

# Repair and Retrofit Handbook

for dwellings in Malawi



## Foreword

This handbook has been prepared for the repair and retrofit of houses in Malawi. It is aimed at householders, artisans, and site supervisors as a reference tool during construction.

The handbook covers key issues surrounding common structural failures and their likely causes. It also includes step-by-step guidance on the repair and retrofit of key elements and the skills and materials required for each task.

The main hazards addressed in this handbook include earthquakes, floods, and high winds. The appropriate repair or retrofit have been split into three main sections; foundations, walls, and roof.

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## User Guide

The purpose of the handbook is to provide a step-by-step guide to completing repairs and retrofit construction of houses. Please read the handbook in the correct order to ensure that all problems have been identified.

The following steps are a guide to help make sure the handbook is been used appropriately;

### Step 1

Each element (foundation, wall, and roof) has a construction standard, this is highlighted in blue boxes. Read the standards and identify any that are missing from a house.

### Step 2

After reading the construction standard, next look at the common problems. Can you identify any failures in the house that match a problem shown in the handbook. If so, identify the likely cause and go to the next section.

### Step 3

Each element has a repair and retrofit section. Alongside the repair of each problem there is a 'skills and materials' page reference. This will take you to the page showing the exact method for carrying out a repair.

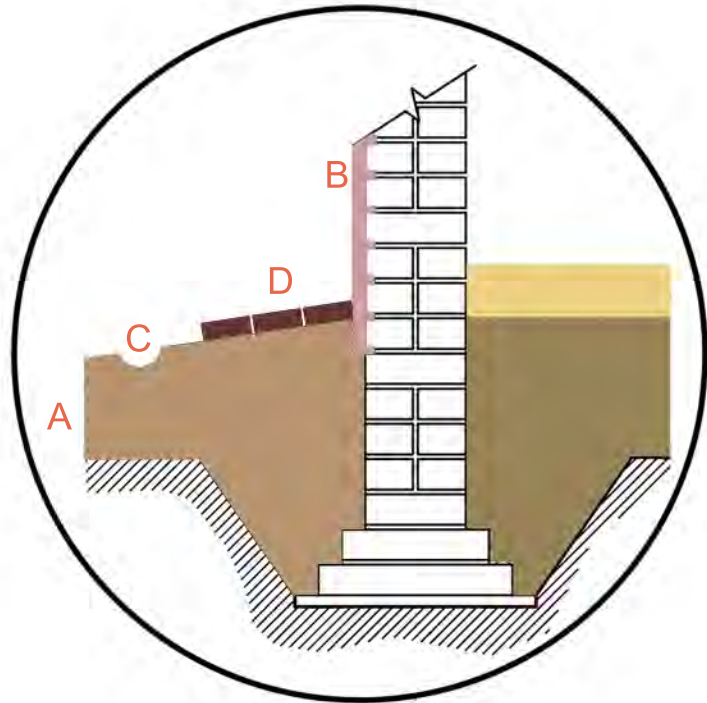
### Step 4

Ensure that the house has been repaired in accordance with the methods demonstrated in the handbook, or as advised by a construction site supervisor.

# Foundations

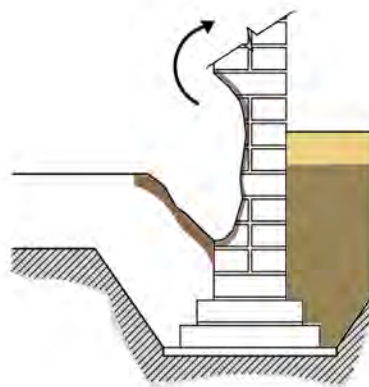
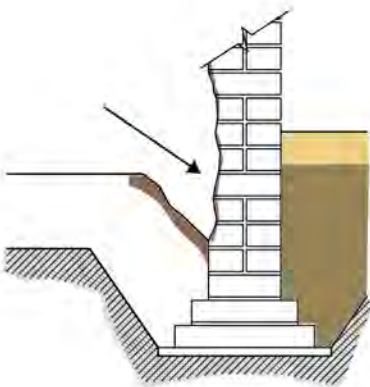
## Construction Standards

- A** Foundations should have sufficient cover to provide protection to the base.
- B** The plinth wall (between ground level and floor level) should be either pointed or rendered.
- C** The ground should slope away from building at a gradient of 1:10 and a drain constructed to channel water.
- D** Ideally brick paving should be laid around the perimeter.

