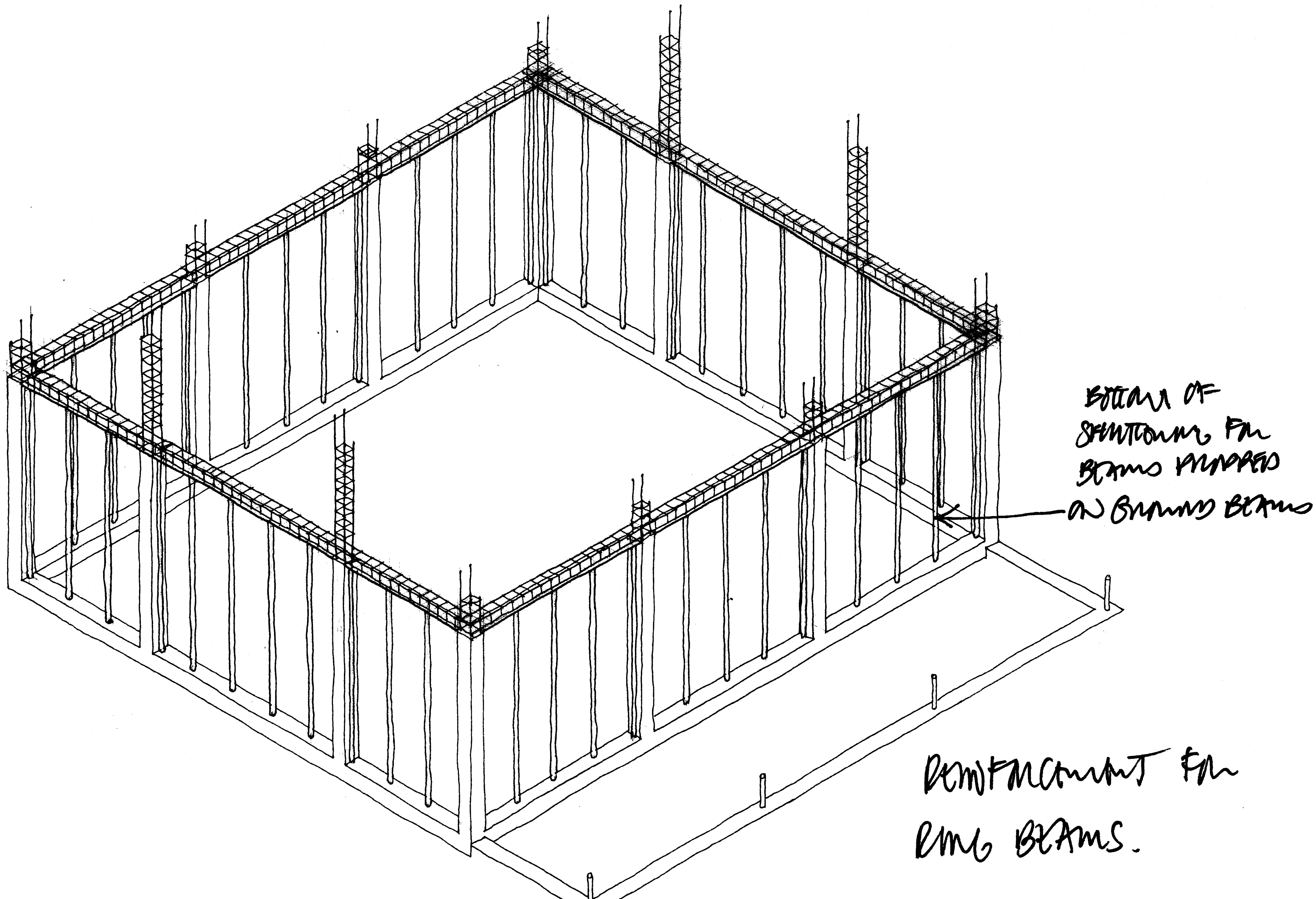
If possible pour the concrete for all ring beams/lintels at one time. If this is not possible concreting should be stopped at a position one third (⅓rd) of the way along the span of a beam (see sketch) and the end of the concrete should be sloped at 45°.

When concreting resumes, hack the end of the old concrete and make sure that it is well wetted with water before pouring the new concrete.

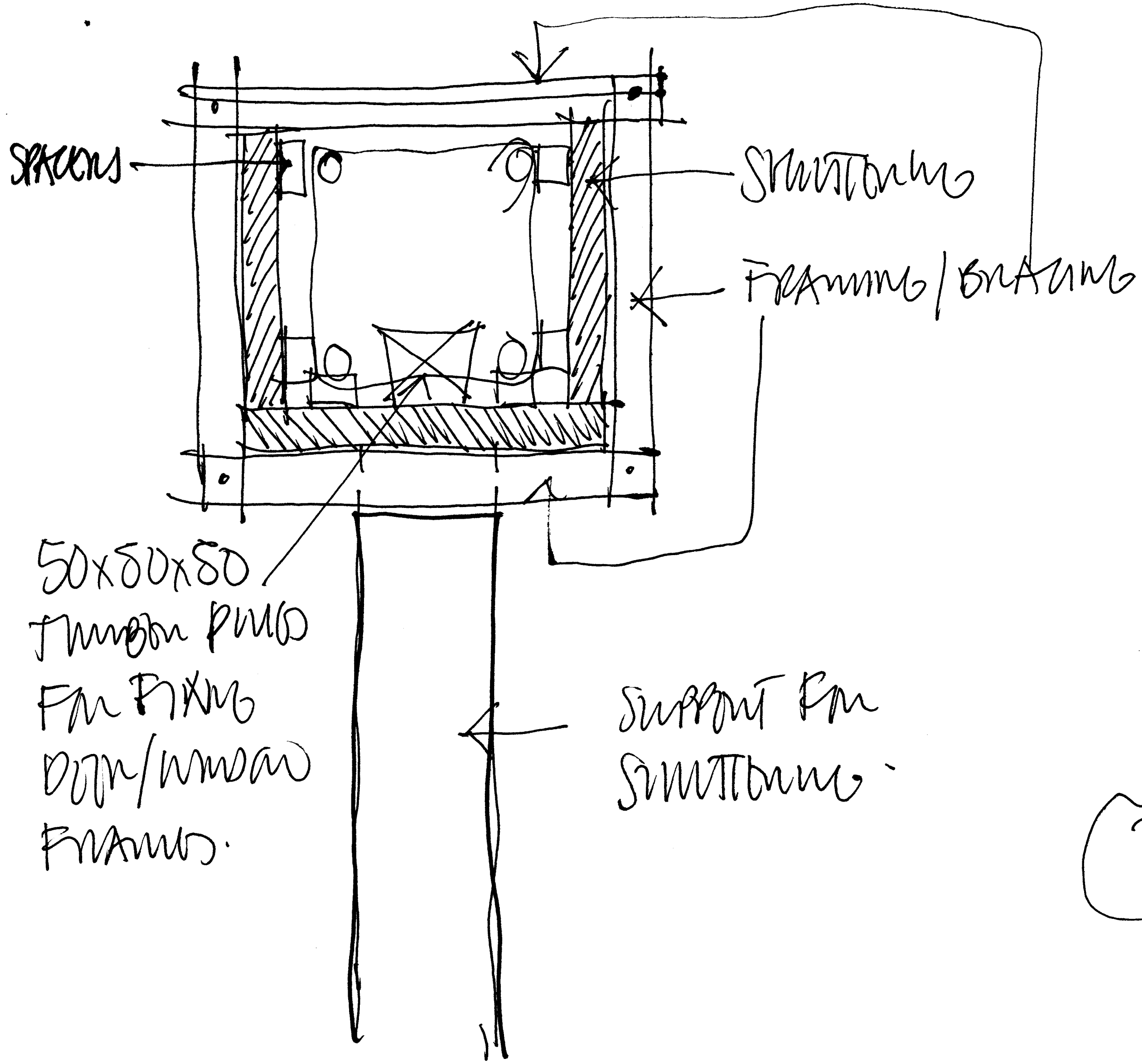
The shuttering to the sides of the ring beams/lintels can be removed after one week but the bottom of the shuttering and the supports under the shuttering must be left in place for at least 3 weeks after the concrete has been poured.

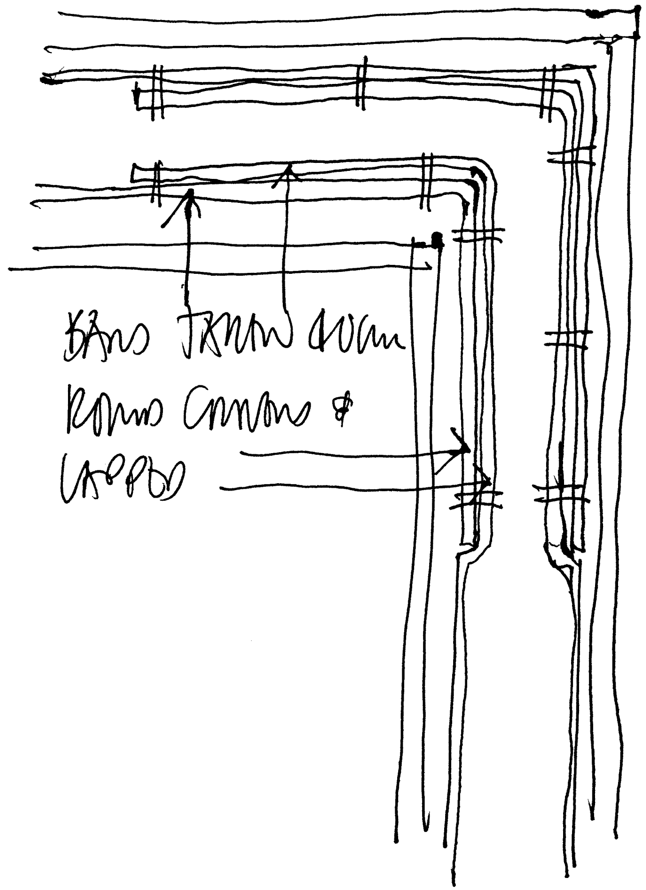
Remember:

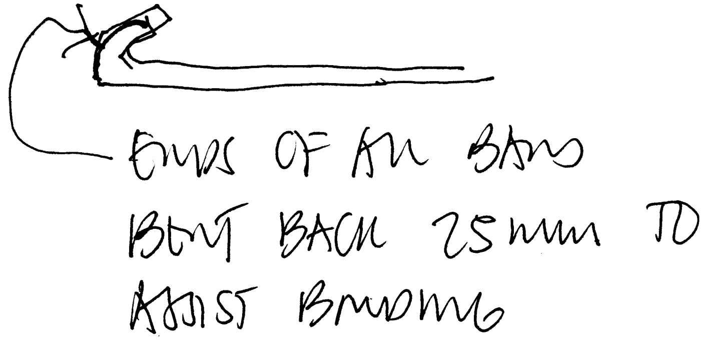
- **Make sure that the formwork for the ring beams is adequately supported underneath and properly braced**
- **Make sure that the formwork is level and straight before pouring the concrete**
- **To build in the fixing bolts for the cantilever brackets before pouring the concrete**
- **To tamp the concrete thoroughly as it is poured**
- **To pour the concrete for all ring beams at one time or if not possible or follow the instructions above for stopping the concreting**
- **To leave the shuttering and supports under the beams for at least 3 weeks before removing them**



REINFORCEMENT FOR RING BEAMS.

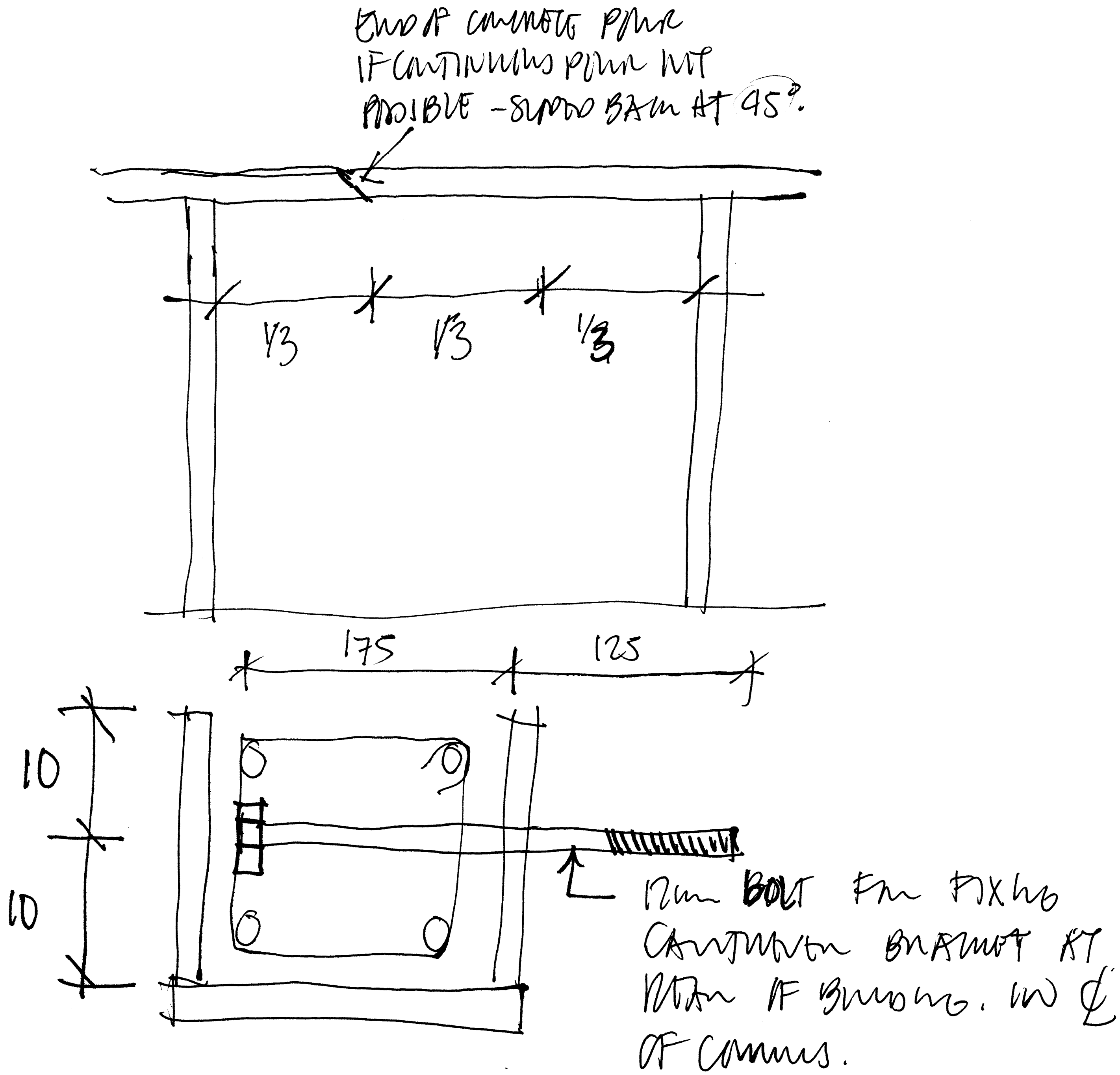

SPACERS
SHUTTERING
FRAMING/BRACING
50x50x50 TIMBER PLUG FOR FIXING DOOR/WINDOW FRAMES.
SUPPORT FOR SHUTTERING.


BARS TAKEN ROUND CORNERS & LAPPED


ENDS OF ALL BARS BENT BACK 25mm TO ASSIST BONDING

Cimu Investigation of alleged malpractices in program implementation

Ind:



14: CONSTRUCTING THE COLUMNS ABOVE RING BEAM/LINTEL LEVEL

When the ring beams/lintels have been left to cure for a week the formwork can be removed (apart from that underneath) and the formwork for the high level columns above the ring beams/lintels can be erected.

These consist of short columns 20cm high along the front and rear of the buildings and two columns 1.3 metres high in each of the cross and end walls.

The shuttering should be 20 x 20cm internally and should be made up in one section up to the top of the columns ie 20cm and 1.3 metres (with sloping top). Check the shuttering with a plumb bob or level to ensure that it is perfectly vertical and make sure that it is braced and propped securely in position to ensure that it does not move when the concrete is poured (see sketch).

Tie bars must be built into the columns in the cross and end walls to tie the brick or block work to the columns. The tie bars should be of 10mm Ø reinforcing bars 80cm long. Drill the shuttering on either side of the columns at 40cm minimum centres (or to match the coursing of the bricks or blocks) and pass the tie bars through so that 30cm protrudes on either side of the shuttering before the concrete is cast (see previous sketch for main columns).

The concrete for the columns can now be poured (mix: 1:1½:3 as before). Pour it very carefully and tamp it thoroughly with a 12mm steel rod as it is poured to ensure that the whole area of the formwork is filled and there are no airspaces which will weaken the column. Tapping gently on the outside of the formwork as the concrete is poured will also assist in getting rid of any air bubbles (see sketch).

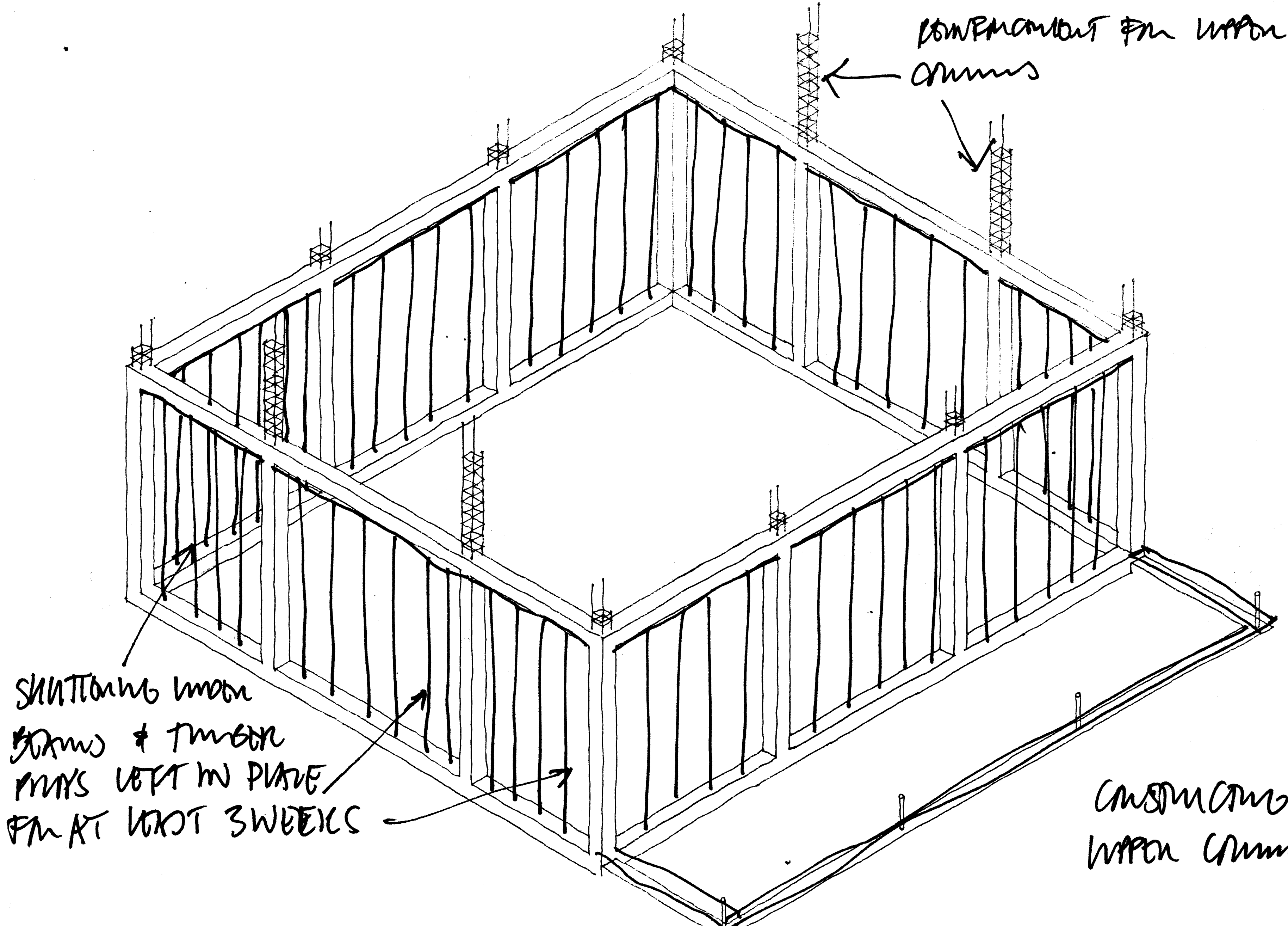
Leave the formwork around the columns for at least a week before removing it so that the concrete can cure.