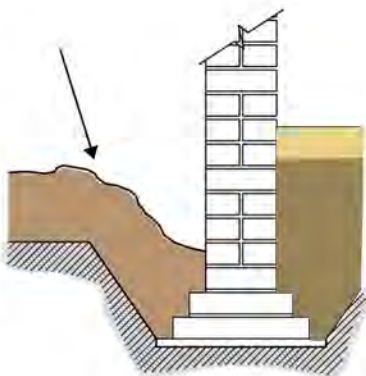


## Common problems with foundations

### 1 Damage to base of wall



### 2 Erosion to foundations



**1** Damage to base of walls and continued exposure will cause the building to collapse.

**2** Erosion to the ground exposes the foundations, causing structural instability.

## Common causes



Rain



Sweeping

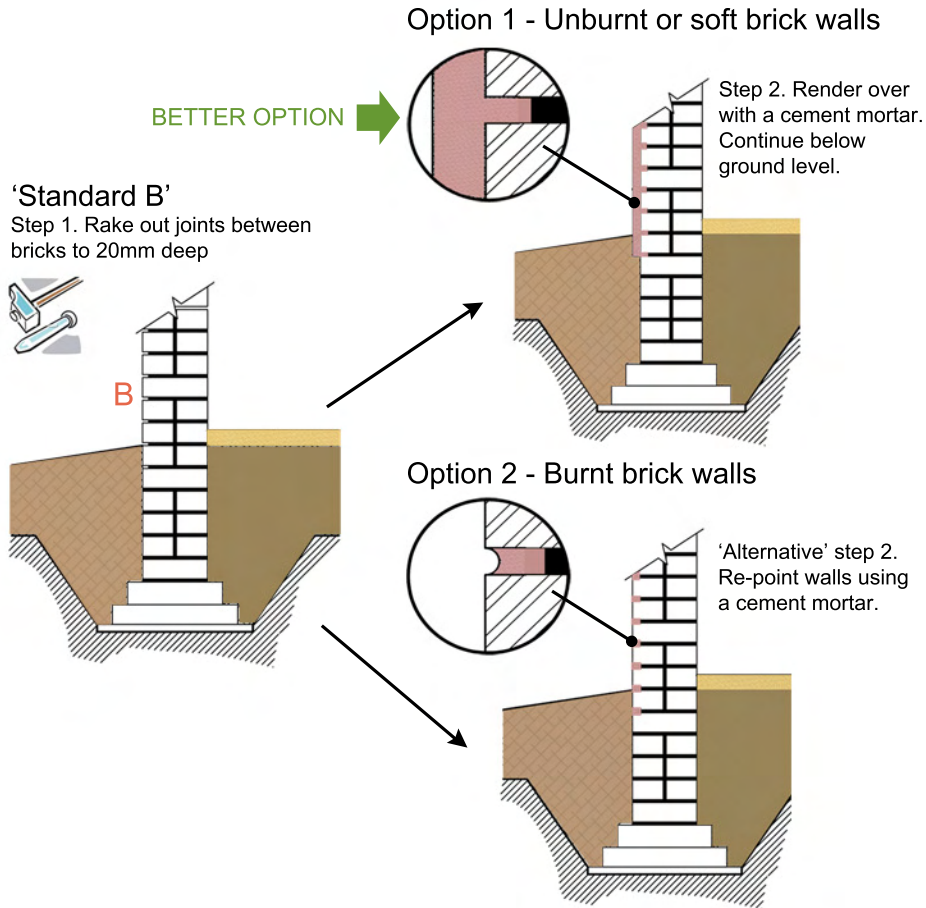


Animals



Flooding

## Repairing damage to the plinth



## Skills and materials

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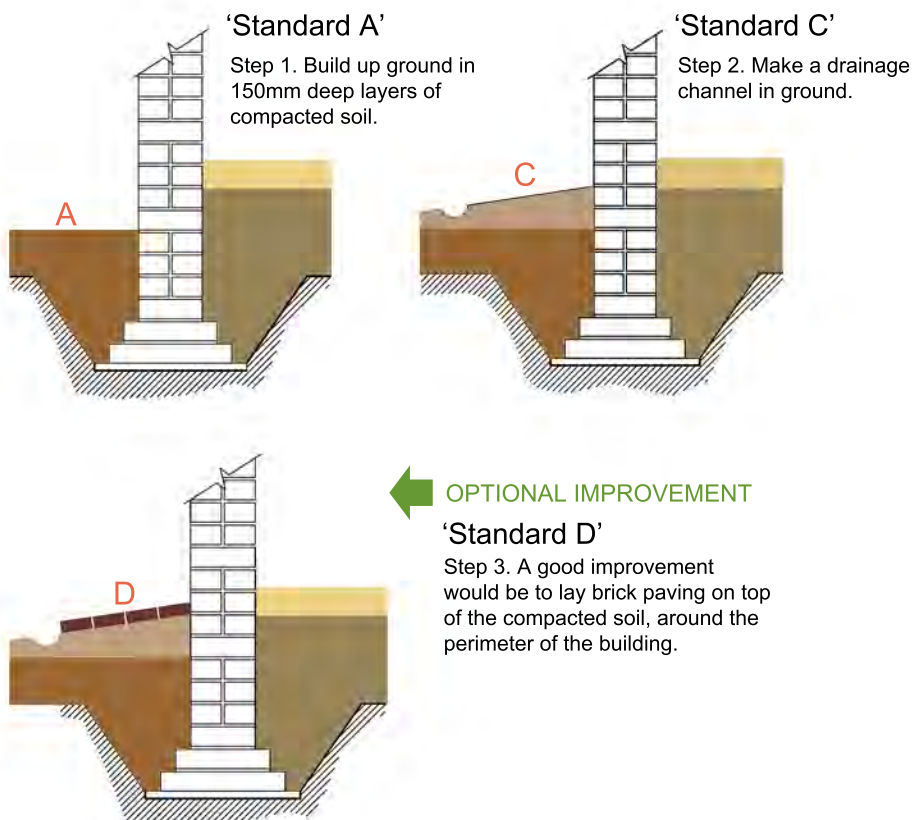
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Page 33 - No 3, 4 & 5

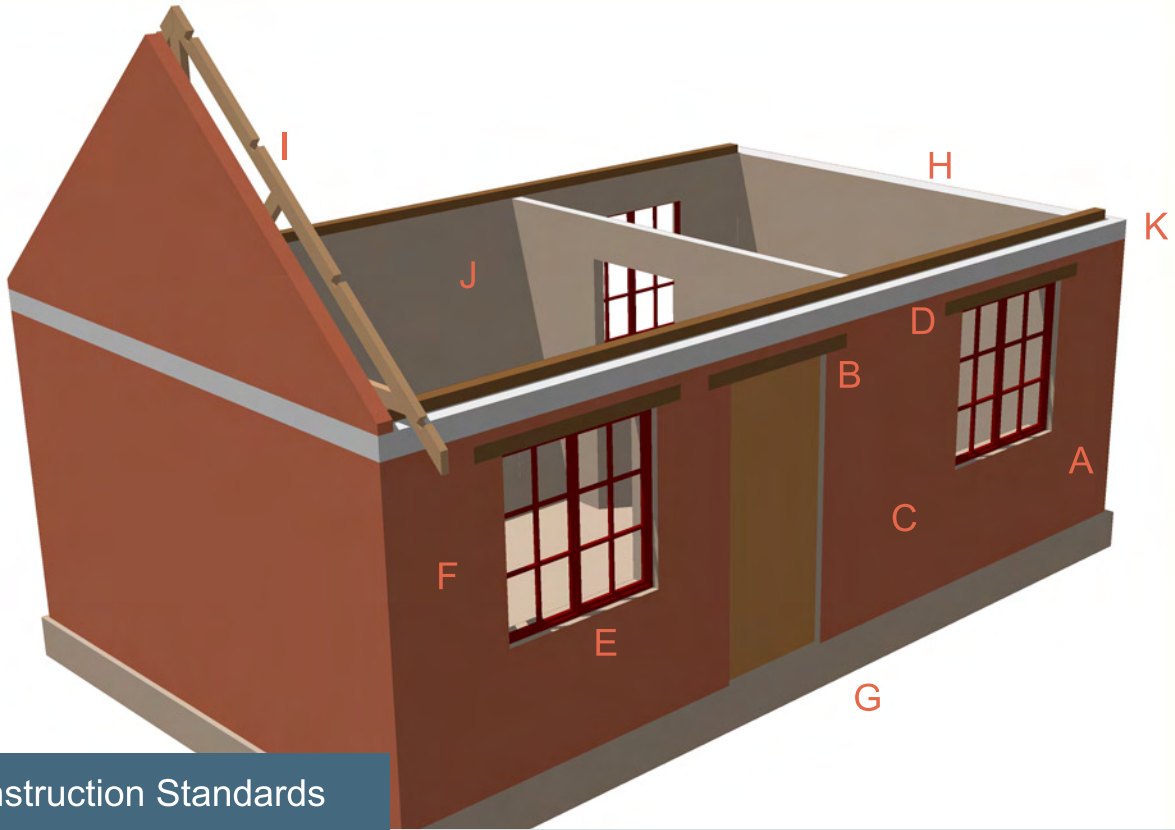
## Repairing erosion to the ground around foundations



## Skills and materials

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# Walls

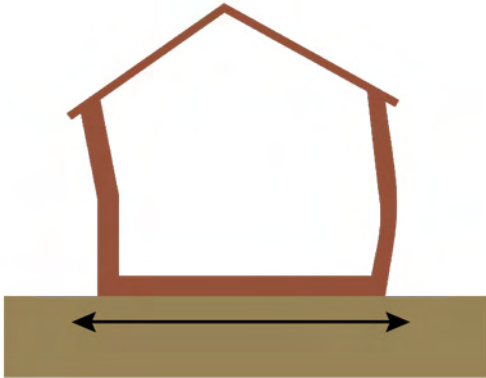


## Construction Standards

- A** Walls are straight and vertical.
- B** There are no broken bricks or long cracks (more than 3 bricks) and no cracks at the top of doors and windows.
- C** There is mortar in all brick joints.
- D** Lintels are fitted above doors and windows.
- E** The width of an opening is not greater than 1200mm (4')
- F** That openings are a minimum 600mm (2') from corners and other openings.
- G** Walls are no longer than 5m (15') long without support of connecting walls or piers.
- H** External walls are a minimum 230mm (9") wide with a brick bond that provides a tie at every 4th course.
- I** That there are no unsupported walls.
- J** Internal walls are tied to the external wall with brick force wire and brick bonds.
- K** A ring beam is fitted at wall plate height to bind the tops of all the walls.

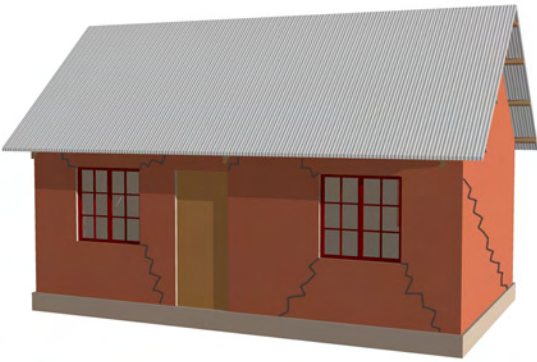
## Common problems with walls

### 1 Leaning or bulging walls



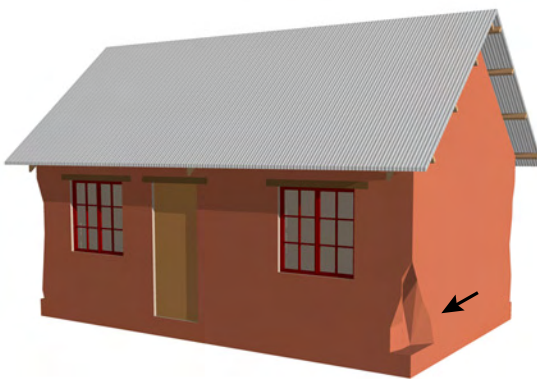
Leaning or bulging walls are unsafe and can collapse.

### 2 Continuous cracks in walls



Continuous cracks in walls weaken the structure. As a guide, cracks more than 3 bricks or above doors and windows are a problem.

### 3 Eroded walls (also see foundations)



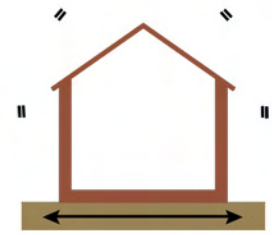
Erosion to walls can make the building unsafe and liable to collapse.

### 4 Unsupported wall collapsing



Unsupported walls such as gables and internal walls can lean or collapse.

## Common causes



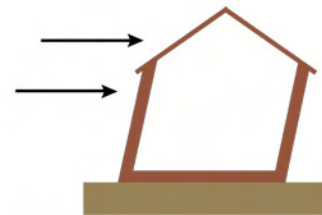
Earthquakes



Flood water



Mud bricks worn away by animals or people.