Remember:

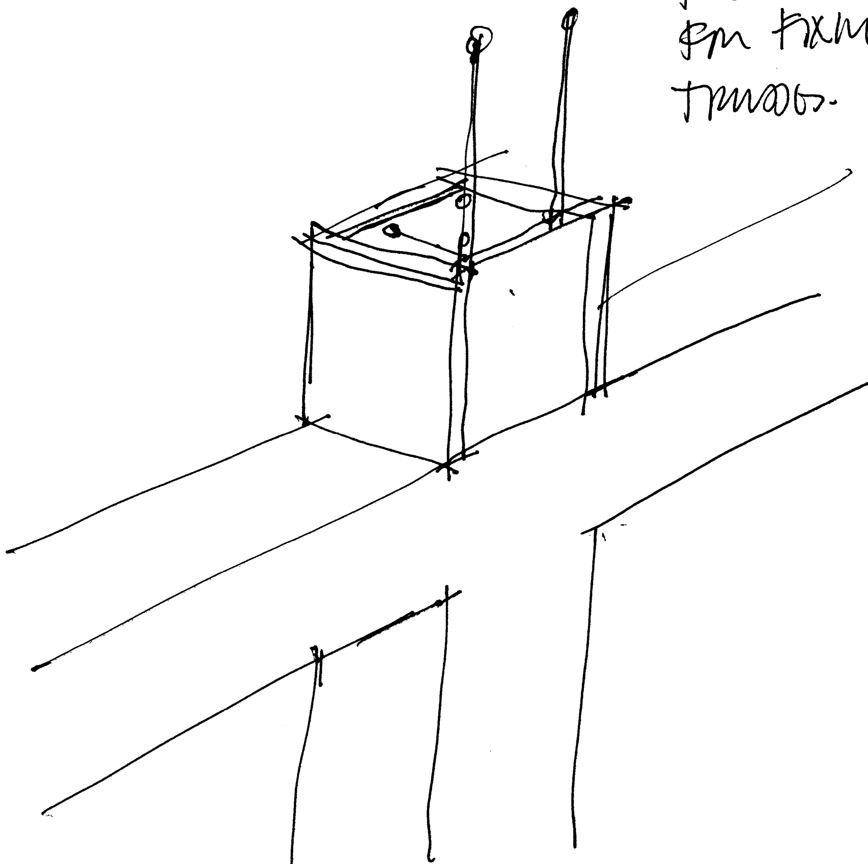
- **To ensure that all column shuttering is plumb and adequately braced before pouring concrete**

- **To build in tie bars in the columns in the end and cross walls for brick or block work before pouring concrete**

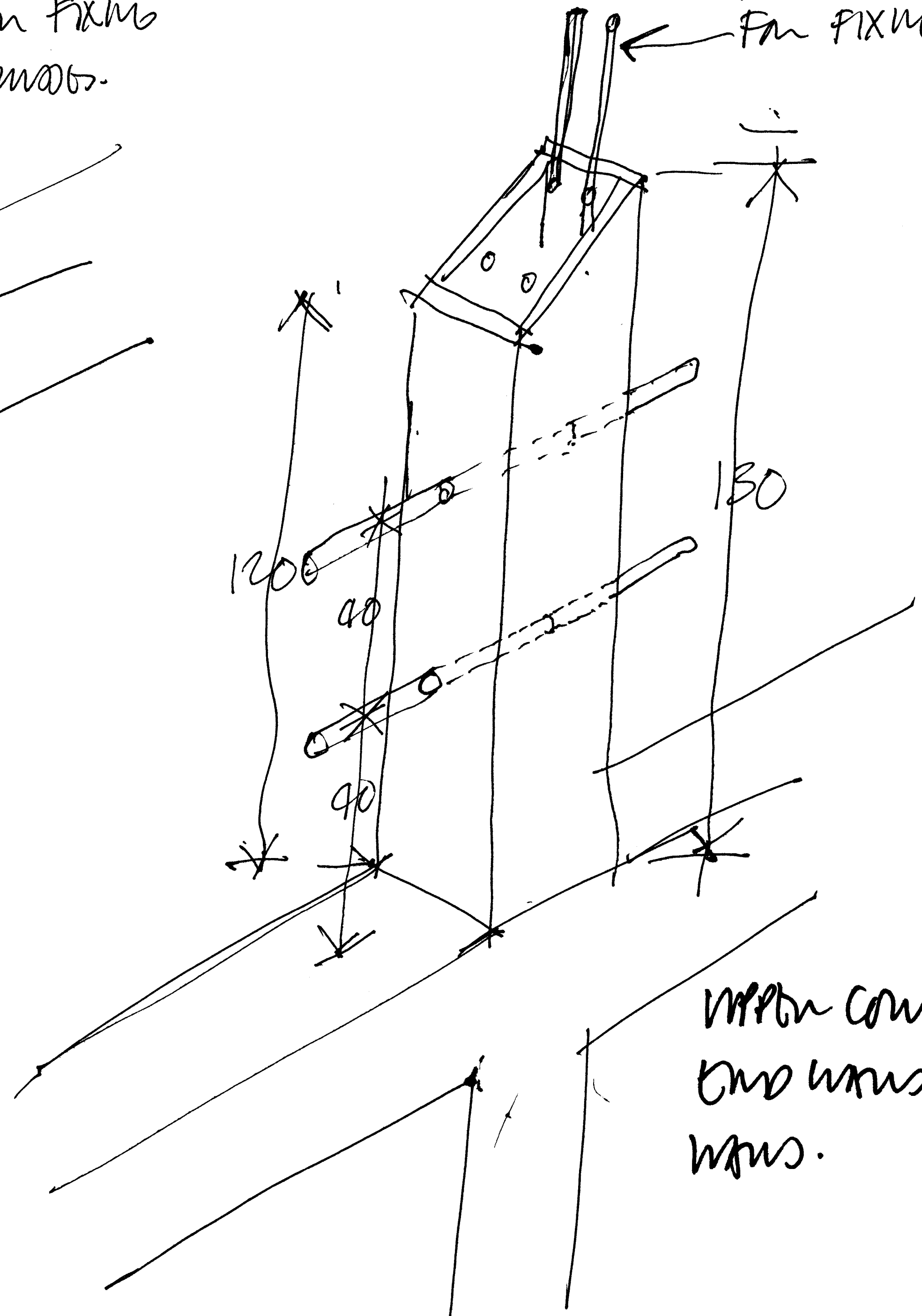
- **To tamp the concrete thoroughly as it is poured**



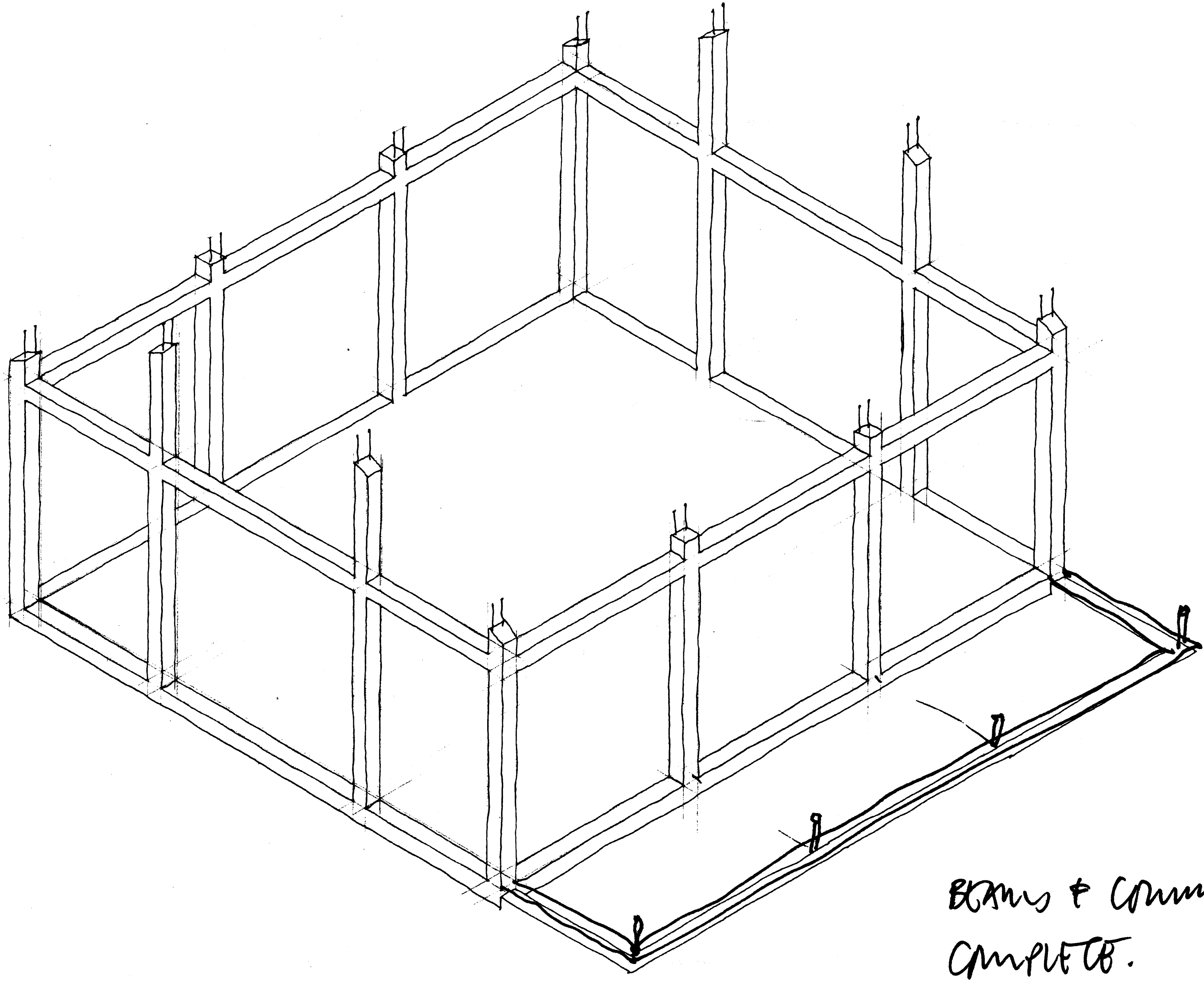
CONSTRUCTING THE UPPER COLUMNS.



UPPER COLUMNS TO FRONT & REAR OF CLASSROOMS



UPPER COLUMNS TO END WALLS & CROSS WALLS.



BEAMS & COLUMNS COMPLETED.

15: ERECTING THE ROOF TRUSSES & RAFTERS

When the concrete structure has been completed, the roof can be constructed. This will enable the completion of all other trades under cover, which will be important if construction is taking place during the rainy season.

Always use the best quality timber for roofing and always use timber that has been well seasoned. Un-seasoned timber will shrink and twist as it dries out and can cause damage to the roof and look unsightly if the roof timbers are exposed.

Store the timber under-cover before it is used and stack it carefully on blocks off the ground. Make sure the stack is level so that the timbers do not bend or twist and put spacers between each layer of timber so that the air can circulate. If un-seasoned timber cannot be purchased, buy the timber as early as possible and stack it as above so that it can season for as long as possible.

Cut the roof truss members to length and assemble the trusses (with temporary fixings) on the ground but under cover if possible. Use the first truss as a template for the remaining trusses so that all of the trusses are exactly the same.

Cut the rafters (15 x 5cm) to go on top of the end and cross walls to length (see sketch).

All roof timbers should be treated against insect attack before they are erected and fixed. Used engine oil is an effective low-cost material for treating timber.

Erect temporary scaffolding of bamboo, poles or timber in the classrooms to assist with the erection and fixing of the roof trusses and the fixing of the ceilings.

Before erecting and fixing the trusses and rafters, clean off the tops of the concrete columns and level them and make them good as necessary. Make sure that the tops of the columns in the cross walls and end walls are to the line of the angle of the roof trusses.

Erect the trusses using temporary supports resting on the ground and bolt the members together using M12 steel bolts with washers to both sides (see truss details).

Erect the two trusses at each end of the building first and run builder's line between these to use for lining up the remaining trusses. Make sure that the trusses are vertical and that the bottom members are level before they are fixed. Using packing members to adjust the level of the trusses if necessary. Then fix the trusses to the top of the columns in the classroom walls by bending over the protruding reinforcing bars and nailing them to the trusses.

Use the string lines between the trusses to position the rafters over the intermediate cross walls and run additional lines to the end walls to position the rafters there. Fix the rafters following the line of the string lines (pack the rafters up or reduce the height of the columns as necessary) to the tops of the columns using the reinforcing bars protruding from the columns. Bend the bars over the rafters and nail them to the sides of the rafters.

Remember:

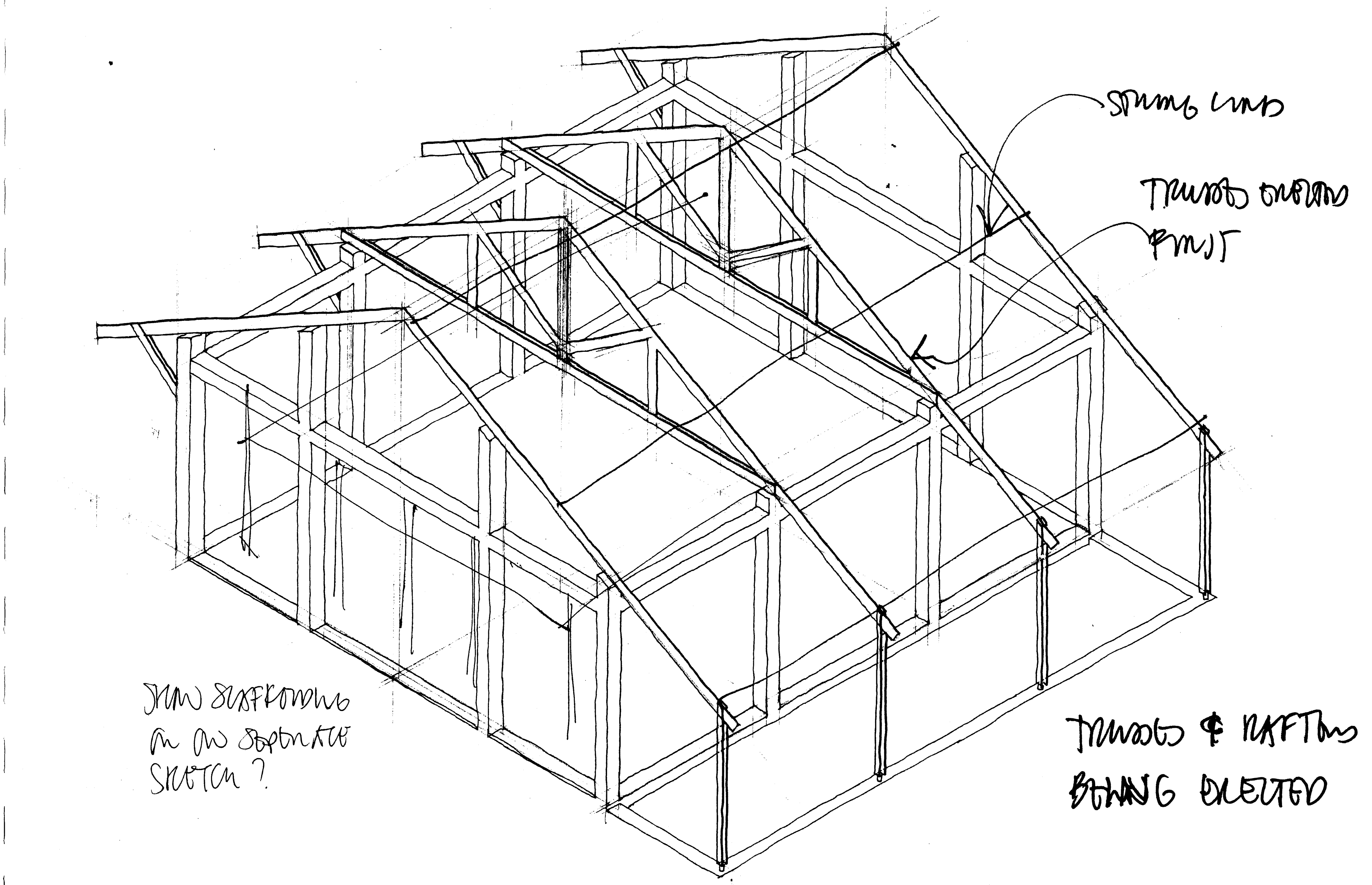
- **Use good quality, seasoned timber for all roof members**
- **Store the timber carefully and under cover before it is used**
- **Assemble the trusses on the ground first to ensure that they are the correct size and shape and use the first truss as a template for the rest**
- **Treat all timber against insect attack before fixing it**
- **Line up all trusses and rafters with string lines to ensure that they are in line and correctly positioned**
- **Fix all truss members with M12 steel bolts and washers**
- **Fix all rafters and trusses with the reinforcing bars projecting from the tops of columns to ensure that they are properly fixed down**

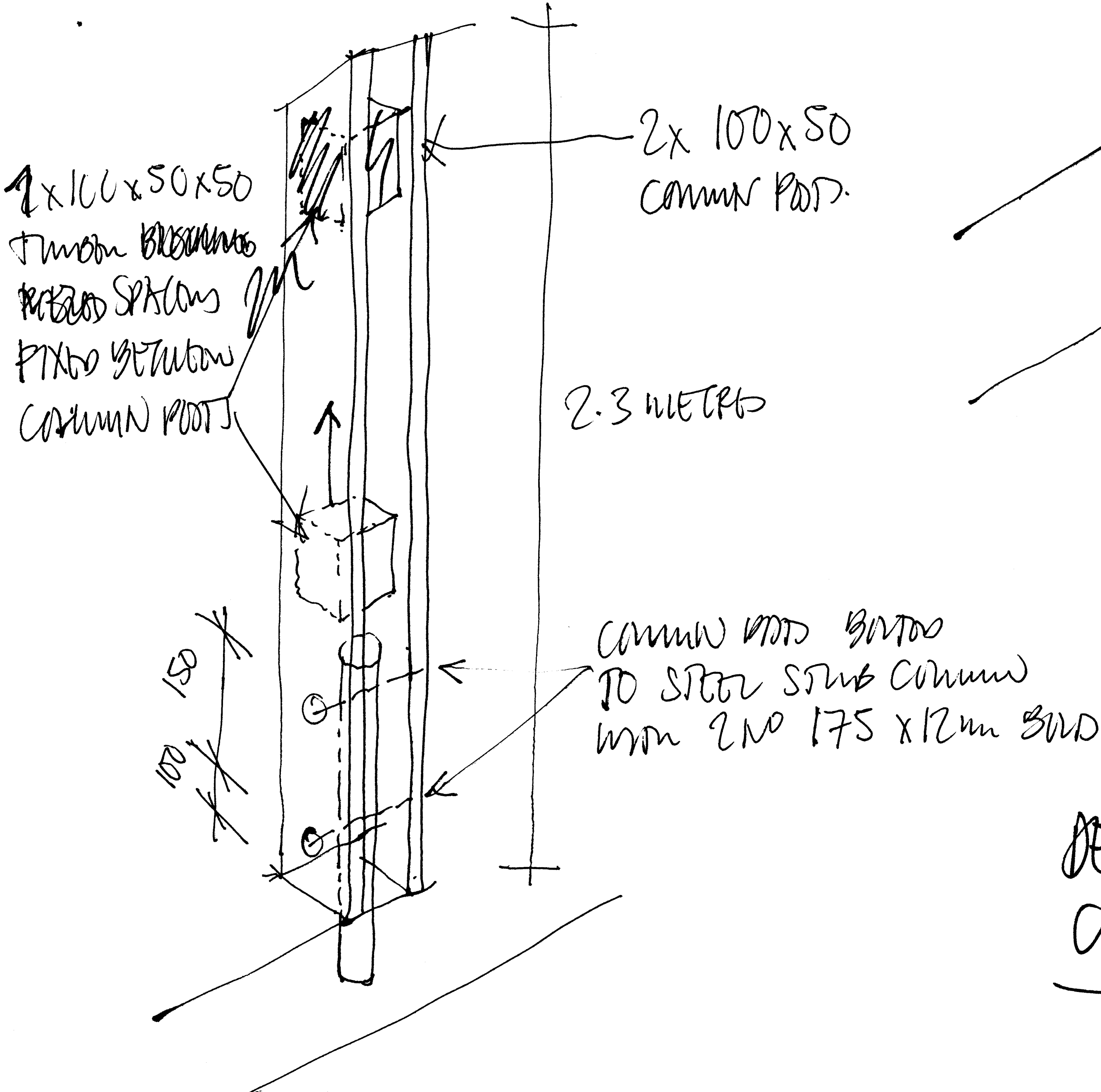
PUT IN HERE –

– DETAILED DRAWINGS OF TRUSSES & RAFTERS. SHOWING SIZE & LENGTH OF ALL TRUSS MEMBERS & BOLT FIXINGS.

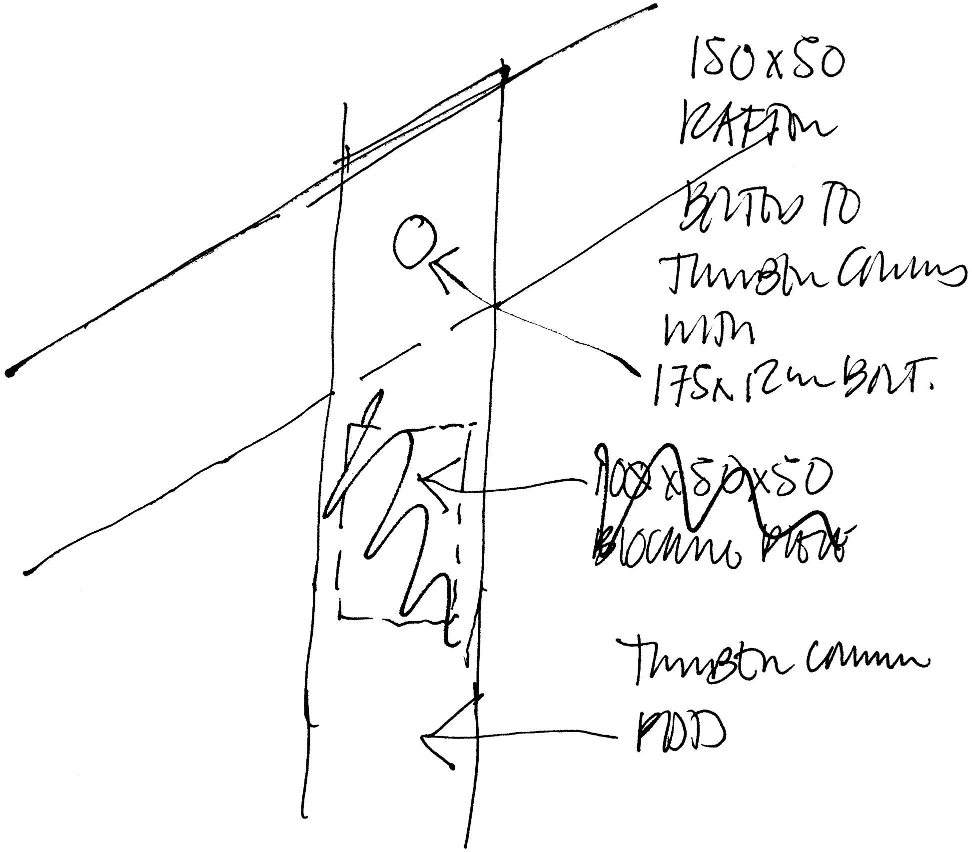
– SKETCH SHOWING TRUSS BEING ASSEMBLED ON THE GROUND.

– SKETCH SHOWING TEMPORARY SCAFFOLDING IN CLASSROOM


STRING LINE
SHOW SCAFFOLDING ON A SEPARATE SKETCH?
TRUSSES & RAFTERS BEING ERECTED



VERANDA COLUMNS



DETAILS OF VERANDA
COLUMNS

16: ERECTING THE VERANDA COLUMNS & CANTILEVER BRACKETS

The roof over the veranda at the front of the building is supported on rafters supported at the outside of the veranda by hardwood columns made of two pieces of timber 10 x 5cm, 2.25 metres long.

The two pieces of hardwood forming each column are first fixed together with a 10 x 7.5 x 5cm hardwood blocking piece in the centre and the column is then twice bolted at the bottom to the steel stub column previously cast into the concrete ring beam with 2No M12 x 175mm steel bolts with washers to both sides. The timber columns should be 15cm above the top of the veranda ground beam.

Fix the end columns first and use string lines stretched from one end of the building to the other to ensure that the intermediate columns line up. Check the columns with a plumb bob or long level to ensure that they are perfectly vertical and then prop them securely in position while the rafters are fixed.

The roof over the veranda is supported on rafters (extensions of the rafters over the cross or end walls or of the top members of the trusses) bolted between the tops of the timber columns with 1No M12 x 175mm steel bolts with steel washers to both sides (see detailed drawings). Make sure that the rafters line through with the main rafters and top members of the trusses before fixing them.

The roof at the rear of the building is supported on rafters (extensions of the rafters over the cross or end walls or of the top members of the trusses) supported on cantilever brackets.

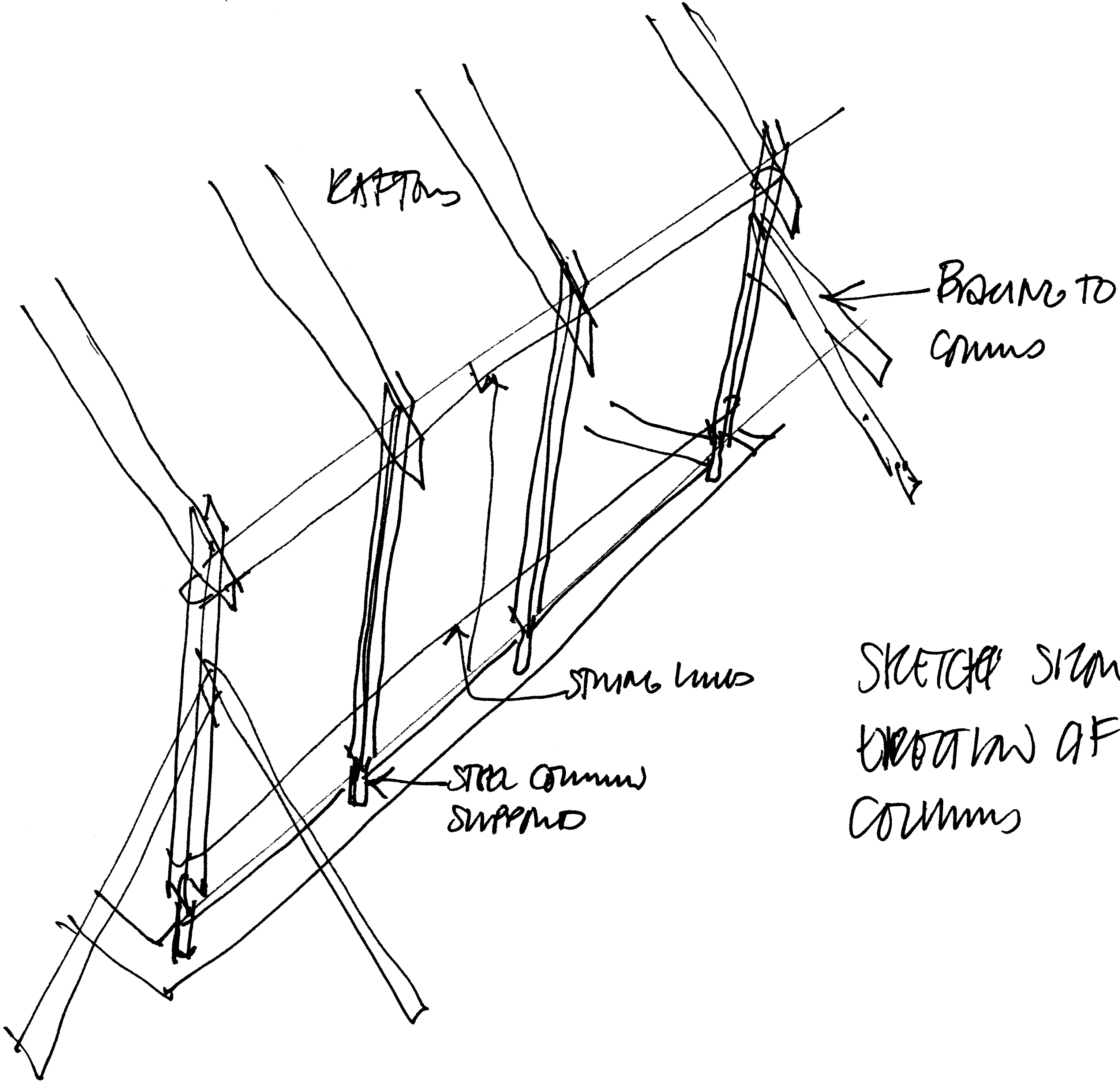
10 x 5cm timber uprights 1.2 metres long are bolted to the concrete columns at the rear of the building immediately below the rafters (see sketch) using the M12 steel bolts cast into the columns. Make sure that the rafters line through with the main rafters and top members of the trusses before fixing them.

Two 10 x 5cm brackets 1.28 metres long are then bolted to the bottom of each upright, one on either side, at an angle of 45° and bolted to the rafters at the top (see sketch) using 2No M12 x 175mm bolts with washers on both sides.

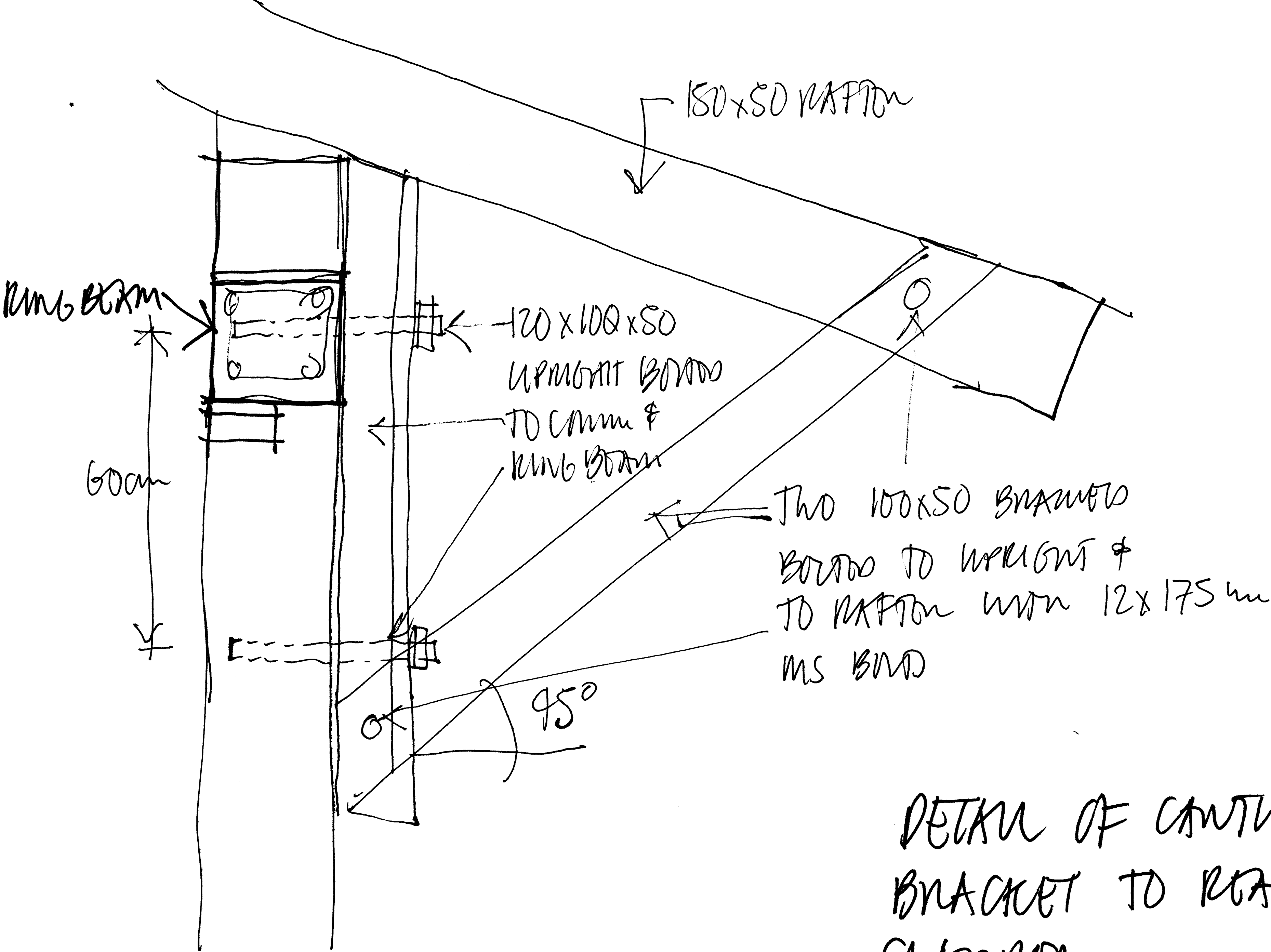
All timbers should be treated against insect attack before they are erected. Used engine oil is a very effective low-cost material for treating timber.

Remember:

- **Ensure that the columns are in line and are vertical before fixing the bolts**
- **Ensure that all rafters line up before fixing the bolts**
- **Treat all timbers against insect attack before they are fixed**



SKETCH SHOWING ERECTION OF VERANDA COLUMNS



DETAIL OF CANTILEVER BRACKET TO REAR OF CLASSROOM

17: ROOF COVERINGS

Three types of roof covering are in common use in Indonesia:

- Clay roof tiles
- Corrugated steel roof sheets
- Corrugated fibre-cement roof sheets.

Use clay roof tiles where these are available as they are relatively easy to fix and have a long life. Care should be taken in selecting the tiles to be used however as those that are under-burnt (these will usually be pale in colour) will tend to deteriorate and cause roof leaks after they have been exposed to a lot of rain.

Where clay tiles are not available the most commonly used alternative is corrugated steel roof sheets. The thickest available sheets should be used (3.5mm) as the thinner sheets will rust and have to be replaced very quickly.

An alternative to corrugated steel roof sheets are corrugated fibre-cement roof sheets. There are problems with using these sheets as they are fairly brittle and easily damaged when being transported and fixed. They also become more brittle with age and if the roof timbers move due to changes in humidity etc they can crack or break. They should however be used in preference to steel sheets on sites close to the sea where the salt in the air will cause the steel sheets to rust very quickly.

It should be noted here that it is not advisable to fix gutters to roofs to collect rain water. They are difficult to keep clean and maintain and will provide an ideal breeding place for mosquitoes. Use storm drains in the ground around the buildings instead to collect and dispose of rain water (see Site Works).

18: FIXING CORRUGATED STEEL & FIBRE-CEMENT ROOF SHEETS

The procedure for fixing corrugated steel and fibre-cement roof sheets is very similar. The procedure will therefore be described in general terms for both materials and any differences will be noted.

When the roof trusses and rafters are fixed and levelled, the purlins (10 x 5cm) for fixing the roof sheets to can then fixed. The maximum spacing for the purlins is 80cm and therefore there will be 9No purlins at the front of the building and 8No purlins at the rear of the building (see section). The purlins should overhang the end walls by at least 60cm; the actual overhang will depend on the length of the building and the number of roof sheets used.

The purlins should be treated against insect attack before they are erected and fixed. Used engine oil is an effective low-cost material for treating timber.

Standard lengths of roof sheets of both materials can be used and the roof illustrated uses 1.8 metre lengths. Longer sheets should be used if available to reduce the number of end laps necessary.

Care must be taken that the side and end laps are large enough to stop leaks. End laps should be a minimum of 20cm and side laps should be either 1½ or 2 corrugations depending on the type of sheet used.

If fibre-cement sheets are used, holes must be drilled for the fixing nails or screws and corners must be cut off of the sheets at 45° where they lap (see sketch) so that they can be laid properly. Great care must be taken when drilling or cutting the sheets and masks should be worn at all times.

Fix the top and bottom purlins first using timber blocks fixed to the rafters. The purlins should be lined and levelled from one end of the building to the other. Then tie two diagonal string lines one from the left hand bottom corner to the right hand top corner and one from the right hand bottom corner to the left hand top corner to check that the roof will be straight, flat and level. The lines should just touch at the centre. If they do not then adjust the purlins using packing pieces until they do. The remaining purlins can then be fixed. All purlins are fixed to the rafters with timber blocks.

Fixing of the roof sheets can now start. The direction of the prevailing wind in the rainy season should be established and the roof sheets should be laid into the wind to reduce the possibility of rain blowing under the side laps of the sheets: ie if the prevailing wind is from the west, the first sheets should be laid at the east end of the building.

Before starting to fix the roof sheets, fix a straight board to the lowest two purlins at each end of the building and tie a string line between them parallel to the face of the building; this marks the lower edge of the roof.

At the east end of the building fix a string line from this board up to the ridge at right-angles to the lower line. This line will mark the eastern edge of the roof against which the first sheets will be laid.

Fixing of the roof sheets can then proceed starting with the bottom sheet in each line. It will be helpful to have a person on the ground sighting the sheets as they are laid to make sure that they are in line and square with the adjoining sheets.

All fixings should be made through the top of the corrugations in the sheets and fixing screws with plastic washers and caps should be used if possible. They are more expensive than roofing nails but will provide a better fixing and are less liable to leaks. If roofing nails are used then use nails with twisted shanks and metal washers on top and plastic or felt washers below.

When the roof sheets to both sides of the building are fixed, the ridge pieces can be fixed, again starting at the eastern end. If possible, for steel sheets only, fix the ridge pieces to the roof sheets with rivets rather than with nails through the sheets to the top purlins as this will provide a more waterproof finish.

When the roof sheets are fixed, fix the timber fascia boards at the eaves and the bargeboards at the verges. Also fix steel flashings over the ends of the roof sheets and the bargeboards at the verges if these are being used (see details).

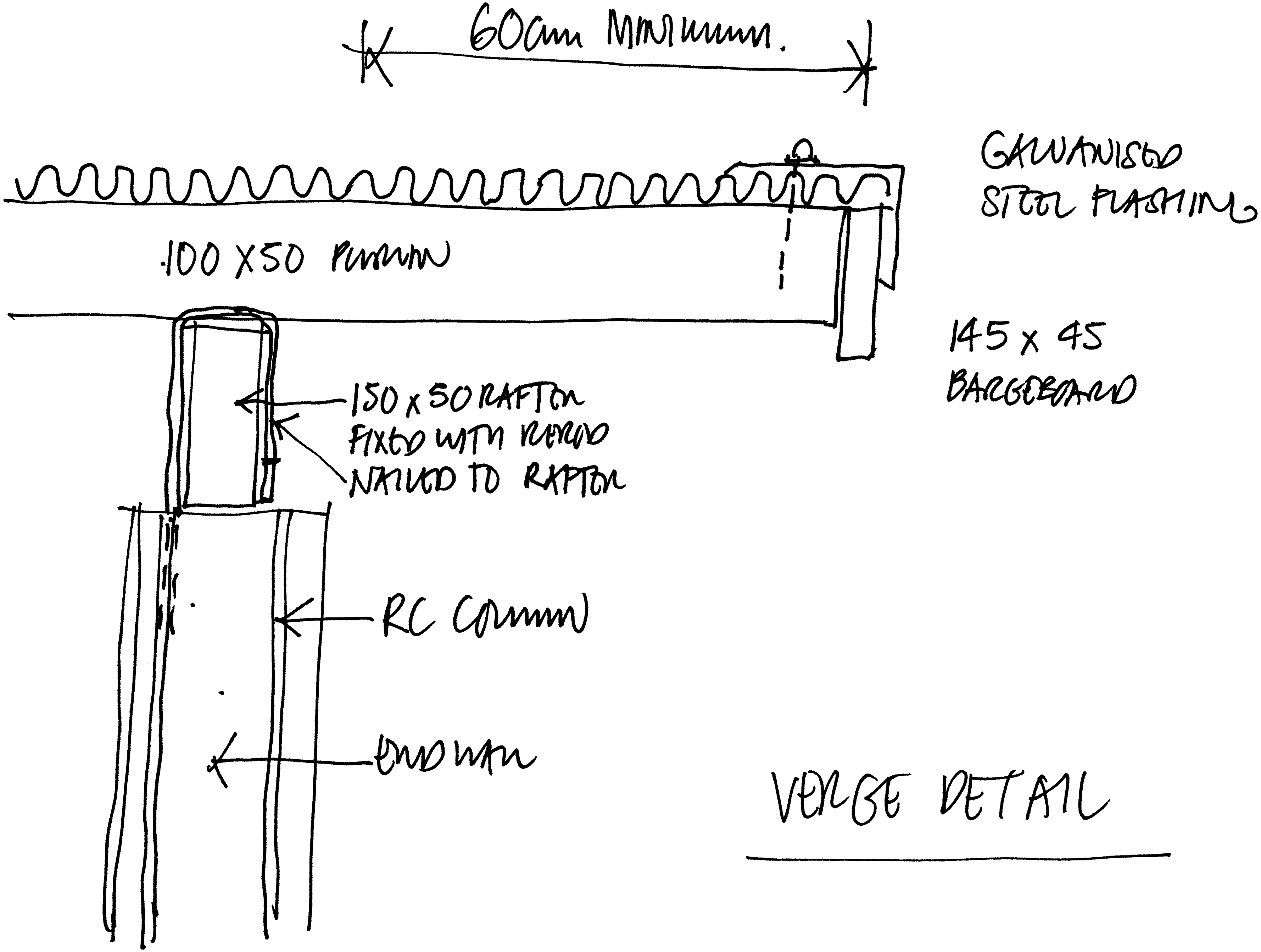
The life of corrugated steel roof sheets can be extended by painting them. Use a special self-etching primer to prime the sheets and then paint them with two coats of light-coloured gloss paint.

Roofing is a dangerous operation and great care should be taken. Always use a ladder to get access to the roof (with the top or bottom secured or someone holding it) and always use crawl boards fixed over the roof to spread the weight of the roofer, especially after the roof sheets have been fixed. Both fibre-cement and corrugated steel sheets are very fragile and will not take the weight of a man without damage.

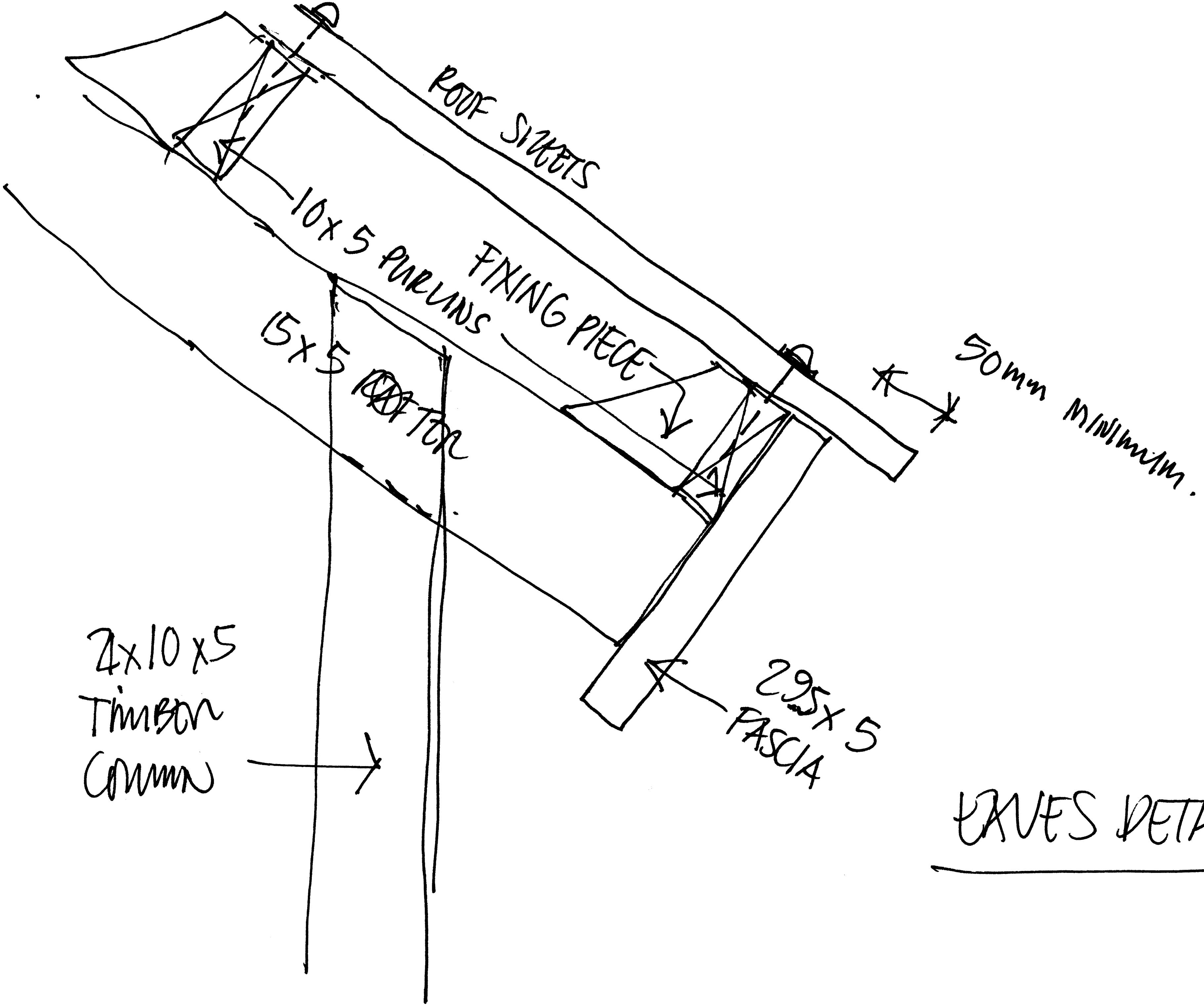
If roofing nails have to be removed, use a claw hammer supported on a piece of timber shaped to fit into the sheet corrugations that will spread the load and stop damage to the sheet. To remove roofing screws, use a spanner of the correct size.