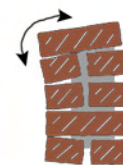
Wind



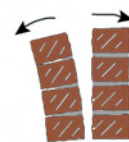
Walls too narrow



No lintels weakening structure

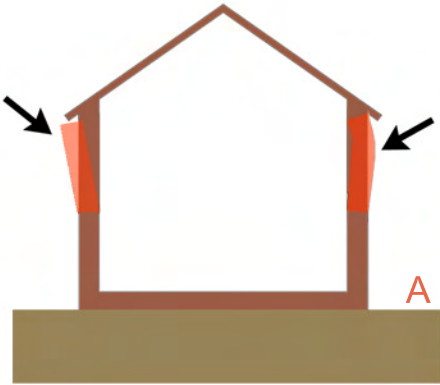


Not enough mortar between joints



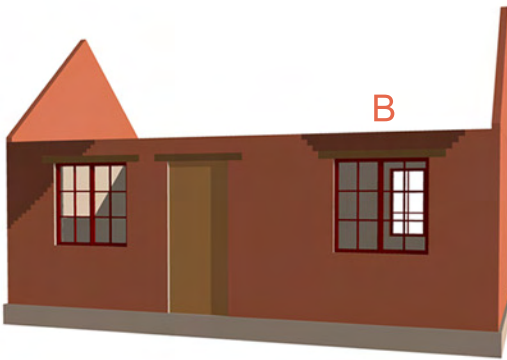
No brick bonding causing walls to break away.

1 Rebuilding leaning walls



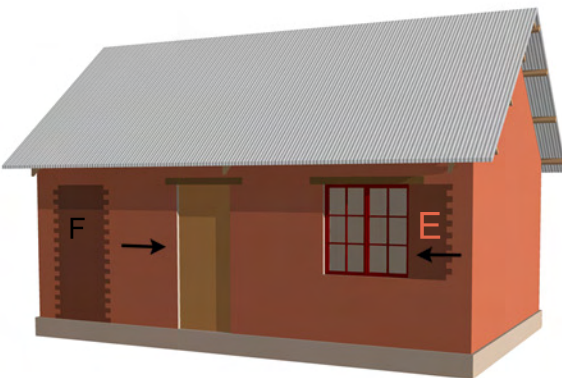
Rebuild sections of walls that lean or bulge.

2 Repairing cracks in walls



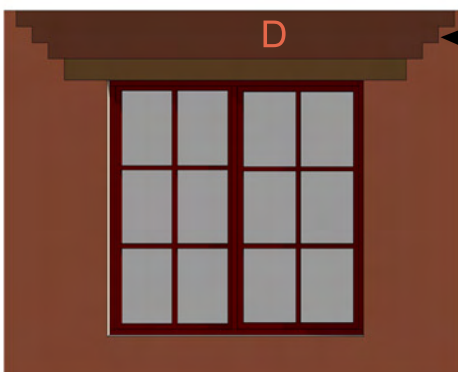
Rebuild sections of walls where there are cracks. (Also see (4) installing lintels over windows and doors)

3 Adjusting window and door positions



Reduce window openings to a maximum 1200 (4') width and move openings so that there is a minimum 600mm (2') between openings and corners.

4 Installing lintels over windows and doors



3 courses of brickwork to wall plate

Remove brickwork above opening. Fit lintel with 200mm (6") minimum bearing. Rebuild brickwork to wall plate level.