Remember:

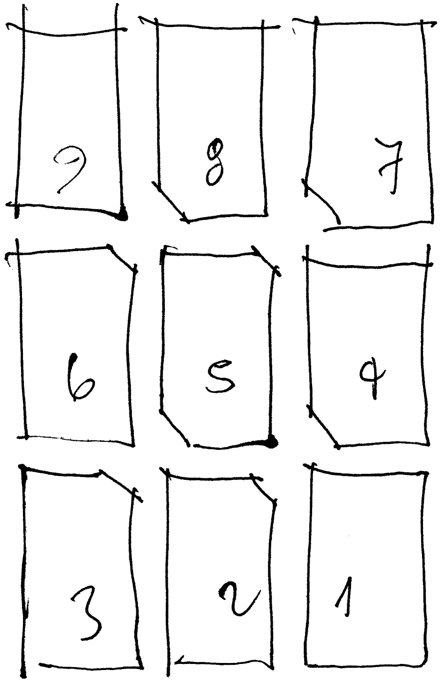
- **Treat the purlins against insect attack before fixing them**
- **Make sure that all purlins are level and straight before fixing the roof sheets**
- **Always lay roof sheets into the prevailing wind to minimise roof leaks**
- **Always fix roof sheets through the top of the corrugations and use proper roofing screws or nails complete with washers**
- **Always use a ladder to gain access to the roof**
- **Always use a crawl board when working on the roof**
- **Always be very careful when working on a roof; it's a long way down!**



VERGE DETAIL

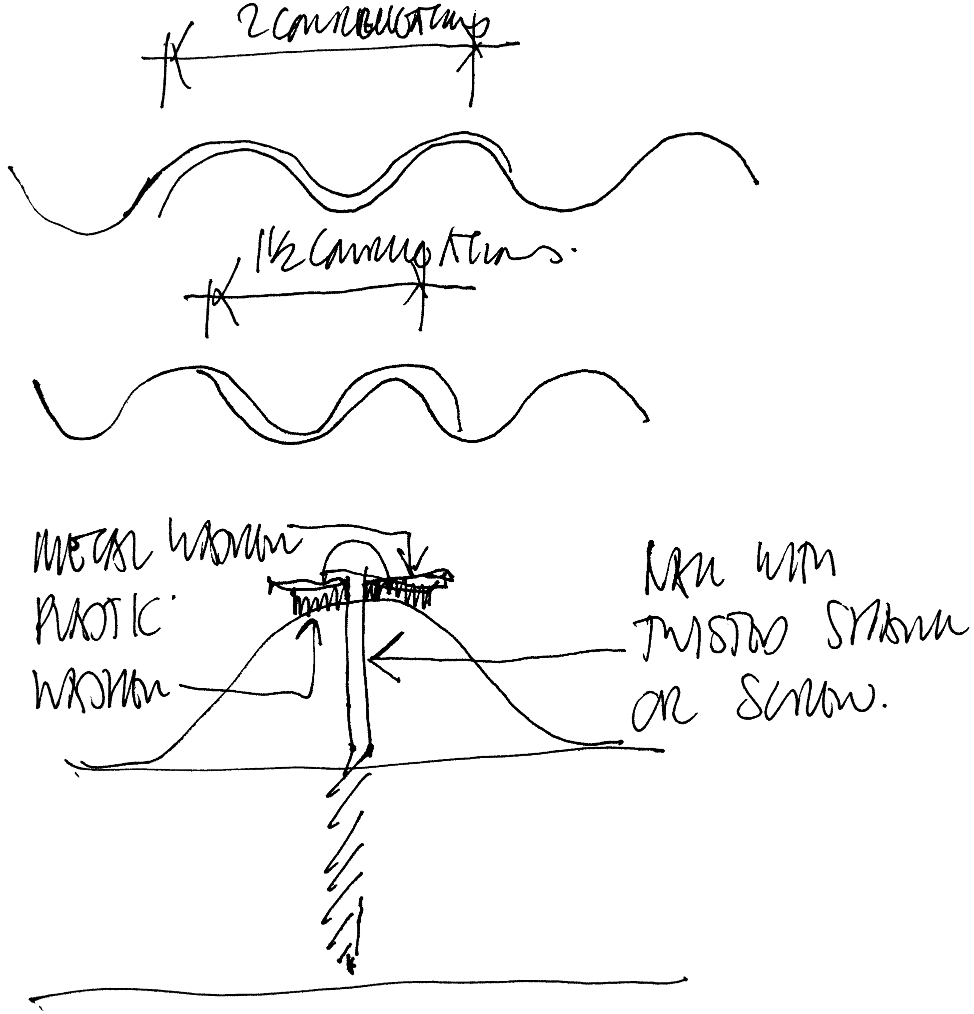


EAVES DETAIL

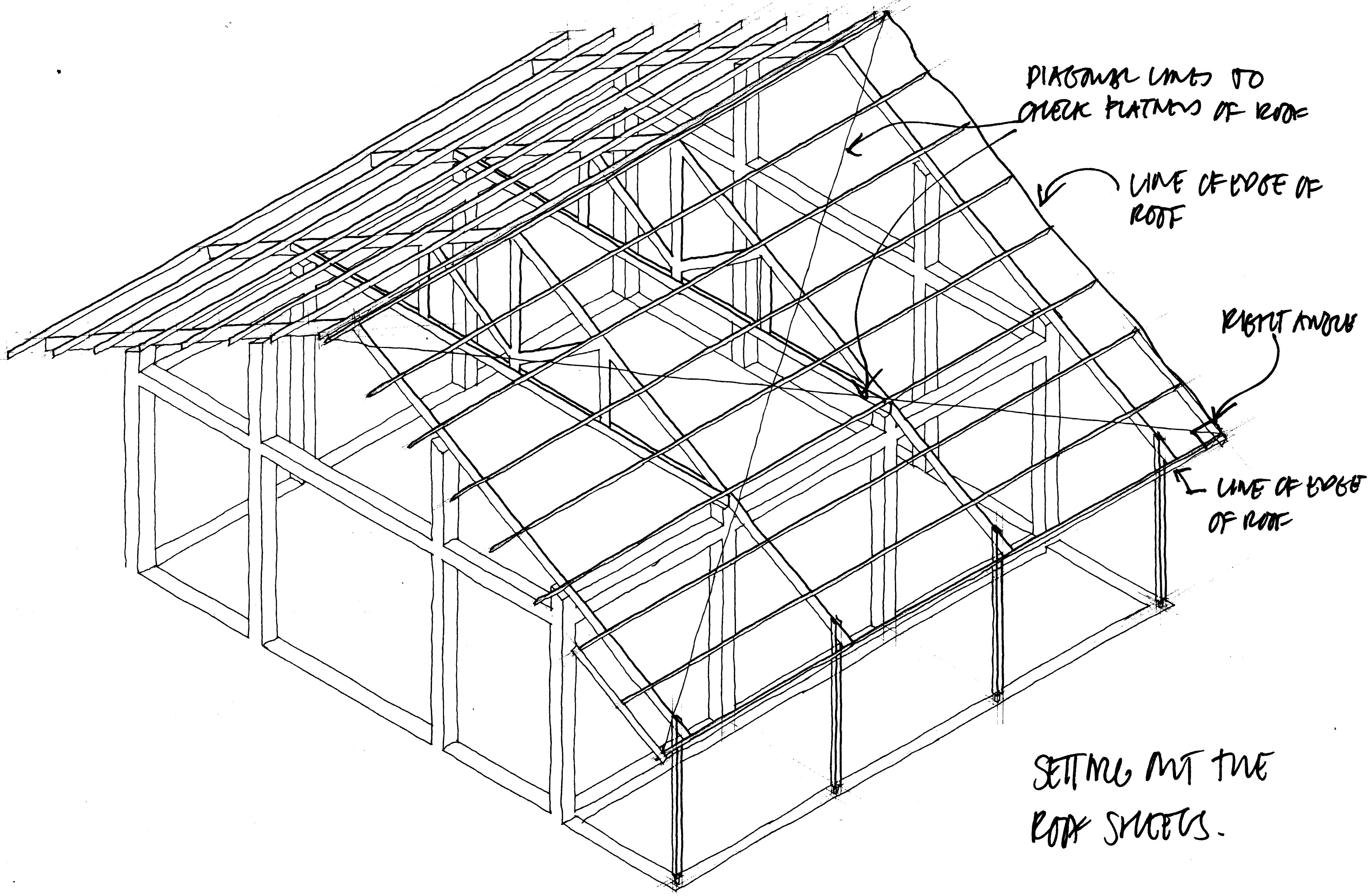


FIBRE-CEMENT ROOF SHEETS LAYING SEQUENCE & CORNERS TO BE MITRED WHEN LAYING FROM RIGHT TO LEFT.

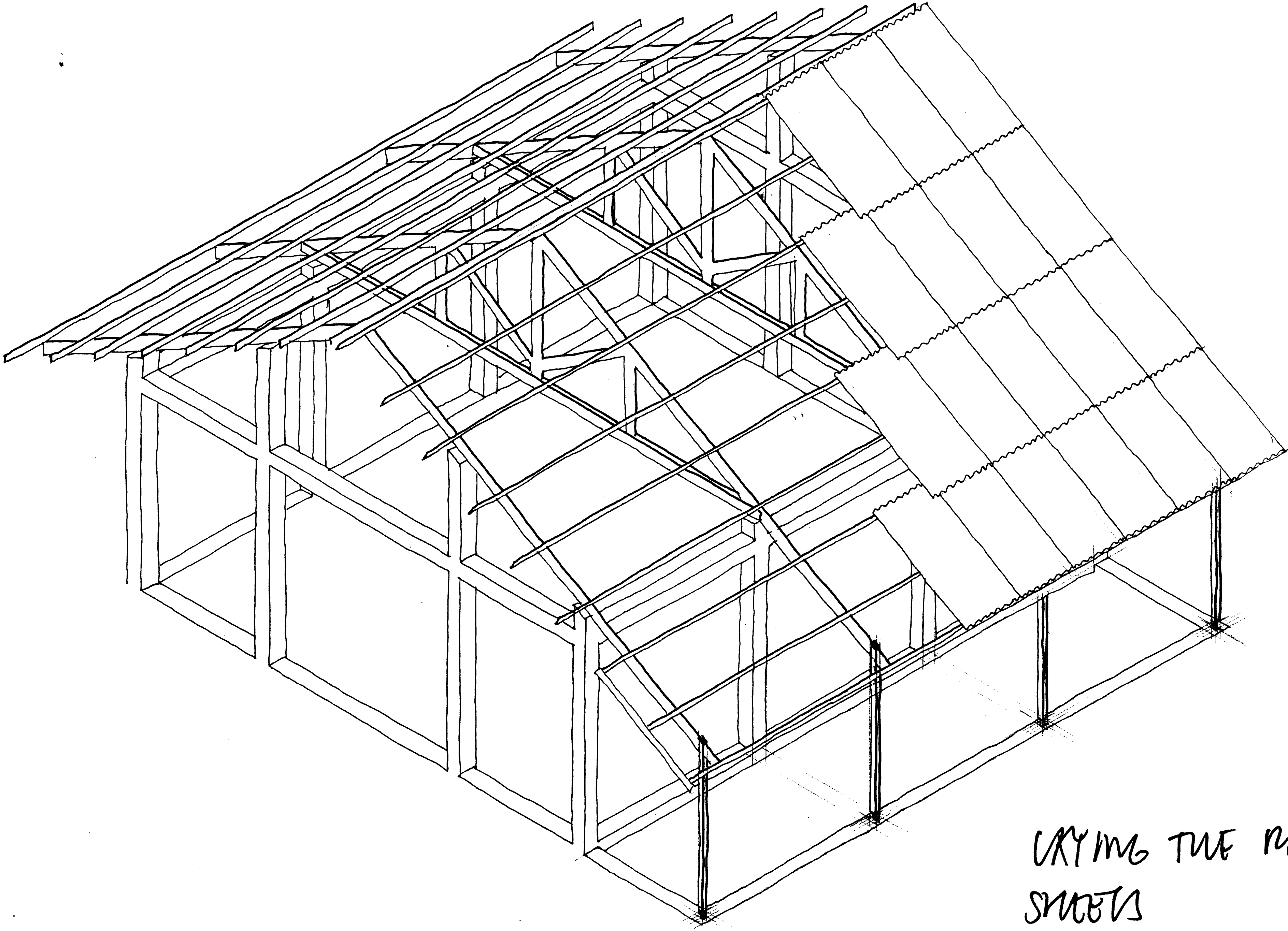
FIBRE-CEMENT ROOF SHEETS



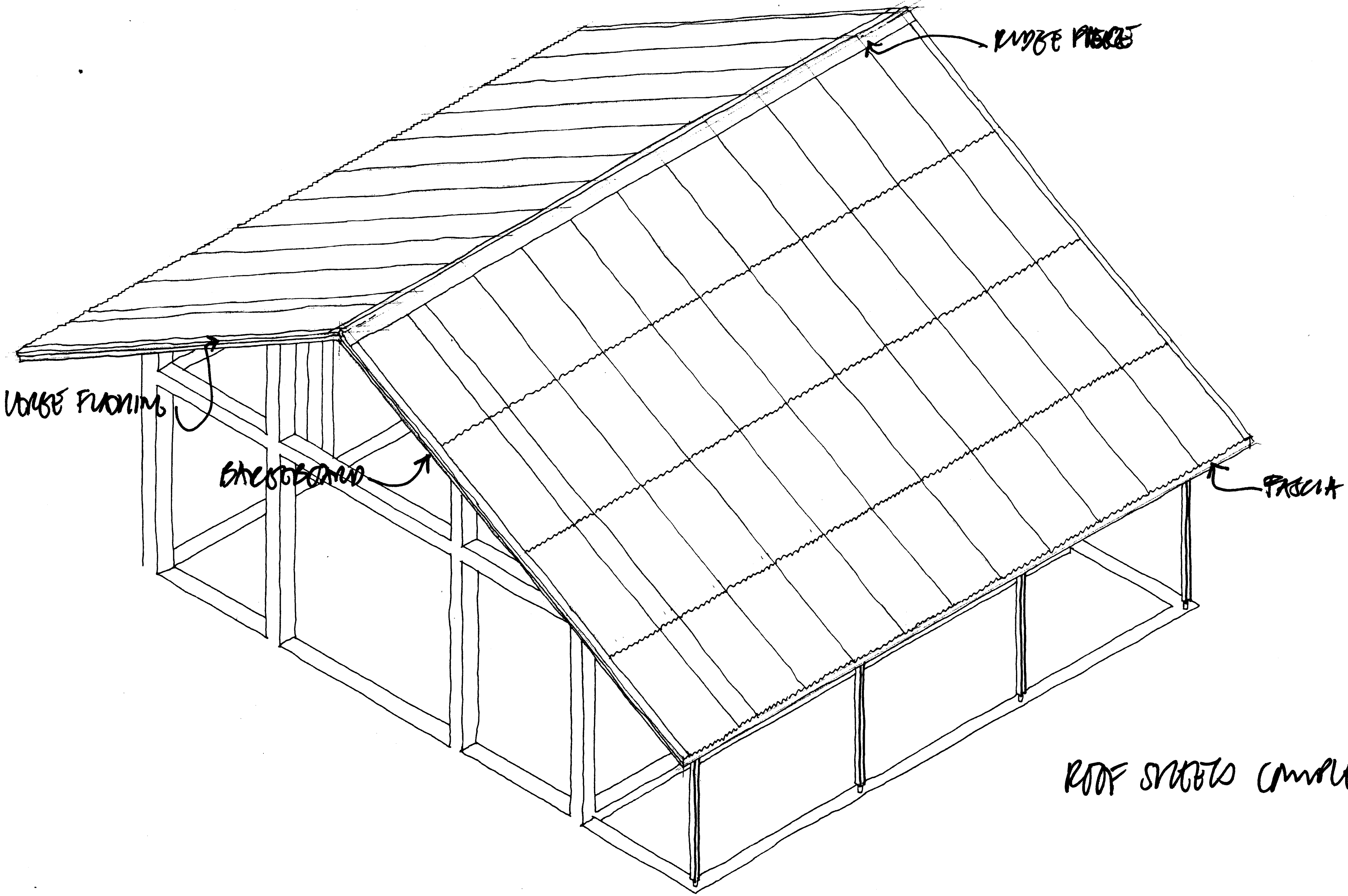
FIXING DETAILS.



SETTING OUT THE ROOF SPACERS.



LAYING THE ROOF SHEETS



ROOF SHEETS COMPLETE

19: FIXING CLAY ROOF TILES

When erecting a clay tile roof, the procedure once the roof trusses and rafters are fixed and levelled is as follows. The ridge board at the centre of the ridge must first be fixed together with any vertical bracing between the trusses (see drawing).

The roof purlins (12 x 8cm) are then fixed: 5No purlins are fixed at the front of the building and 4No purlins are fixed at the rear of the building (see section for spacing). The purlins should overhang the end walls of the building by at least 60cm.

Fix the top and bottom purlins first using blocks fixed to the rafters. They should be lined and levelled from one end of the building to the other. Then tie two diagonal lines one from the left hand bottom corner to the right hand top corner and one from the right hand bottom corner to the left hand top corner to check that the roof is straight, flat and level. The lines should just touch at the centre. If they do not then adjust the purlins using packing pieces until they do. The remaining purlins can then be fixed.

When the purlins are fixed the rafters (7 x 5cm) running down the roof can be fixed at approximately 40cm centres. When the rafters are fixed the tile battens can be fixed; the spacing will depend on the type and size of tile being used.

The roof tiles are then fixed taking care to select good quality tiles. Under-fired tiles (which will be very pale compared to properly fired ones) will be liable to disintegrate when they get wet and any poor quality ones should be rejected. When both sides of the roof are tiled, the ridge tiles are fixed using mortar. The ridge tiles are laid from both ends of the building simultaneously, joining at the centre with a tile overlapping both adjacent tiles.

When tiling is complete, fix the fascia boards at the eaves and the bargeboards at the verges (see details).

All purlins, rafters and battens should be treated against insect attack before they are erected and fixed. Used engine oil is an effective, low-cost material for treating timber.

Roofing is a dangerous operation and great care should be taken. Always use a ladder to get access to the roof (with the top or bottom secured or someone holding it) and use crawl boards fixed over the roof to spread the weight of the tiler, especially after the tiles have been fixed.

Remember:

- **Treat all roof timbers against insect attack before fixing them**
- **Make sure that all purlins are level and straight before fixing the rafters**
- **Always select the best quality roof tiles and throw away the poor quality ones**
- **Always use a ladder to gain access to the roof**
- **Always use a crawl board when working on the roof**
- **Always be very careful when working on a roof; it's a long way down!**

· PUT IN DETAILS OF ~~FAX~~ FIXING CLAY TILES ?

- FIXING PURLINS
- FIXING RAFTERS
- FIXING BATTENS & TILES.
- DETAILS OF VERGE, EAVES & RIDGE

20: CONSTRUCTING THE BRICKWORK OR BLOCKWORK

When the roof has been completed, the construction of the walls can be started. Walls can be built of either fired bricks or 150mm concrete or sand-crete blocks.

If locally made fired bricks are used they should be carefully selected in order that bricks that have been fully fired are used. Under-fired bricks (which will be very pale compared to properly fired ones) will be liable to disintegrate if they get wet.

There are two sorts of blocks that could be made on site or purchased for use. These are concrete blocks that are made from a mix of cement, sand and aggregate (1 cement to 2 sand to 4 aggregate) or what are called 'sand-crete' blocks that are made from a mix of cement and sand (1 cement to 6 sand). Both sorts of blocks should be solid not hollow.

They can both be made on site and to achieve their maximum strength they should be vibrated. If there is no vibrating machine available, then they should be made in timber moulds and be well compacted by hand. All blocks should be made under cover out of reach of the sun and rain and cured for at least 4 weeks during which time they should be covered with cement bags and kept damp by spraying with water at least once a day.

Before laying of the bricks or blocks starts, clean off the top of the ring beam and chip off any projecting aggregate so that the top of the beam is level. Use 1:4 mix mortar for laying the bricks or blocks (see section above on mixing mortar) and wet the bricks or blocks by dipping them in water before use. This will prevent them absorbing too much water from the mortar.

Lay the bricks or blocks on the centre lines of all walls. They will then form panels between the columns and any cracks between the columns and the brick or block work will not be as obvious.

Lay the bricks or blocks using a string line fixed to the end columns of the building and stretched tight between the columns to set the brick or block courses. Courses or joints between bricks or blocks should be a maximum of 10mm thick and should be marked on the end columns for positioning the string lines.

Lay the bricks or blocks using stretcher bond (see sketch) with vertical joints, again 10mm thick, set above one another on alternative courses. All joints should be raked out to provide a key for the plastering.

Build all walls up together and build the tie bars in the columns into the horizontal courses as the brick or block work is built up.

To help to stop cracking of the block or brick work under windows, build two lengths of 6mm reinforcement for the full width of the bay into every other block course or every fourth brick course (see sketch).

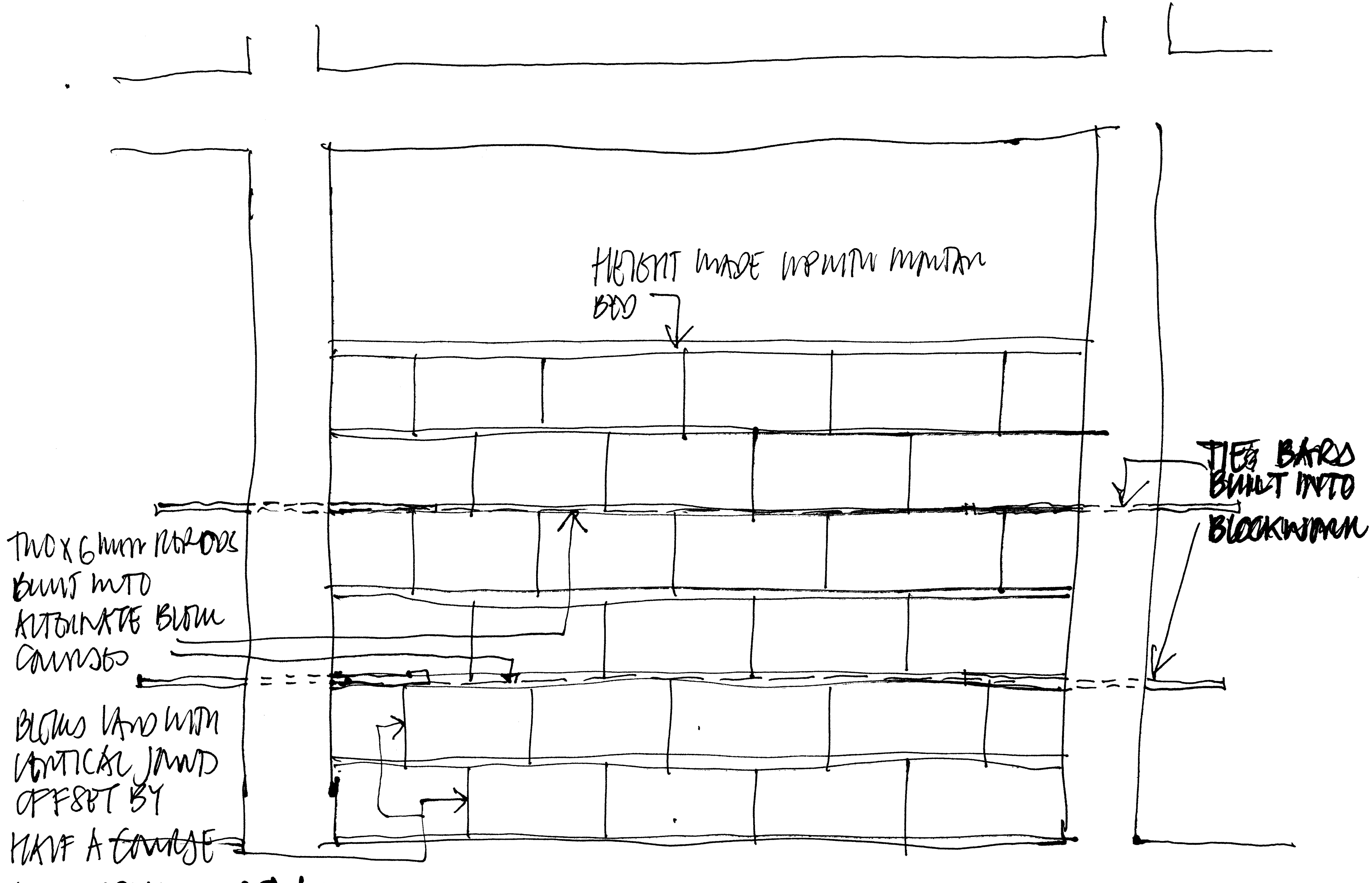
Walls under windows should be built up to 125cm above ground beam level on the veranda side and 85cm above ground beam level on the rear side of the classrooms. If these heights do not correspond with a brick or block course, make up the difference with mortar.

Fill the 20cm space above the ring beam/lintel to the walls on the front and rear of the classrooms with either cut blocks or with bricks laid across the beam so that there is not a ledge left on top of the beam that could be used by birds or could gather dirt.

Build the brickwork or blockwork to the cross and end walls up to the underside of the rafters, the bricks or blocks being cut as necessary to follow the line of the rafters (see sketch).

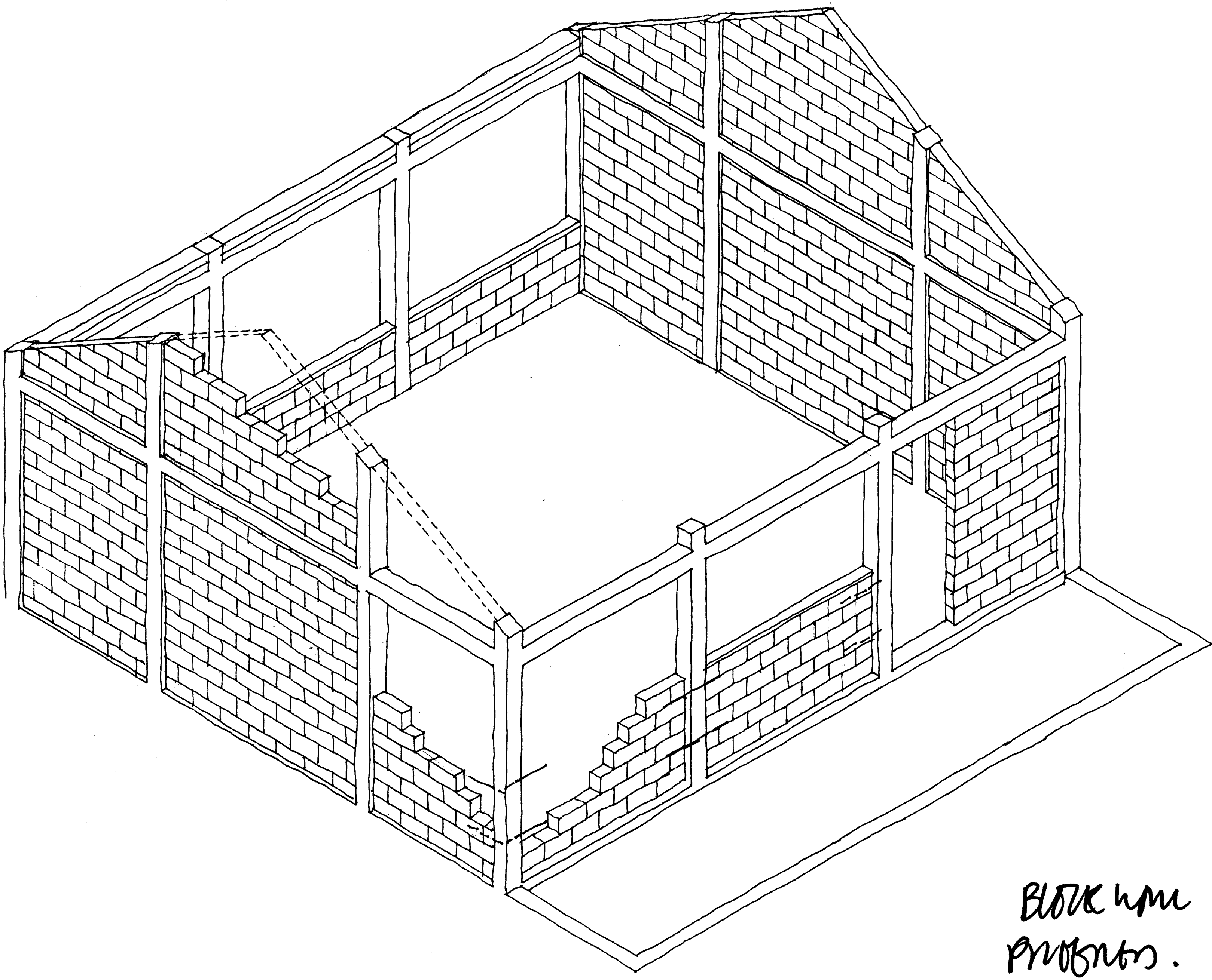
Remember:

- **Always select the best bricks or blocks**
- **Always wet bricks or blocks before use**
- **Always use string lines for laying the blocks**
- **Joints between bricks and blocks should not be bigger than 10mm**
- **Build all the walls up together**
- **Use stretcher bond for both bricks and blocks**



STRETCHER BOND.

TYPICAL BLOCKWALL PANEL



BLOCK WALL IN PROGRESS.
[ROOF NOT SHOWN]

21: CONSTRUCTING THE FLOOR

After the building has been roofed and the walls built, the floors can be laid. Before this can be done, the floor area will require back-filling to bring it up to the required level. Any material from the foundation trenches that is left over from back-filling the trenches can be used together with any suitable material from other sources.

It is very important however that no top-soil or vegetable matter is used for back-filling and that the back-filling is properly consolidated in layers. The use of unsuitable material or the lack of proper consolidation will inevitably lead to the collapse of the floors later!

Spread the back-filling in 15cm layers, each layer being wetted and compacted before the next layer is spread (a simple tool for compacting the back-fill can be made from a pole with a heavy concrete or timber base). Lay the back-fill up to a level 50mm below the top of the ground beams.

Level the top of the back-fill and then spread a layer of coarse sand 50mm thick, levelled and compacted so that it is level with the top of the ground beams all round.

A hard-wearing and non-dusting floor finish is required in primary schools; one that will stand up to the hard wear inflicted by children and furniture.

The most common type of floor consists of floor tiles laid on cement/sand screed laid on the sand bed. White glazed floor tiles are quite commonly used but these are expensive and not very practical. They are very slippery when wet (and thus dangerous when used on open verandas), are easily scratched and show the dirt. If tiles are required then plain concrete tiles are cheaper, harder wearing and have a non-slip surface.

Dip the tiles in water before laying them so that they do not absorb water from the screed and then lay them on a minimum 30mm layer of cement/sand screed (mix: 1 cement to 3 sand). The finished level of the tiles should be 50mm above the top of the ground beam.

Set out the tiles square in both directions from the centre of the room; any cut tiles should occur around the perimeter of the room. A gap should be left around the perimeter of the room to allow for movement and expansion of the floor tiles. This gap can be covered by a tile or timber skirting.

An alternative floor finish which is inexpensive and hard wearing is a 10cm thick bed of concrete finished with a steel trowel to give a smooth finish (mix: 1 cement to 2 sand to 4 aggregate). Lay the concrete on thick plastic sheet (to stop too much water being absorbed by the sand bed) and the sand bed should be laid lower than for floor tiles, the top being 50mm below the top of the ground beams. The concrete slab can be reinforced with steel mesh to make it stronger. In this case, the mesh should be laid on 50mm thick spacers to position it in the middle of the slab.

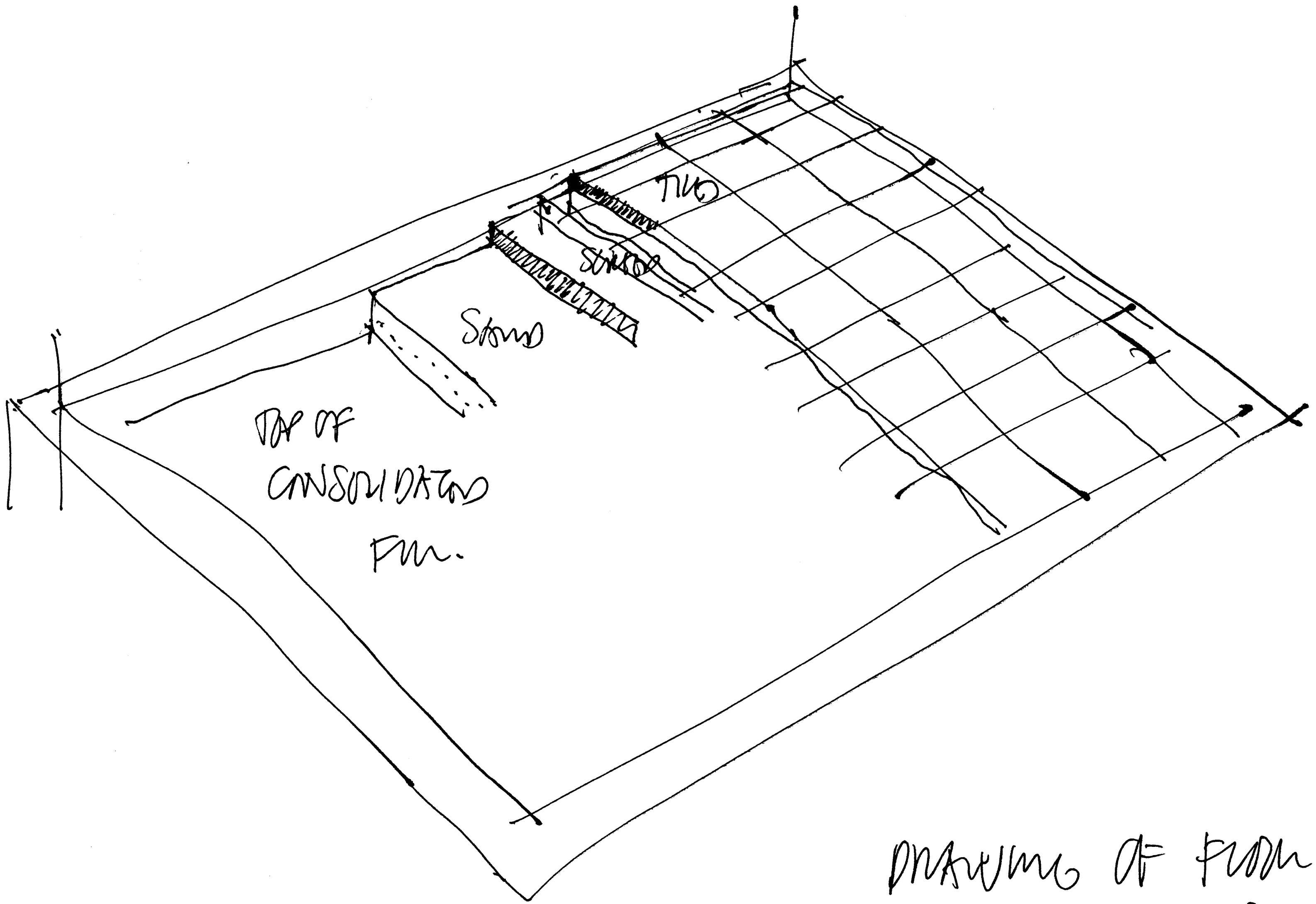
The concrete should be laid in two bays to a classroom and in similar bays along the veranda to prevent cracking. Form a 'V' joint between the panels of concrete.

If concrete is used for flooring, it needs to be properly cured in order that it reaches its full strength. Cover it with a layer of plastic, cement bags or sand and keep it damp by watering at least once a day for 2 weeks. If it dries out too quickly this will reduce its strength and increase the likelihood of cracking.

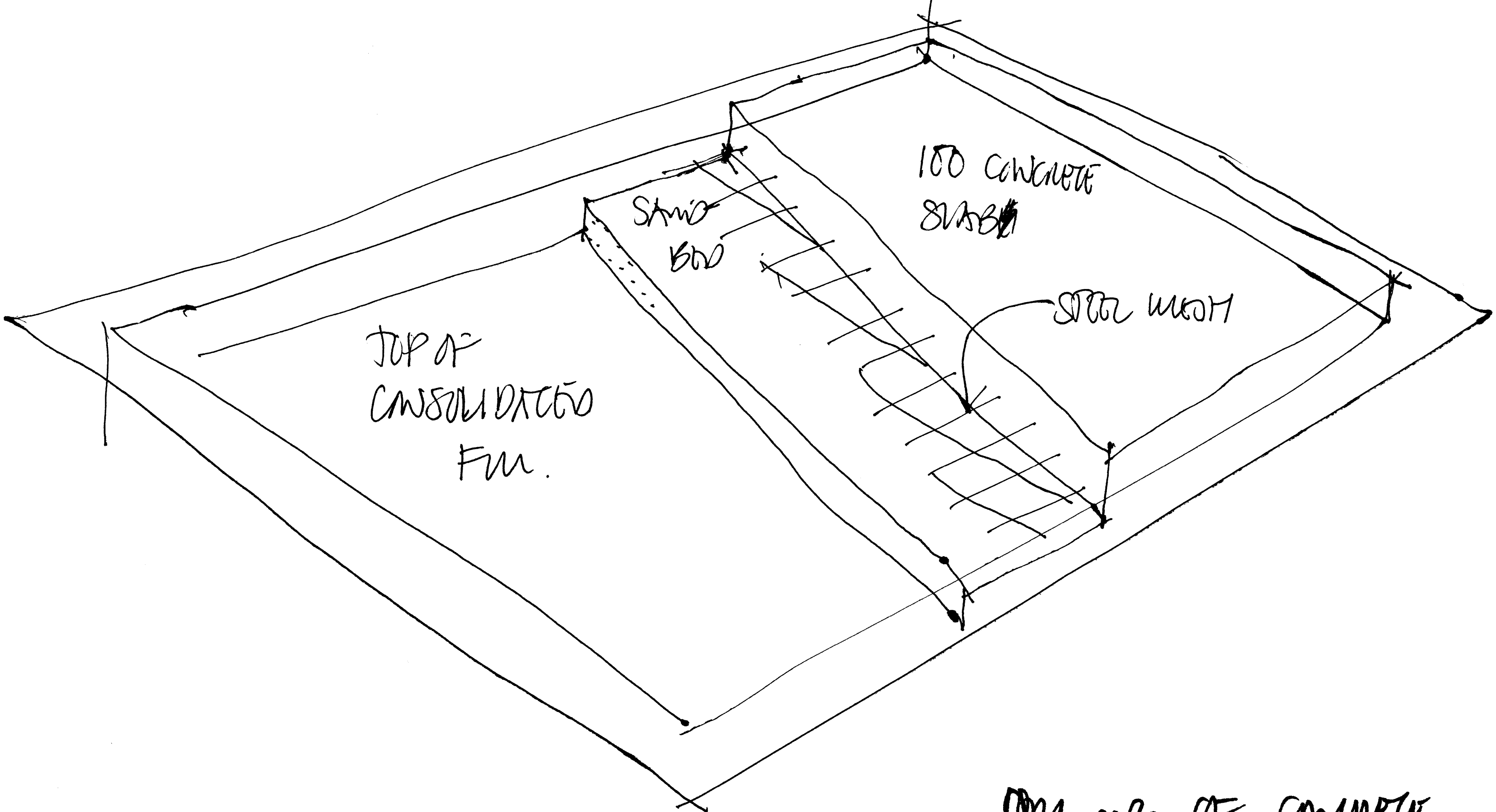
A skirting around the walls can be provided which will make the bottom of the walls look neat. The skirting can be made of timber, of tiles let in flush with the face of the render or of render painted a dark colour, 150mm high with a ‘V’ joint at the top. See sketch.

Remember:

- **Fill and consolidate the area of the floor between the ground beams in layers a maximum of 15cm thick**
- **If using tiles, wet them before laying them**
- **Do not use white glazed tiles on verandas**
- **Set out tiles from the centres of rooms, square with two walls**
- **Provide a gap for expansion around all floors that are tiled**
- **If concrete is used for floors make sure that it is properly cured**



DRAWING OF FLOOR CONSTRUCTION SHOWING TILES, SCREED BED, SAND & HARDCORE FILL.



DRAWING OF CONCRETE FLOOR

22: DOORS & WINDOWS

Door frames can be built in as the brick or block work is laid or they can be fitted later. As the window frames fit between columns there is no need to build them in and it will be easier to fit them later when the concrete work and the brick or block work is complete and they will be less liable to damage.

If door frames are built in while the brick or block work walls are being built, they should have 100mm nails driven into the back of the frames (on the line of the brick or block courses) which will be built into the brick or block work and hold the frames in place (see sketch).

Both door and window frames are designed to have open timber louvres over the door or window opening. The window cills to the veranda side of the classrooms are higher than on the rear side to give more privacy in the classrooms (see window and door details).

Both window and door frames should be made on site following the drawings. Modify the sizes of both as necessary to suit the actual built dimensions on site. Make up the frames in a covered work area on the site and then lift them up into position. Door frames should have a temporary brace fixed at the bottom to ensure that they stay square while they are being fixed.

If timber plugs have been cast into the columns and ring beams, screw-fix the frames to these after ensuring that the frames are level and plumb. If timber plugs have not been cast into the columns and ring beams then the concrete can be drilled for plastic plugs or the frames can be fixed using 100mm masonry nails.

Fix the frames with the side frames flush with the front of the rendered walls. The timber cill will then overhang the wall at the bottom of the frame and water will fall clear of the wall. See sketch.

In order to avoid damage, windows and doors should not be fixed until the building is complete. Only the frames should be fixed.

Doors are designed as hard wood panel doors (not flush doors as these will soon be broken) and windows as top-hung, opening out, glazed, timber-framed windows. Sizes and details of construction are shown on the detailed drawings. All doors and windows should be made from best quality, selected hardwood and all timber should be planed and well sanded before the doors, windows and frames are made.

The entrance doors to the classrooms are shown as large single doors. The double doors usually provided in classrooms always cause maintenance problems and should not be used.

The glass for all windows should be 4mm thick. When ordering glass for the windows measure the size of each frame and then subtract 5mm from the dimensions so that the glass is easy to fit. If using putty to fix the glass, measure the total area of glass in square metres, multiply this number by two and this will give the amount of putty required in kilos.

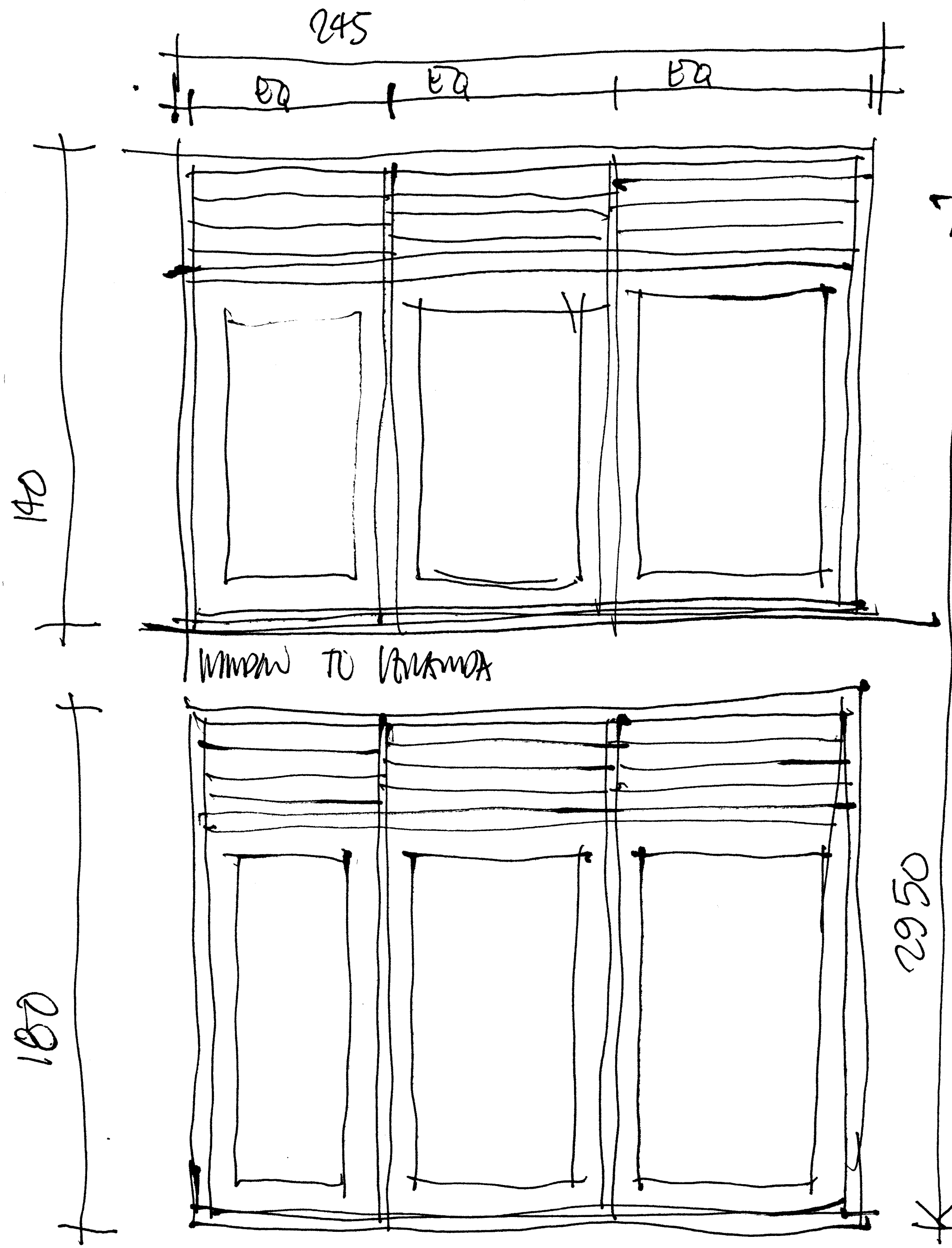
Note: it is possible to use steel louvre carriers with glass blades for windows but the quality of these is not very good, the glass blades are always sharp and dangerous, the steel carriers rust quickly, the blades break, etc so the use of louvres is not recommended.

All hardware (locks, handles, bolts, window stays, catches, etc) should be the best quality that can be afforded and only wood screws should be used for fixings, never nails. The school committee will be responsible for maintenance of the school and these fittings, though more expensive initially, will reduce the cost of maintenance. Cheap hardware will quickly break and will then need replacement!