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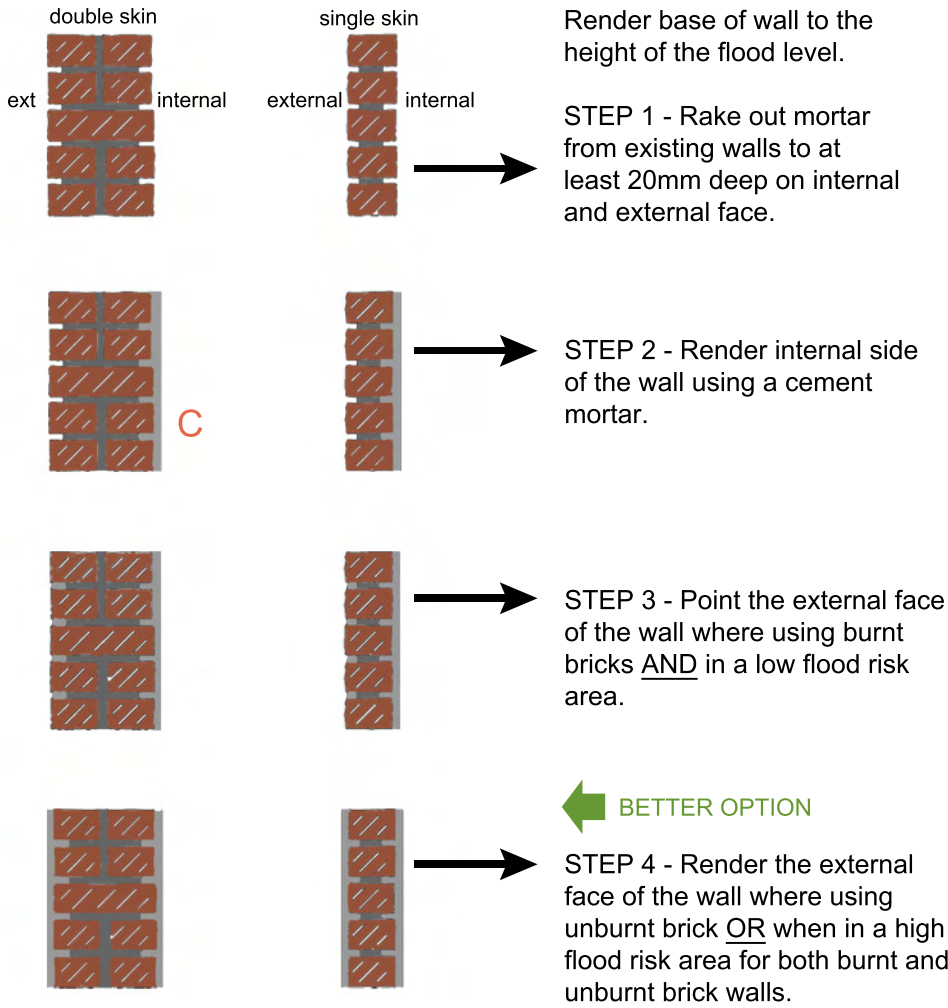
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5 Strengthening and protecting walls (also for flood risk areas)

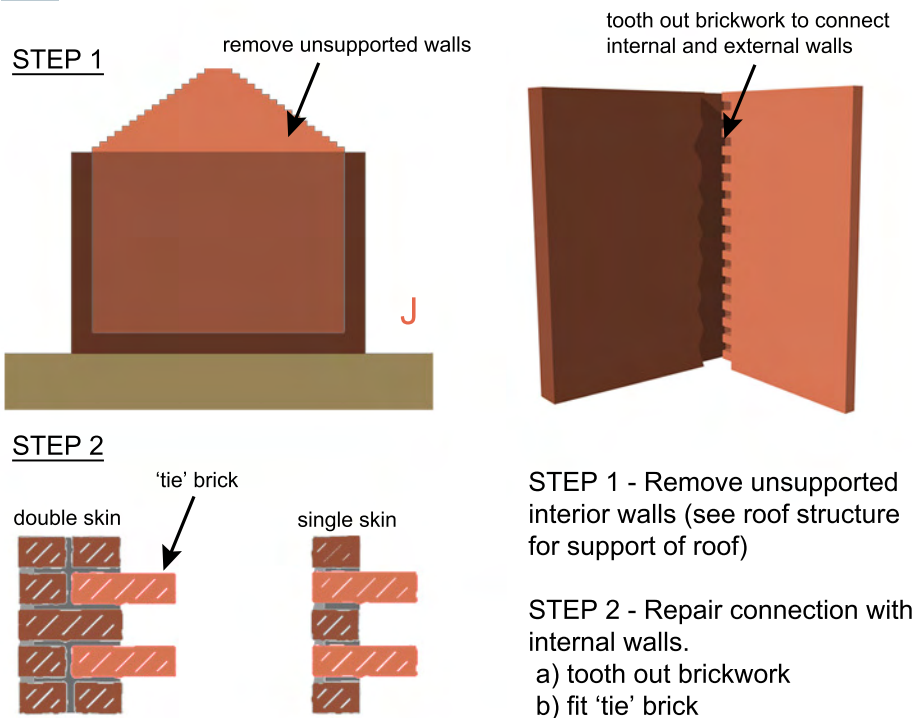


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6a Strengthening internal walls