Remember:

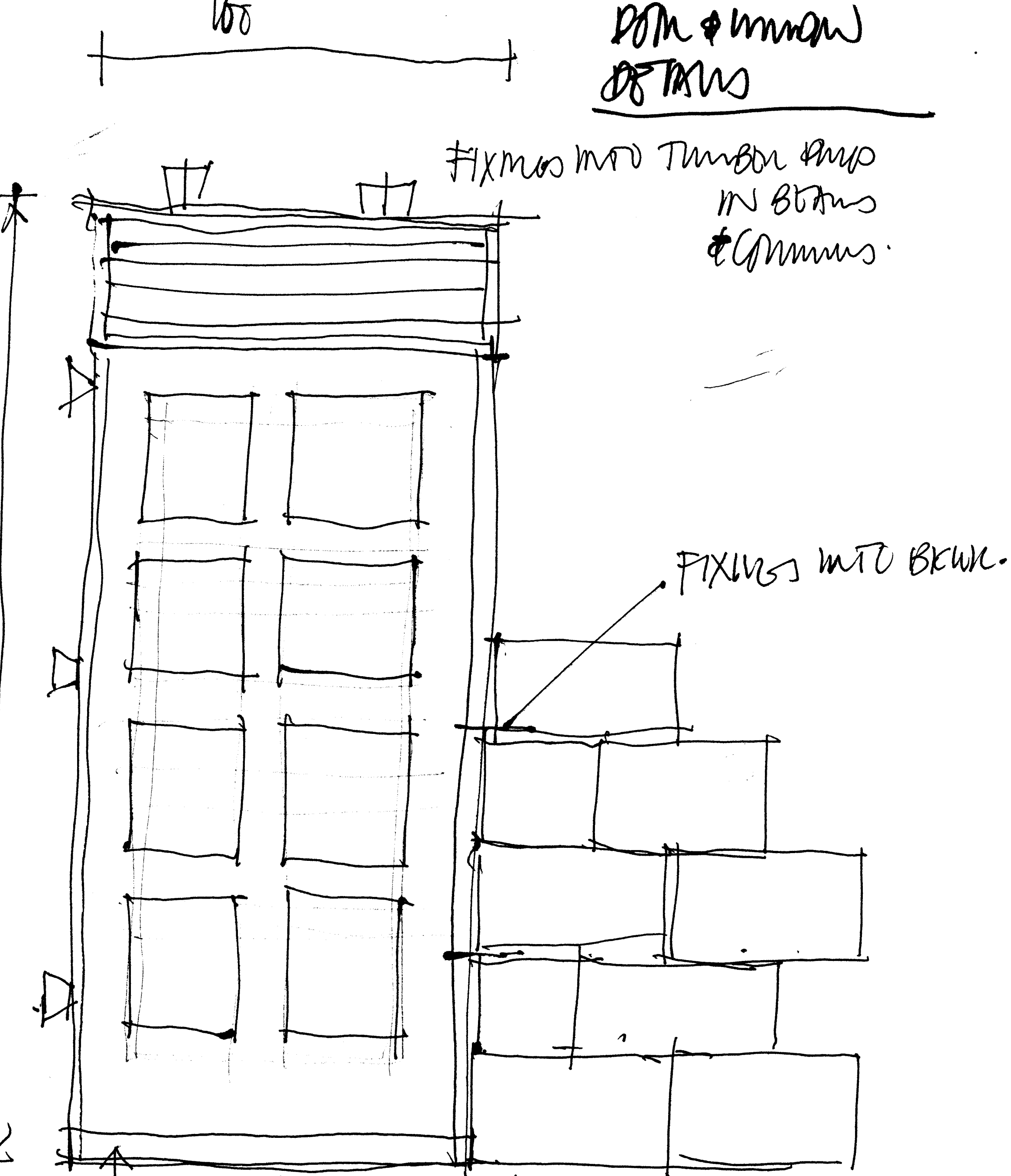
- **Always use the best quality timber for doors, windows and frames**
- **Always finish all timber by planing and sanding it before fixing it**
- **Fix doors and windows only when all other trades are finished to reduce damage**
- **Always use the best quality hardware; this will reduce maintenance costs**

DOOR & WINDOW DETAILS

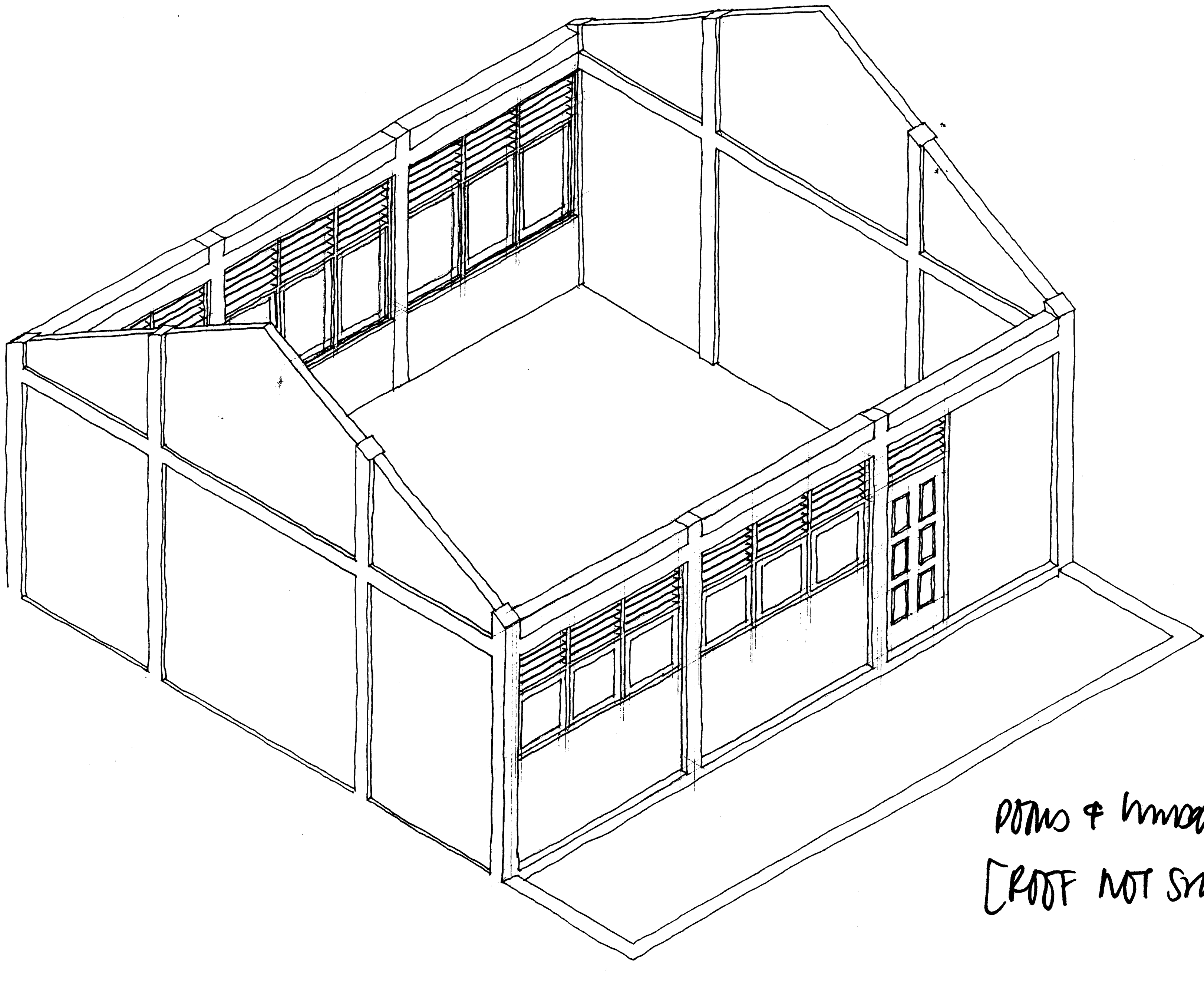


WINDOW TO REAR

FRAMES EX 100 x 50 OR EX 150 x 50.



TEMPORARY BRACE ACROSS BOTTOM OF FRAME UNTIL FRAME FIXED.



DOORS & WINDOWS FIXED
[ROOF NOT SHOWN]

23: FIXING THE CEILINGS

Internal ceilings will help reduce the amount of heat transmitted through the roof and they are therefore worth installing. There are two positions where ceilings can be fixed: 1) directly under the purlins providing a sloping ceiling or 2) suspended below the roof trusses providing a flat ceiling.

It is usual to fix the ceiling suspended below the roof trusses, however, fixing ceilings directly under the purlins (especially in roofs where corrugated steel or fibre-cement sheets are used and there are more purlins than in clay tiled roofs) is very cost-effective as the amount of framing required is reduced if compared to suspended ceilings. This method will give a higher ceiling and should make the rooms cooler but there are however two drawbacks: 1) the roof trusses are exposed and will therefore have to be very well made and neatly finished and 2) the end and cross walls have to be rendered and painted up to the apex of the roof.

If the ceiling is fixed directly under the roof purlins, 5 x 5cm timber battens fixed to the underside of the purlins are used for fixing the ceiling panels. The battens are fixed at 40cm centres set out from the centre of the room and run down the slope of the roof. Any cut sheets will then occur at the ends of the rooms. Battens will also be required at the top and bottom of the roof and where two sheets are joined.

If a flat ceiling is required, the battens should be fixed directly to the bottom members of the roof trusses. Main battens of 10 x 5cm timber span between the roof trusses and 10 x 5cm battens are fixed to the end walls. 5 x 5cm timber battens, set out from the centre of the room, spanning across the room at 40cm centres are then fixed below the main battens. 5 x 5cm battens will also be required around the perimeter of the room.

Whichever type of ceiling is being used, once the ceiling battens are complete then the ceiling linings can be fixed. There are two materials that are commonly used for lining the ceilings: 1) 'tripleks' (4mm plywood) or 2) fibre-cement sheets. Care should be taken when fixing either material as they are both easily damaged.

Both types of materials should be nailed to the battens using panel pins for the triplex or flat headed nails for the fibre-cement panels.

It should be noted here that the use of local materials such as mats made bamboo or other local materials should be seriously considered for constructing ceiling panels. These can form a low-cost alternative ceiling that is as good if not better than Tripleks in terms of insulation and one that also looks very good.

Joints between panels can be treated in two different ways: 1) they can be covered with cover strips of 45 x 1.5cm timber or 2) a gap can be left between adjoining panels. If the latter method is used, then plane the bottom face of the battens smooth before fixing, sand the edges of the panels and ensure that the gaps between the panels are at least 10mm wide and equal so that they are easy to paint and look neat. A similar gap should be left around the perimeter of the room. On no account use filler to fill the gap between either type of sheet; it will look very untidy and will crack and eventually fall out.

Access panels should be provided in ceilings to all roof spaces in order that the roof and ceiling structures can be checked and maintained. Access panels should be at least 60 x 60cm and can be made of ceiling battens finished with the same material as the ceiling and painted to match.

Ceilings can be fixed under the veranda roofs if it is felt necessary. Tripleks or fibre-cement panels (or local materials) can be used as the lining material and the ceiling should be fixed on battens as described above fixed to the underside of the purlins.

If the ceilings in the classrooms are fixed directly under the purlins, this ceiling can continue down over the veranda leaving a ventilation space over the wall between the classroom and the veranda.

Do not fix ceilings externally under the roof at the end and rear of the buildings. This simply increases the cost of the building and adds greatly to the maintenance costs as these areas are easily damaged by rain and damp and will require constant painting, repair and replacement.

Remember:

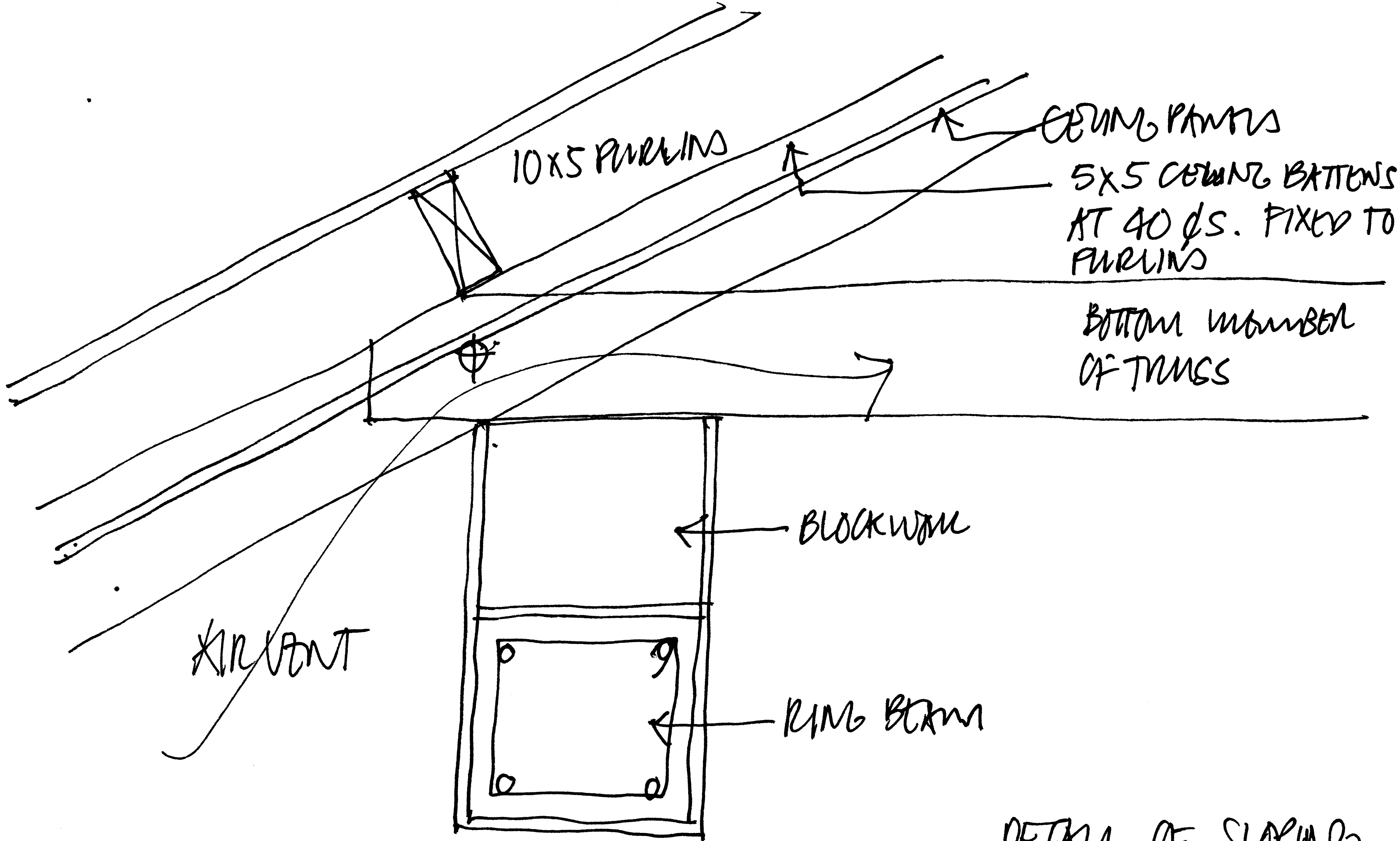
- **A sloping ceiling fixed directly to the purlins will be cheaper than a flat ceiling**

- **Always set the ceiling out from the centre of the room so that any cut pieces occur along the walls**

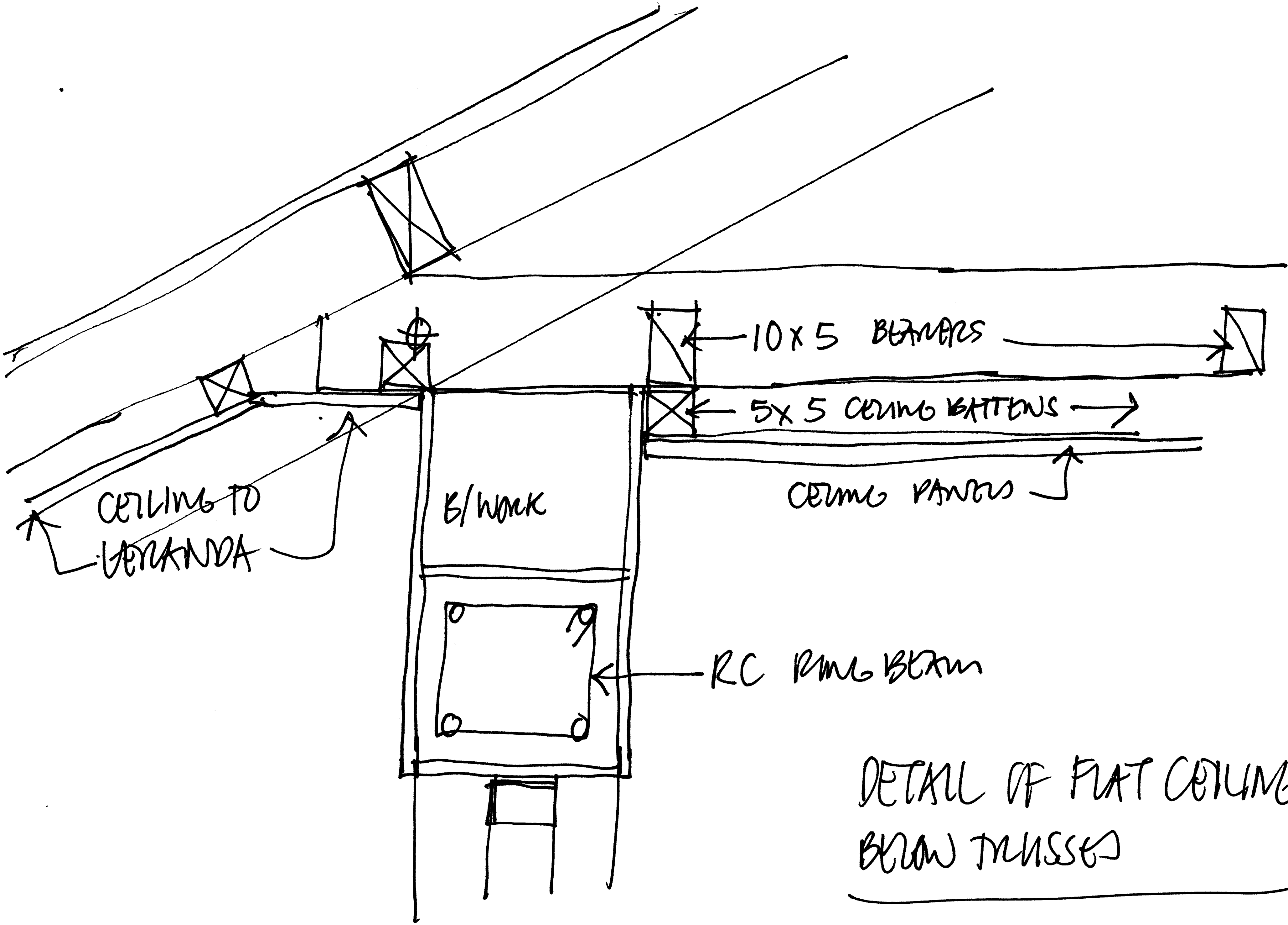
- **Never use filler to fill joints between panels**

- **Never fix ceilings externally except if really required over the veranda**

- **Consider the use of local materials for ceiling panels**



DETAIL OF SLOPING CEILING



DETAIL OF FLAT CEILING BELOW TRUSSES

24: PLASTERING THE BUILDING

All new buildings will move slightly as they dry out and as the foundations settle. This is normal but it will be best if the plastering of the building is left until the other trades are finished in order that the building can dry out and settle for as long as possible and thus reduce the amount of movement that will take place after the plastering is completed. Any movement will cause cracks in the finished plaster.

Before the plastering is started, brush the walls to remove all loose dirt and dust and fill any large holes in the bricks or blocks.

Walls should be wetted before plastering starts to stop them absorbing too much water from the plaster as it is applied. This will cause the plaster to dry out too quickly and reduce its strength.

The mix for plaster is 1 cement to 4 sand (or 1 cement to 1 lime to 3 sand) and the sand should be clean and fine. Mix the plaster on a screed platform to keep it clean and use only enough water to make it workable as described above. Never add more water to the mix or use plaster that is more than one hour old.

Plaster can be applied in either one or two coats but the total thickness of both types should be 12mm. Two coat plaster will take longer but will give a better finish. Leave the first coat (approximately 10mm thick) to dry for a few hours and then scratch and wet the surface to enable the second coat to adhere better.

Plaster can be finished with either a wood float to give a slightly rough finish or with a steel float to give a smooth finish. Only an expert plasterer should use a steel float as the smooth finish will show up the slightest defect. A wood float finish is therefore preferable even though it will take more paint to cover it.

Apply the plaster evenly and to the correct thickness. One way of doing this is to apply vertical strips of plaster of the correct thickness at regular intervals along the wall. These strips are then used as guides for the rest of the plastering, a straight board being run from guide to guide to ensure a consistent thickness of plaster.

At the ends of walls edge boards are used to give the correct thickness of plaster. They are held in place by spring clips made from 6mm reinforcement bent in a 'U' shape and the edge boards project past the end of the wall by the thickness of the plaster.

Always start plastering at the top of walls and continue downwards. Lay a board at the bottom of the wall to catch any plaster that falls and this can then be used again provided it is still fresh. Plastering should never stop at a corner but should continue past for 15cm.

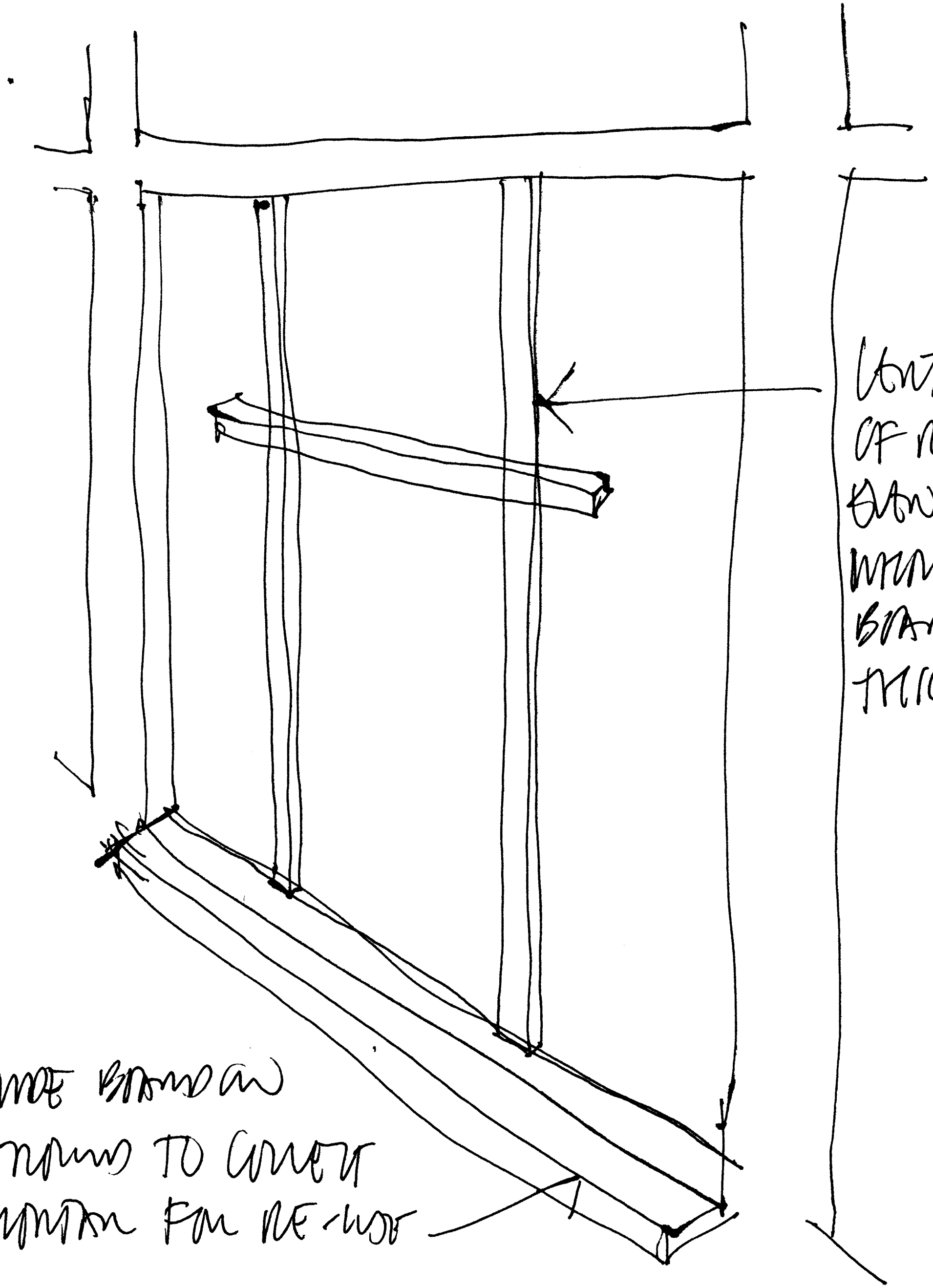
Wherever possible a whole wall should be plastered at the same time. The large end and cross walls are however divided into panels by the columns and ring beams so plastering these should not be difficult.

Do not plaster external walls when they are in full sun but only when they are in shade.