Page 22 - No. 6a

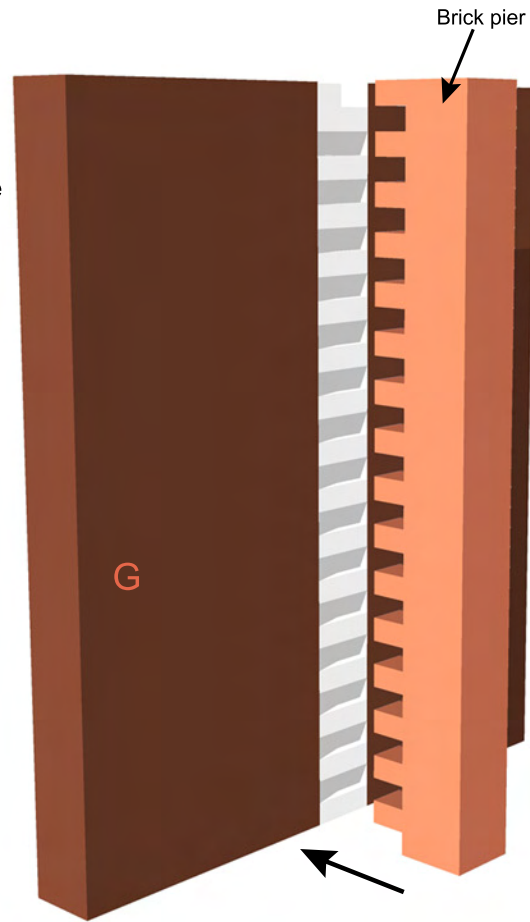
6b Internal brick piers - strengthening walls

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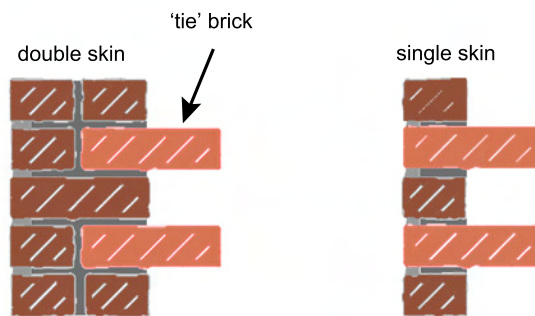
STEP 1 - Brick piers to support walls that are too slender, and walls over 5m long.

As a guide, brick piers should be spaced out at a maximum of 3m intervals to strengthen wall.



STEP 2  
Make connection with internal walls;