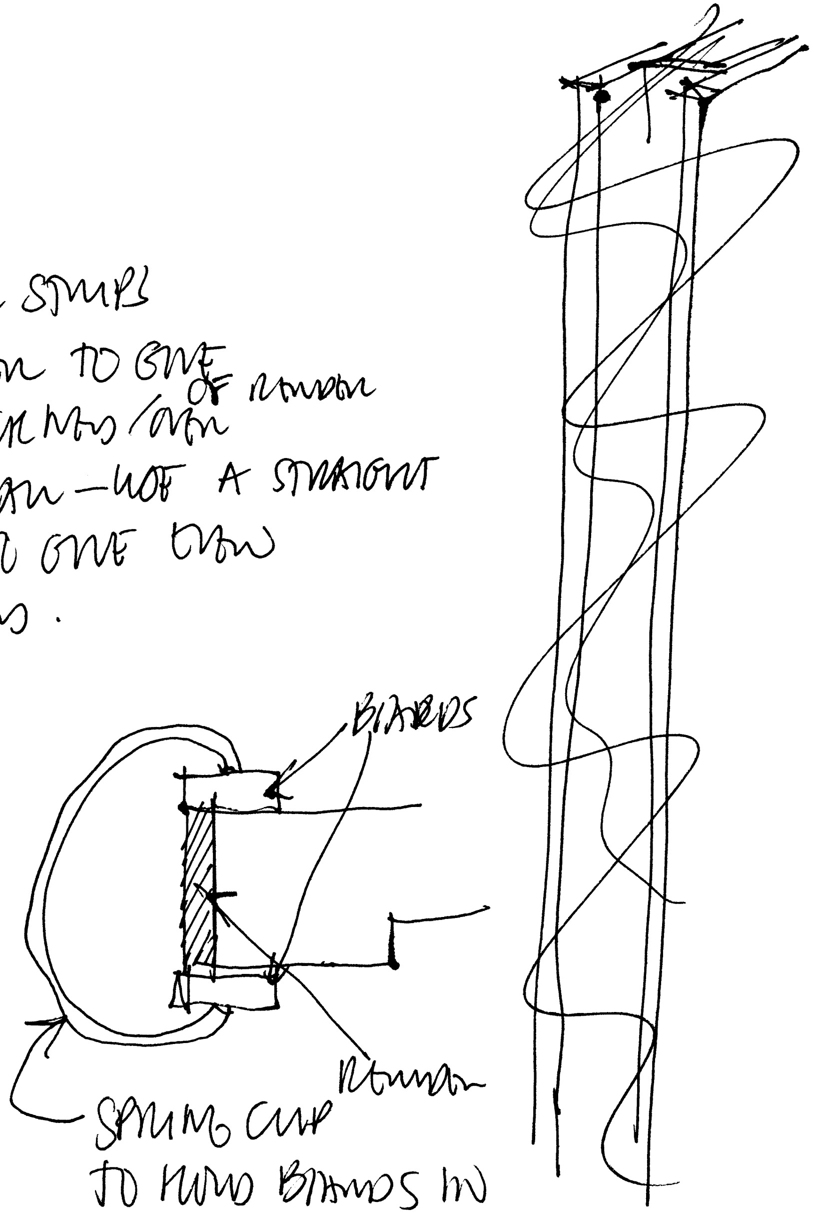
When complete, keep the plaster damp for one week, especially those walls exposed to the sun. This will help to cure the plaster and reduce the amount of cracking that will take place.

Remember:

- **Always mix materials on a clean platform**
- **Always measure materials accurately and by volume**
- **Always mix materials thoroughly dry before adding any water**
- **Use as little water as necessary to achieve a workable mix**
- **Apply the plaster evenly**
- **Use a wood float to finish the plaster**
- **Keep the finished plaster damp for a week to let it cure**



RENDERING GUIDES.



RENDERING A CORNER AT END OF WALL

25: PAINTING THE BUILDING

Preparation is the key to good painting whatever the surface. It is necessary therefore to thoroughly prepare all surfaces before painting: they should be cleaned, washed down and sanded before painting. Wash off all dust and dirt with clean water and detergent or white spirit if necessary.

Rectify all defects before starting painting: fill any hollows or cracks in walls; punch in any nails in timber and fill the holes with wood-filler before painting. Prime all exposed or new surfaces to wood or metal with the appropriate primer before painting.

Always use the best quality paint and brushes that can be afforded and always clean brushes thoroughly after use. Use clean water for cleaning brushes used for emulsion and white spirit for brushes used for oil paint.

Take great care when using ladders: the ladder angle should be 1:4 i.e. if the ladder is 4 metres high then the bottom of the ladder should be 1 metre away from the wall.

Always secure the top or bottom of the ladder: if the ladder is positioned on soft ground, knock a long peg into the ground and tie the bottom of the ladder to the peg.

Always use a paint tin hook when painting off a ladder: a hook can be made from a piece of 'S' shaped 6mm rod which hooks onto a rung of the ladder and through the handle of the paint tin leaving both hands free for painting.

Always start painting at the right-hand side of the wall if right-handed (left-hand side if left handed) and move the ladder towards the left so that the ladder is never placed on the newly painted wall.

PAINTING WALLS

When the plaster to walls has thoroughly dried out, the walls can be painted.

Walls should be painted with good quality emulsion paint. New walls will require 3 coats of paint: a priming coat and 2 finishing coats. The priming coat should consist of emulsion paint thinned with 20% of clean water.

5 litres of emulsion paint will cover approximately $30m^2$ of wall with one coat although this area could be reduced to as little as $20m^2$ if the render is finished with a wood float and is slightly rough.

To reduce maintenance, the lower section of the wall (say up to cill level – 120cm – on the veranda side of the classroom) can be painted with 2 coats of gloss paint to give a hard wearing and washable surface.

PAINTING CEILINGS

To improve lighting levels within the classrooms, all ceilings should be painted with white paint.

If tripleks is used for ceiling panels with timber cover strips, then paint the whole ceiling with one coat of water-based wood primer. Then paint the ceiling panels and cover strips with two coats of white emulsion paint.

If fibre-cement sheets are used for ceilings, prime them with emulsion paint diluted with 20% clean water and paint any timber cover strips with water-based wood primer. The whole ceiling should then be painted with 2 coats of white emulsion paint.

PAINTING DOORS, WINDOWS & FRAMES

If the doors, windows and frames are well made of good quality timber, they can be finished with a clear polyurethane lacquer.

They should be first sanded with fine sandpaper to remove any rough grain and splinters and primed with lacquer diluted with 10% white spirit. They should then be finished with two full coats of lacquer, the timber being sanded down with fine sandpaper between coats.

If the quality of the timber is not so good, paint the doors, windows and frames with good quality gloss paint. Sand them first with fine sandpaper to remove any rough grain and splinters and prime them with wood primer. Then paint them with two full coats of oil paint, the paint being sanded down with fine sandpaper between coats.

PAINTING ROOF TIMBERS

All roof timbers such as fascias and bargeboards should be painted in order to protect them. Punch in any nails that are protruding from the timber and fill the holes with wood-filler before painting. Rub down the timbers with sandpaper, prime with good quality wood primer and paint with two coats of oil paint.

Remember:

- **Don't paint over dirt or grease: the paint will take a long time to dry and the finish will not look good!**
- **Always prepare surfaces before starting to paint**
- **Don't sweep the floors just before or during painting: the dust will ruin the new paint!**
- **Don't use an old or dirty paint brush: it will spoil the finish of the new paint!**
- **Always sand down between coats of paint**
- **Don't over-thin the paint!**
- **Don't forget to remove the skin from paint that has been used before!**
- **Don't forget to read the instructions on the paint tin!**

26: TOILETS & PLUMBING

The school toilets are designed as an extension of a 3-classroom building. Three toilets are shown, one with one compartment for teachers, one with two compartments for girls and one with two compartments for boys.

Note that urinals for boys are not provided as these, (especially those constructed using tiles) are impossible to keep clean and end up by being very smelly! There is also no need to provide wash basins if water tanks are provided; wash basins are expensive and are easily broken by school children.

Each toilet compartment has a squat toilet pan set into the floor and a water tank for flushing the toilet and for washing hands (a 'mandi').

A 150mm high step is constructed of concrete (1:2:4 mix) to the width of the water tank (70cm) and the toilet is set into the step. This will mean that the soil pipes running from the toilets will not have to be too deep. Each toilet should have a separate pipe taken outside to an inspection chamber. See drawing. This will make it easy to rod the pipes if there is a blockage. The minimum fall of the pipe should be 1 in 60.

The floor and the top of the step should be tiled and the tiling should be taken underneath the toilet pan rather than being cut round it. This will make both sealing the joint between the pan and the top of the step easier and also keeping the toilets clean easier.

There is often a problem with water penetrating through the wall of the toilet from the water tank into the adjoining classroom. This is especially common if the tank is tiled on the inside. One way to avoid this is to use plastic or fibre-glass tanks set in the block walls but these need to be carefully sealed with silicone sealer where the tank meets the wall. The walls around the tank should be tiled and then grouted with waterproof grout.

If a tiled water tank is constructed, the tank should be tiled inside and outside and the outlet should be made of a piece of 50mm galvanised pipe 200mm long with a flange welded on and threaded on the outside at the outside end, fitted into the wall and the pipe cast in using 1:2:4 concrete with some PVA glue added to make it water-proof. A steel plug is then screwed onto the outside of the pipe using some plumbers tape to seal the outlet.

All walls to the toilets should be tiled to top of door height if there are funds available as this make cleaning and maintenance of the toilets easier. All tiles should be grouted with waterproof grout.

If the floors are tiled, non-slip tiles should be used, not the usual white-glazed ceramic tiles as these are very slippery when wet.

Water supply pipes should be buried in the walls where they cannot be damaged and should be of galvanised steel not plastic as plastic is easy to break. All water supply pipes to water tanks and any other fittings should have stop-cocks fitted so that if there is a problem in one toilet then the water supply to that toilet can be turned off without affecting the remaining toilets.

All supply taps should be the best possible quality as cheap taps will soon be broken.

Doors to toilets should be good quality hardwood panel doors not flush doors and the doors should be made so that the bottom is at least 10cm from the floor so that they do not get wet and rot.

Remember:

- **Do not build urinals**
- **Use water-proof grout to tiles**
- **Use non-slip tiles in toilet areas**
- **Provide stop-cocks to all water supply pipes and taps**
- **Use the best quality fittings that can be afforded**

27: ELECTRICAL INSTALLATIONS

Most primary schools, especially in the rural areas are only used in the mornings when light levels are usually high and artificial lighting in the classrooms is not required. It is also true to say that most primary schools do not have many or any items of electrical equipment. An electrical installation that can be expensive both to install and to run is not therefore essential, especially in the rural areas.

If however an electrical installation is considered necessary then it is essential that a properly qualified electrical engineer carries out the installation.

All electrical wires for both lighting and power should be installed in plastic conduit both in walls and ceilings.

If lighting is required in classrooms so that they can be used in the evenings, sufficient numbers of light fittings should be installed to give an acceptable lighting level. One 40W tungsten light fitting in the middle of the classroom will not give an acceptable level of lighting!

In order to achieve an acceptable level of lighting in a classroom, install at least 4No. 1200mm single fluorescent light fittings or 4No 600mm double fluorescent light fittings. If funds are limited then it will be better to install the correct number of fittings in one or two classrooms in order that they can be used at night rather than one light fitting in every classroom.

If electrical sockets are required then an adequate number of fittings should be installed which will be at least 4No. double sockets per classroom, one to each wall.

If funds are not immediately available for a complete electrical installation but it is considered that one will be required in the future, then install the necessary plastic conduits in the walls and ceilings fitted with pull wires in order that the wiring and fittings can be installed at a later date.

If an electricity supply is not available at a rural school but an electricity installation is considered necessary then consider the provision of solar power. Solar installations are still quite expensive but it might be possible to put fittings for light and power in say one classroom that could then be used at night. Solar installations have the advantage that they cost nothing to run but it must be borne in mind that there are maintenance costs: for instance the batteries will need to replaced at some point and these are expensive.

If an electrical installation is built into the school then the school should keep copies of the wiring diagrams and drawings showing where conduits have been run, etc for use in maintaining the installation and if anything goes wrong.

Remember:

- **Only provide an electrical installation if the school can afford to run it**

- **If a full installation is not possible, run conduits in walls and ceilings so that wiring and fittings can be installed later**

- **Always use a properly qualified electrician to carry out the installation**

- **Always provide at least 4No 1200 fluorescent lights in a classroom**

- **In rural areas, consider the provision of solar power and lighting to one classroom**

- **Always keep copies of wiring diagrams, etc for use in repairing and maintaining the system**

D. SITE WORKS

1. INTRODUCTION

When the school buildings are complete, there will be a number of site works that will be required that are either necessary or will have practical benefits. These will include:

- Site drainage.
- Paving and site paths.
- Retaining walls.
- Septic tanks and soakaways.
- Water supplies and wells.
- Refuse disposal

There are other site works that might be beneficial but are not absolutely necessary such as fences, gates, etc and these are left to the school committee to construct if they feel they are needed.

2. SITE DRAINAGE

Drainage around the site and particularly around buildings is very important to stop flooding of the site and buildings during the rainy season and to stop erosion of the soil around the buildings.

Drains around buildings should be placed under the low points of the roof on both sides of the buildings and the drains should be wide enough to catch the run-off from the roof both when the rainfall is light and when it is heavy.

Drains can be built of pre-cast concrete, concrete blocks, etc but a simple, wide dish-drain can be constructed of fired clay bricks (or concrete blocks laid on their side) laid on a concrete bed.

The bricks should be laid 3 bricks wide with the two outside bricks sloping down to the middle brick (see sketch). Lay the drain to falls (minimum fall 1:100) and render the drain with cement/sand render (1:3 mix). Take care not to form low points in the drains where water will collect and mosquitoes can breed.

The drains should be built around all buildings and any paved areas such as play grounds and then collected in a main drain that will drain the water off the site to a main drain in a nearby road or to a stream or swamp. See drawing.

Remember:

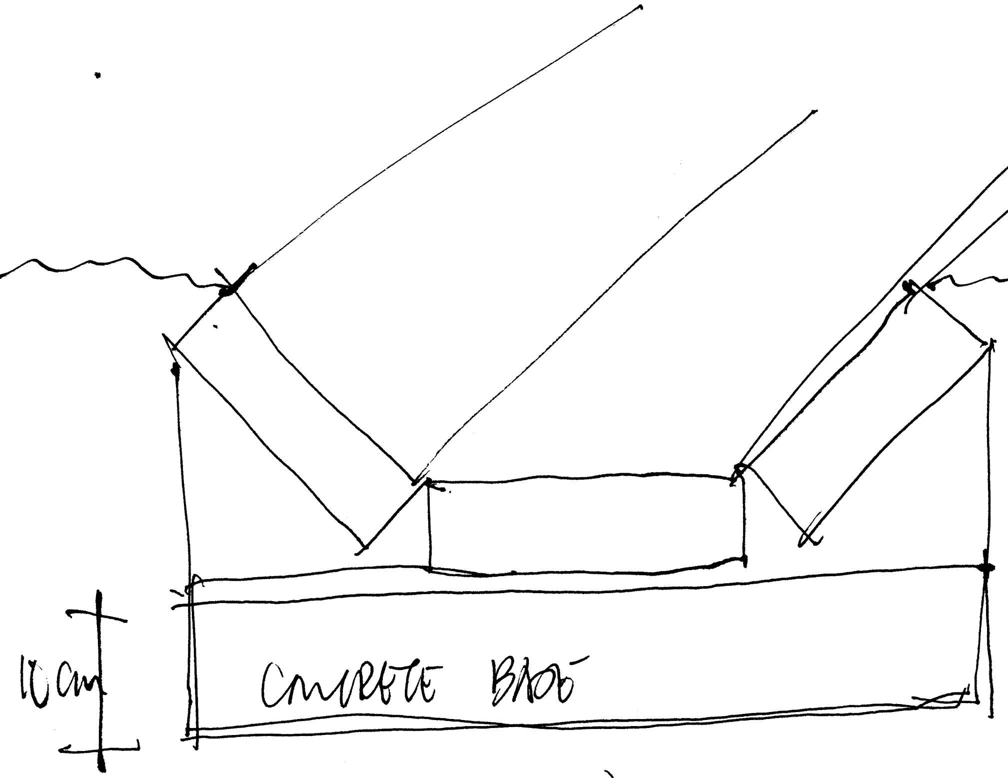
- **Always provide drainage around buildings**
- **Always collect storm water and drain it off the site**

3. PAVING & SITE PATHS

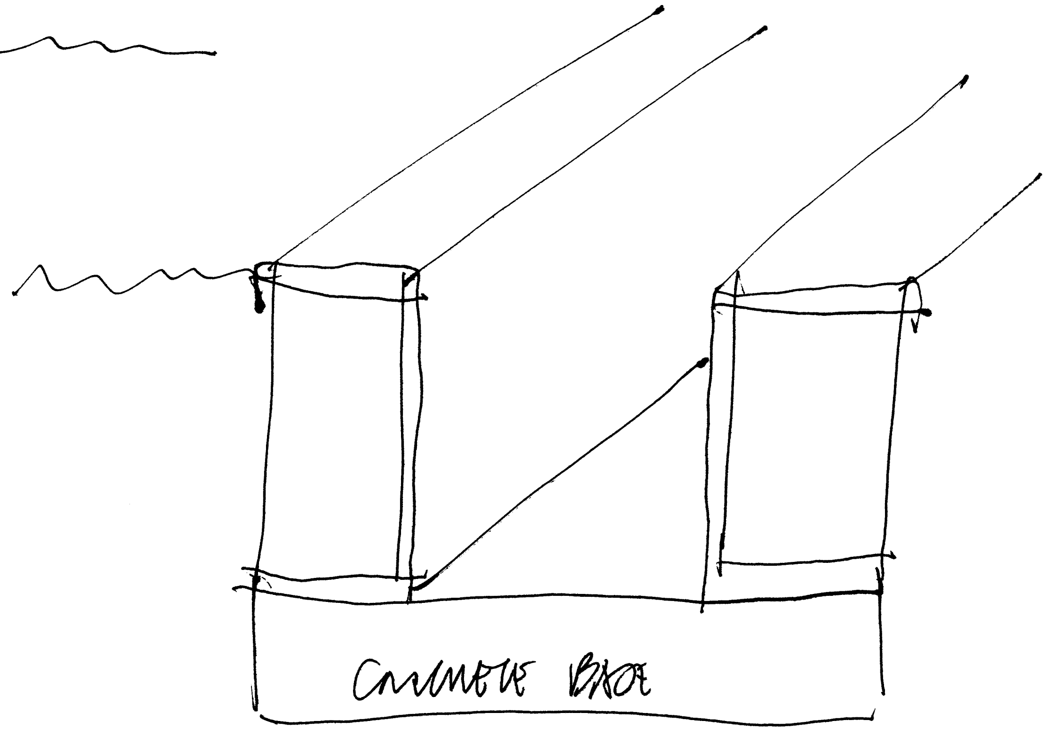
Paving around the buildings between the external walls and the storm drains will help to stop soil erosion. The paving should slope away from the building down to the drain.

Construct the paving from concrete (mix 1 cement to 2 sand to 4 aggregate) rather than screed and make it a minimum of 75mm thick. Cast the paving in small panels to reduce the risk of cracking.

Paths around the site can be very useful particularly on very wet or sloping sites. On wet or muddy sites, paths can reduce the

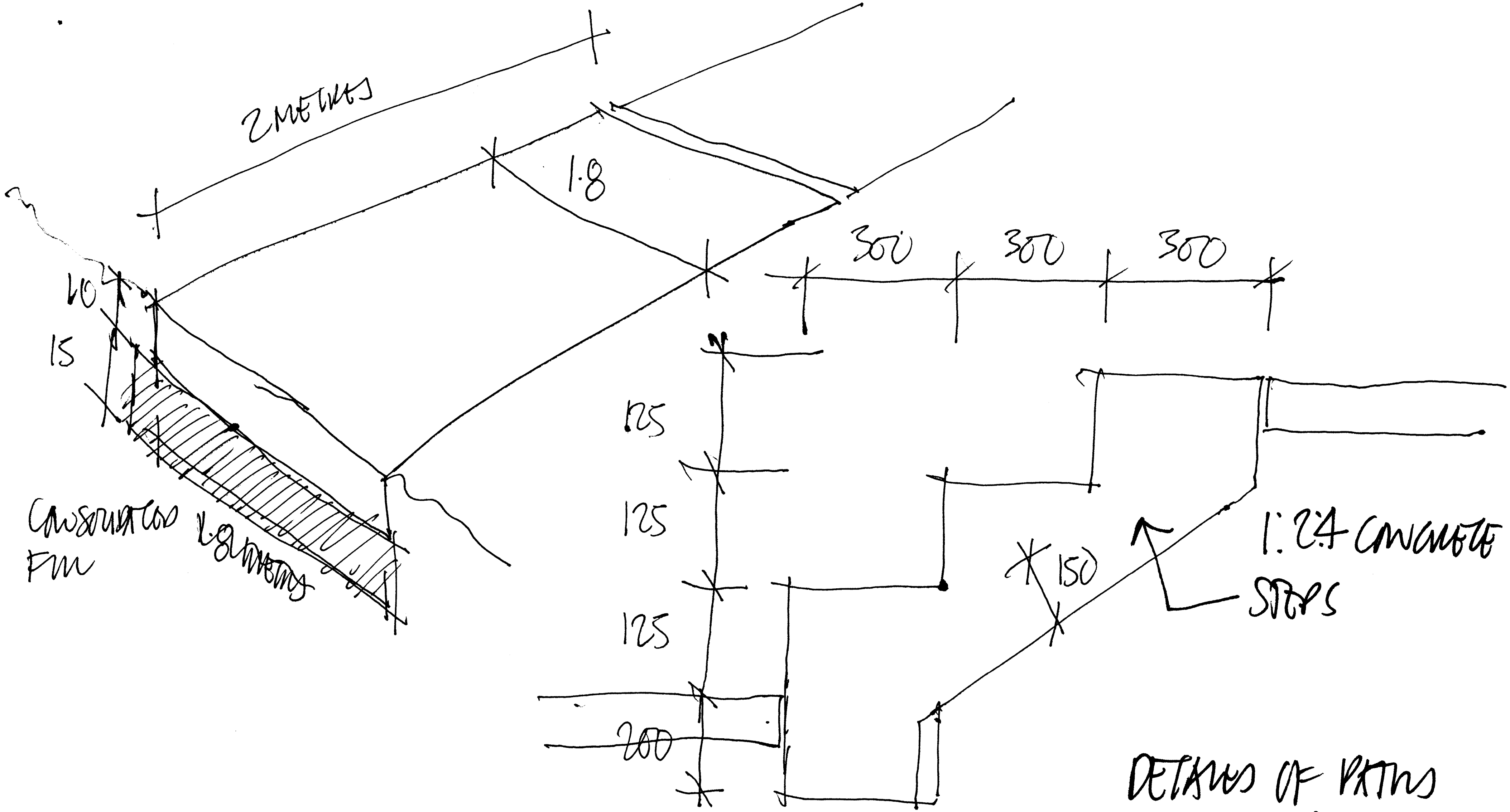


BRICK DISH DRAIN



CONCRETE BOX DRAIN

DETAILS OF STORM
DRAINS ROUND BUILDING



DETAILS OF PATHS & STEPS

amount of soil trodden into classrooms or verandas and help keep them clean.

Paths will be useful on all sites in directing pedestrian traffic and will be particularly useful on sloping sites in reducing erosion. It must be remembered however that paths must follow 'desire lines'; if the paths do go where people want to go they will not be used and will be a waste of money. The paths should also be wide enough for the number of pupils and teachers who will be using them. A minimum width of 1.8 metres is recommended and paths should be widened at all corners and changes of direction.

Strip off the top soil on the line of the path and lay and compact a 150mm thick layer of selected fill. Paths should be constructed of 1: 2: 4 mix concrete, 100mm thick and should be cast in panels a maximum of 2 metres long. See sketch.

Steps will be required on many sites particularly on those that slope steeply.

Construct steps of 1:2:4 mix concrete on 150mm of selected fill. Treads should be 300mm wide and risers should be a maximum of 125mm high. The minimum thickness of the concrete at the 'waist' should be 150mm. See sketch.

Remember:

- **Paving around buildings will help stop soil erosion**
- **Use concrete for paving rather than screed**
- **Paths around the site will help stop soil erosion and also help keep the school clean**

4. RETAINING WALLS

If the site slopes, then it will probably be necessary to construct retaining walls to form platforms for the buildings, play areas, etc. If the site slopes steeply then it might be necessary to construct high retaining walls.

Where there is a change of level, it will be necessary to construct a retaining wall to retain the soil at the higher level.

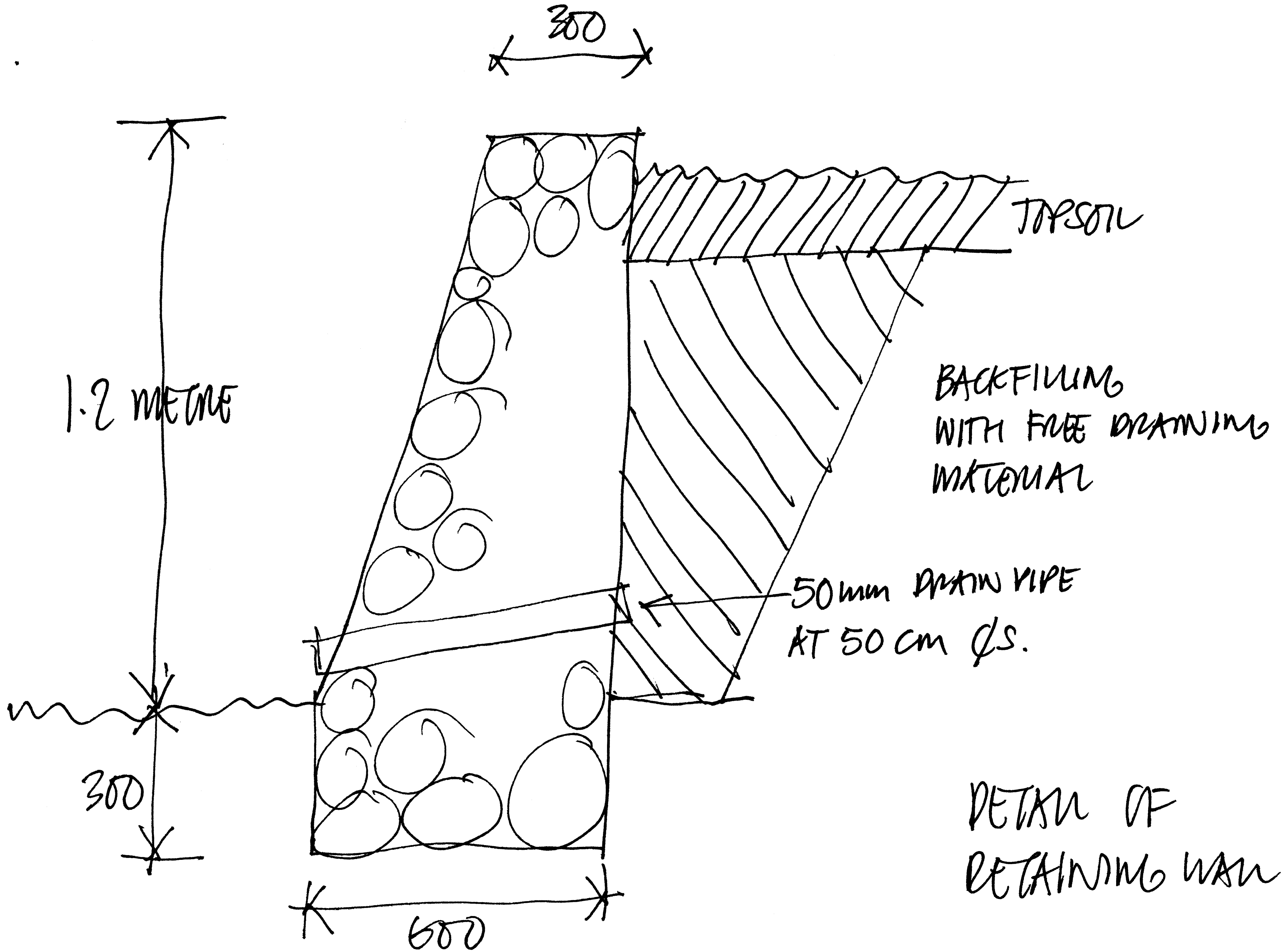
Retaining walls are built of large pieces of stone. The rear face of the wall should be vertical and the front face should slope back from the bottom to the top so that the wall is thicker at the bottom than at the top.

Excavate the foundation of the wall down to firm soil and build the wall on layers of sand and stone as in a normal building foundation.

When the wall is built, back-fill the area behind the wall with free-draining material that is consolidated in layers. Build 50mmØ plastic or bamboo drainage pipes into the wall at low level at 1 metre centres to enable water to drain out from behind the wall. If the soil behind the wall is not drained and becomes water-logged the wall could eventually collapse.

If retaining walls over 1.2 metre high are required or if the site has very loose soil conditions, then the advice of a properly qualified engineer should be taken on the design and construction of the walls.

Walls over 1.2 metre high should be protected with a handrail, wall or flower box to stop children falling over or jumping off the edge.


300
1.2 METRE
TOPSOIL
BACKFILLING WITH FREE DRAINING MATERIAL
50mm DRAIN PIPE AT 50 cm C/S.
300
600
DETAIL OF RETAINING WALL

Remember:

- **Always construct a retaining wall where there is a change of level greater than 60cm**
- **Make sure that retaining walls sit on firm ground as in a normal foundation**
- **Always provide drainage for water to escape from behind a retaining wall**
- **Always get the advice of a qualified engineer on retaining walls higher than 1.2 metres**
- **Always protect a retaining wall higher than 1.2 metres with a handrail or similar**

5. SEPTIC TANK & SOAKAWAYS

On normal sites, septic tanks and soakaways should be built following the standard drawings. See drawings.

Septic tanks and soakaways must be kept at least 3 metres away from the school buildings so that if there are any leaks the soil beneath foundations to walls and columns will not be saturated and cause subsidence.

It will be very useful to have an inspection chamber on the soil pipe from the toilets before it enters the septic tank in order that the pipe can be rodded in case of a blockage. Inspection chambers should also be built at any changes of direction in the pipe or at 6 metre intervals if the septic tank is a long way from the toilets. All inspection chambers should have removable concrete covers.

On very wet sites, especially those with a high water table, ordinary septic tanks and soakaways will not work and special precautions need to be taken.

The septic tank in this situation must be water-proof to stop any water from the site getting in and soil water from the tank getting out and the septic tank must be set as high out of the ground as possible given the constraints of the level of the toilets and the falls required for the soil pipe.

Construct the base of the tank of 150mm thick 1:1½:3 mix concrete reinforced with steel mesh. If possible construct the sides of the tank of similar concrete using timber shuttering. Care will have to be taken when casting the walls to hack the concrete base around the edge and to wet it to ensure a good bond between the base and

the wall. If a water-proofing agent is available then this should be added to the concrete mix for both base and walls (if not available then mix some PVA adhesive into the concrete mix).

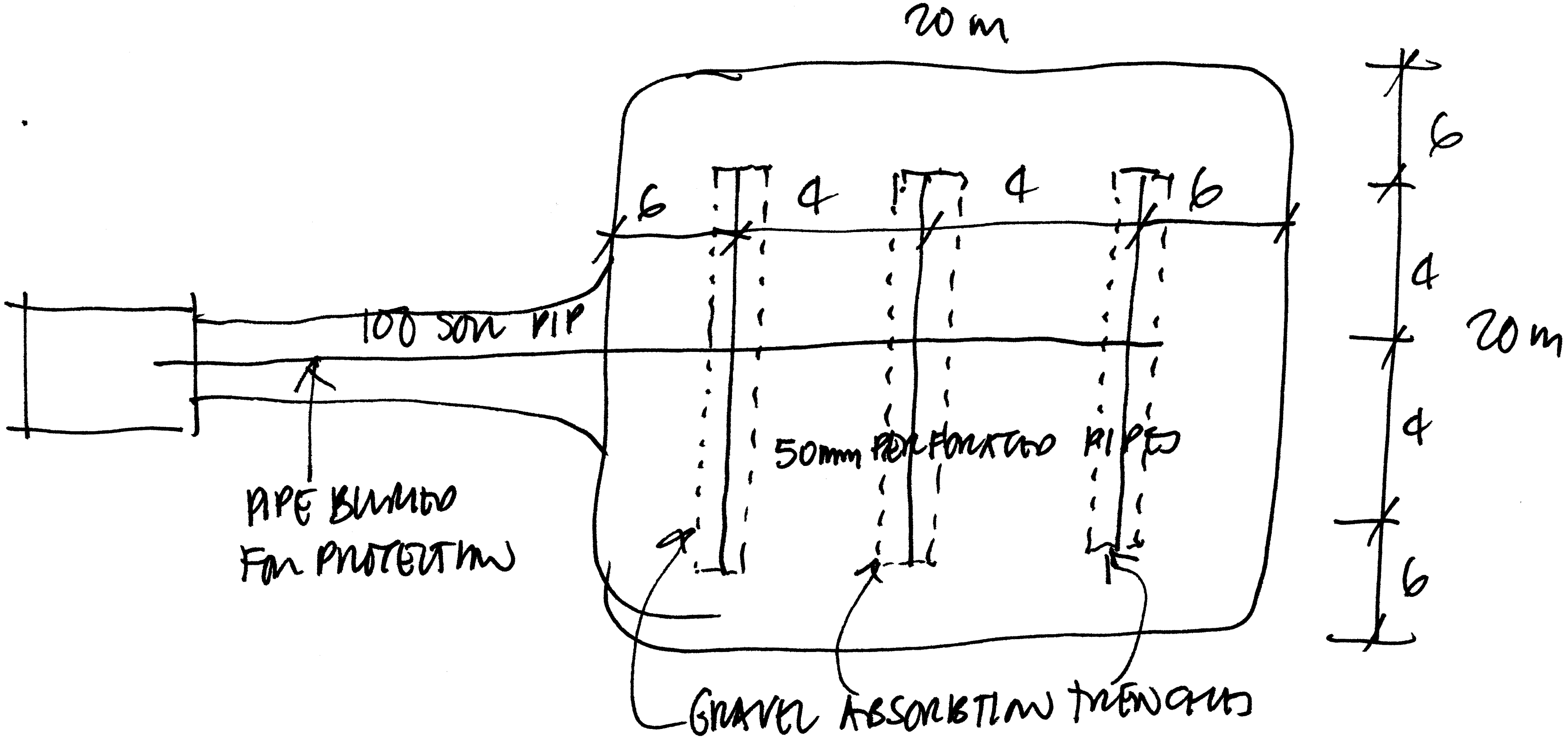
If bricks are used for the walls, then the brickwork should be two bricks thick. If concrete or sandcrete blocks are used they should be solid, 20cm thick blocks. Render the walls (mix 1:3) on both the inside and the outside and if a water-proofing agent is available then it should be added or add some PVA adhesive to the mix.

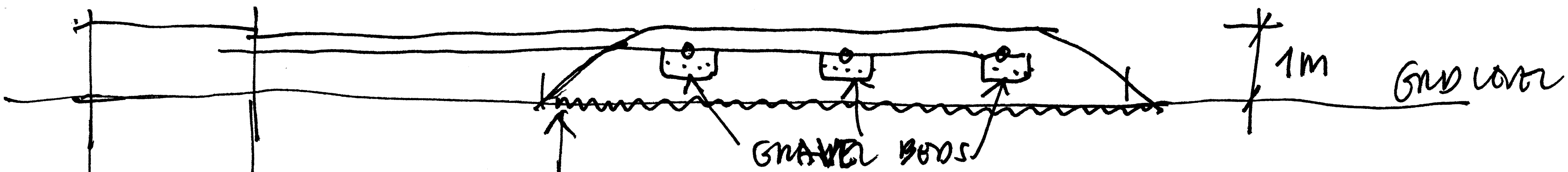
The type of soakaway that should be used in this situation is called a 'mound' soakaway or an evapo-transpiration bed. This

. PUT IN —

- STANDARD DETAILS OF SEPTIC TANKS & SOAKAWAYS.

- MAIN SOAKAWAY (SEE NEXT PAGE)





GROUND PLOUGHED UP BEFORE MOUND BUILT.

MOUND PLANTED WITH LOCAL GRASS.

MOUND SOAKAWAY FOR VERY WET/ROCKY SITES

consists of a 1 metre high bed of coarse sand sitting on natural ground level (the ground should be dug over before the mound is built) covered with a 100mm layer of top-soil. 50mm perforated plastic pipes are laid in trenches in the mound filled with gravel and covered in straw. The 50mm pipes are connected with a 100mm pipe to the septic tank. See drawing.

The top-soil is then planted with fast-growing local grasses which have high transpiration rates and the water content of the mound is lost to the atmosphere through transpiration. The organic matter in the soil water fertilises the grass which should be cut periodically.

Build an earth bank around the mound to protect it from flooding during the rainy season.

A mound soakaway for a 6-classroom primary school should be approximately 20 x 20 metres. See sketch layout.

Remember:

- **Keep septic tanks and soakaways 3 metres away from buildings**
- **Follow the drawings carefully when constructing septic tanks and soakaways**
- **Provide inspection chambers on long lengths of soil pipes**
- **Take special precautions as outlined above when constructing septic tanks and soakaways on very wet sites**

6. WATER SUPPLIES

All primary schools whether in rural or urban situations should have a dependable drinking water supply.

Some primary schools, especially those in towns and large villages will have access either to a main town water supply or to a village supply, usually from a spring.

In these situations, a main pipe should be brought into the school site via a branch from the town or village supply. The pipe should either be flexible plastic (polyethylene) or galvanised steel. Rigid plastic pipes although cheaper than these are very easily damaged. Whatever the type of pipe used however, it should be at least 32mm diameter (but preferably 35mm) and be buried at least 60cm deep in the ground to protect it from physical damage and should be surrounded by a bed of sand.

If the school is supplied form a government supply a meter will have to be installed. Whatever the type of supply, a main stop-cock should be installed in an accessible position so that the supply to the school can be cut off in case of a leak or other problem.

If there is a meter the stop-cock should be close to this but on the school side of the supply. Both the meter if fitted and the main stop-cock should be protected by a small concrete chamber with a concrete lid and be clearly marked.

Each building that is supplied with water should have an individual stop-cock so that the supply can be cut off in case of leaks, etc. These stop-cocks should also be protected by a small concrete chamber with a concrete lid and be clearly marked.

7. WATER TANKS

If the school has a piped water supply but the supply is intermittent, it might be necessary to install one or more water storage tanks.

If the site slopes and the water supply comes in at the top of the site, a ground water tank could be built using concrete for the base and brick or block work or concrete for the walls (the construction will be similar to a septic tank: see below). The tank size will depend on the number of pupils and the regularity of the water supply.

The inlet pipe for the water should be situated at the top of the tank and should be controlled with a float valve to stop the water when the tank is full and thus not waste any water. The outlet pipe should be built into the bottom of the tank and can feed the school buildings using gravity only.
If the site is flat and the water pressure is sufficient to reach the top of the tank when the water supply is on, a high-level tank on a stand should be provided. A glass-reinforced plastic tank will last longest and the tank should be big enough to provide at least one day's water supply to the school (a minimum of 7,500 litres for a 6-classroom school). The tank stand itself should be designed by a properly qualified engineer to make sure that it is strong enough for the load of the water and if it is not galvanised, it should be primed and painted with two coats of gloss paint to protect the steelwork.

The inlet and outlet pipes should be of galvanised steel and there should be stop-valves for isolating the tank on both pipes.

If the water pressure is low, then it will be necessary to construct a ground level storage tank and pump water up to a high-level tank on a stand from where the water will be supplied to the school buildings.

A hand or electric pump will have to be provided to pump water up from the ground tank to the high-level tank. It will be hard work to pump water up using a hand pump but if there is no electricity this will be the only option and a roster will have to be made for students to do this every morning.

If an electric pump is used care must be taken to make sure that it is big enough to do the job taking into account the height of the tank stand and any difference in level between the ground tank and the bottom of the tank stand. The pump will also have to be regularly maintained.

If a well is used for the school water supply (see below) then a pump of either kind could be used to pump water from the well to a high-level tank.

8. WELLS

Many primary schools, especially those in the rural areas, will depend on a well as their source of drinking water.

Traditionally, wells in Indonesia are not lined and are not covered. This means that they are open to contamination from the top and from the sides. If a new well is going to be excavated for a school, it should be both lined and have either a hand-pump fitted to a concrete top, a removable timber top or a concrete top with an access hatch.

Wells should always be excavated at the end of the dry season and should go down to at least 3 metres below the water table at that time. This will mean that the well will always contain water. If a well is excavated during the rainy season, it is likely that it will dry out during the dry season.

Because the well has to go down at least 3 metres below the water table, it will probably be necessary to hire a pump to pump water out and keep the well dry during excavation.

Wells should never be positioned close to septic tanks or soakaways or downhill from them because of the danger of contamination. Wells should be at least 15 metres and are better positioned 30 metres away from a septic tank or soakaway. On sites with very wet or loose soil, they should always be at least 30 metres away.

Wells can be lined with either brickwork or pre-cast concrete rings. Concrete rings are better because they can be lowered into position as the well is dug (the digger excavates while standing in the ring and the ring drops down as he excavates; see sketch). If brickwork is used, the whole well has to be excavated before the brickwork is built and this means that there is the danger of the sides collapsing on the diggers before the well can be lined.

The lining to the well must be water-proof at least to the top of the water table position during the rainy season. This will stop contamination from the ground around the well. The lining below the water table should be built with open joints between the rings or open brickwork and coarse sand or gravel should be used for backfilling between the rings and the ground. Fill the bottom of the well when complete with a layer of clean gravel 150mm thick to keep the water coming up from the bottom clean.

When the well has been excavated and lined, raise the top of the well at least 1 metre above ground level if buckets are going to be used to bring up water. If a hand-pump is going to be used then stop the well at about 30cm above ground level. Whatever the height of the head wall, the well should have a concrete apron at least 1.5 metres wide around and sloping down away from the well to protect it from surface water. The joint between the apron and the head wall of the well must be sealed so that surface water cannot penetrate down into the well.

The first water that is taken from a well will always be dirty. The best way to clean the well is to empty it completely three times. If it fills up quickly it will be necessary to use a pump to do this. If a bucket is used to obtain water it should be a bucket with a round bottom attached to the well rope so that it cannot be put on the ground and get dirty.

Remember:

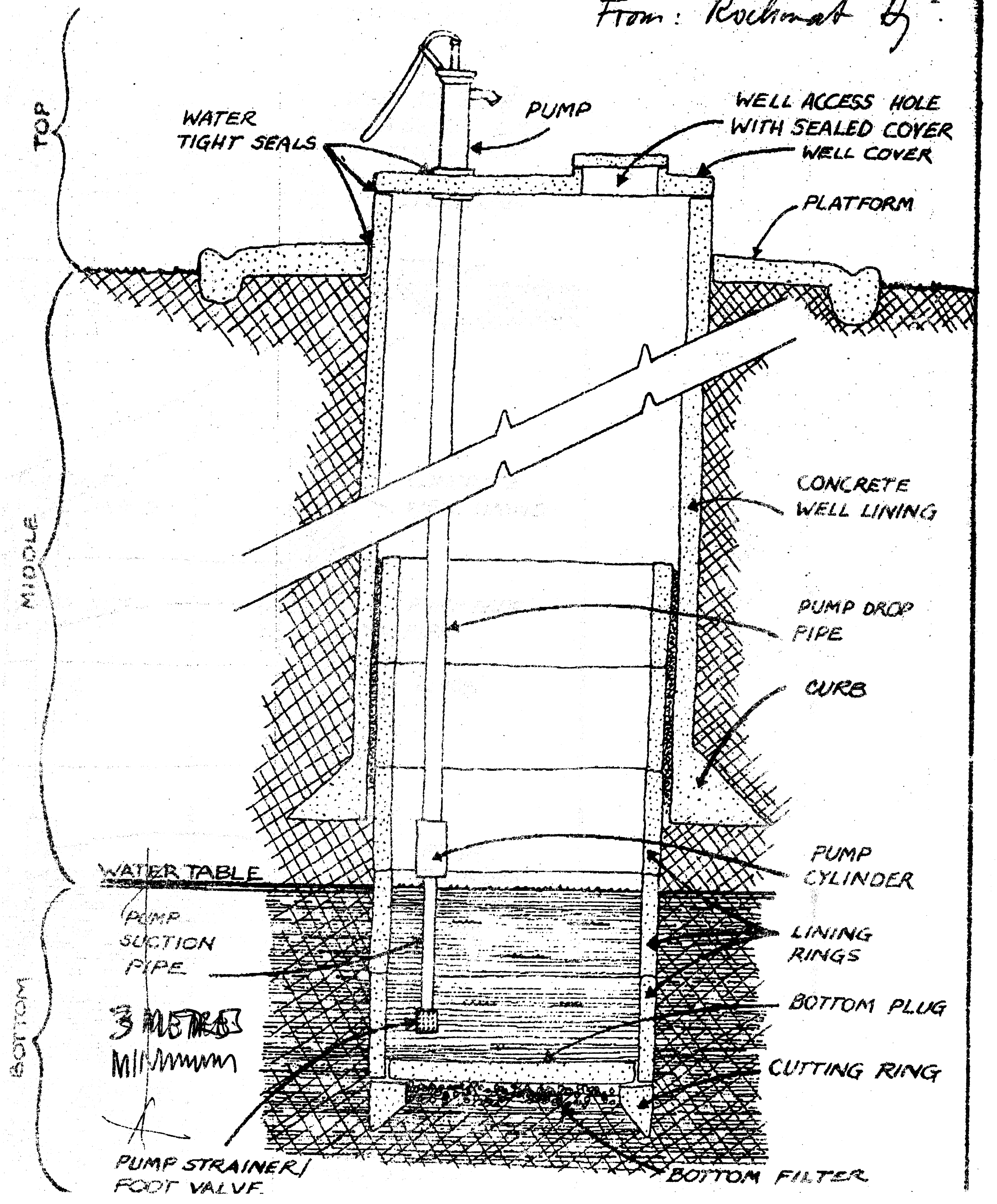
- **Never position a well downhill from a septic tank or soakaway**
- **Never position a well within 15 metres or better 30 metres of a septic tank or soakaway**
- **Always excavate a well at least 3 metres below the water table at the end of the dry season**
- **Always cover the well**

1 of 8

To: [illegible] Lambert WB

From: Rochmat Dj.

FIGURE A
CROSS SECTION OF HAND DUG WELL



9. REFUSE DISPOSAL

When the new school is complete, the school grounds will need to be kept clean and tidy both to improve the appearance of the school and to stop any disease that might be spread by decaying rubbish, etc.

School staff and pupils will both need to be made aware of the need to keep the grounds clean and tidy and of the school rules that govern this and a roster system should be developed so that everyone takes part in keeping the school clean.

In order to facilitate keeping the grounds clean, rubbish bins should be made and positioned around the site and a simple incinerator made in which rubbish can be burned. The incinerator should be positioned well away from the school buildings and in a position where it will not annoy any neighbours! The rubbish should be collected every day or every week depending upon the amount and then be burned in the incinerator.

The incinerator can be made of an old 200 lire steel drum that has had the top removed and holes punched in the sides and bottom. The drum should be set on bricks or blocks to raise it off the ground with a concrete slab beneath. The ash from the burned rubbish should be collected and buried in ash pits situated close to the incinerator. Each layer of ash should be covered with soil and when the pit is full it should be covered with top-soil and a new pit excavated.