- a) tooth out brickwork
- b) fit 'tie' brick

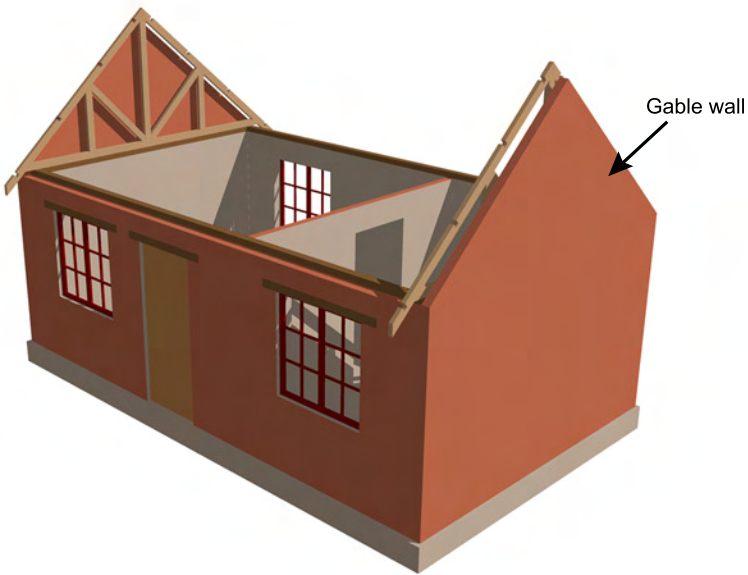


7 Strengthening gable walls

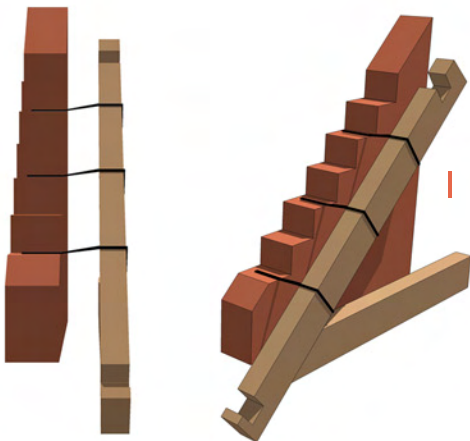
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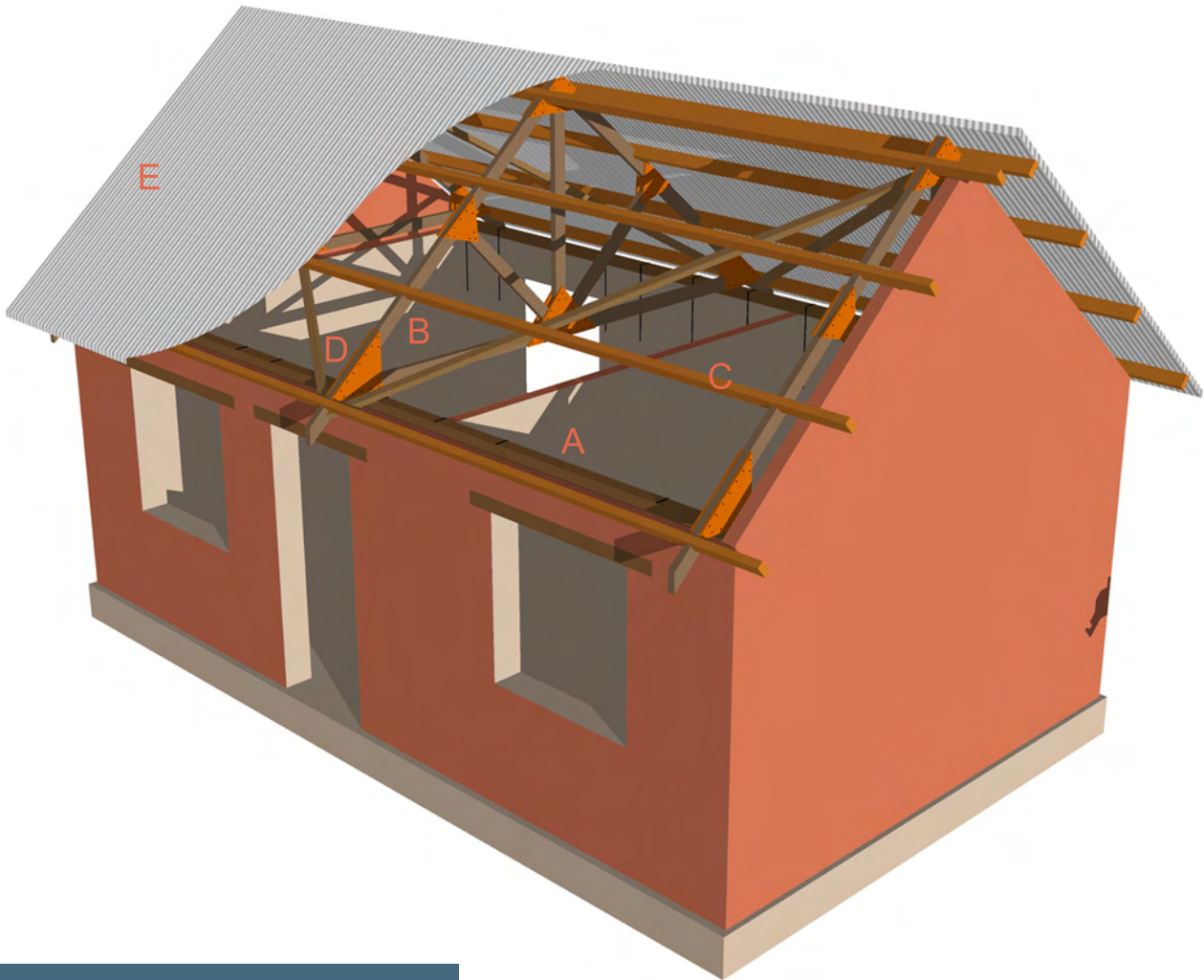


STEP 1 - As part of roof repairs (see roof structure). Rebuild gable where necessary as single brick width.



STEP 2 - Brick gable wall to be attached to timber truss with wire ties.

# Roofs

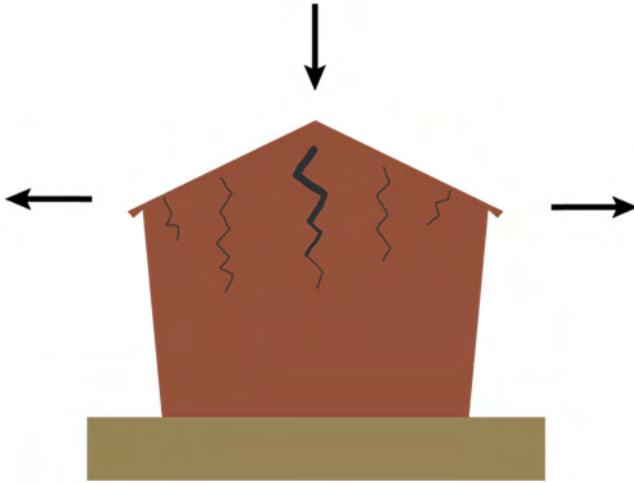


## Construction Standards

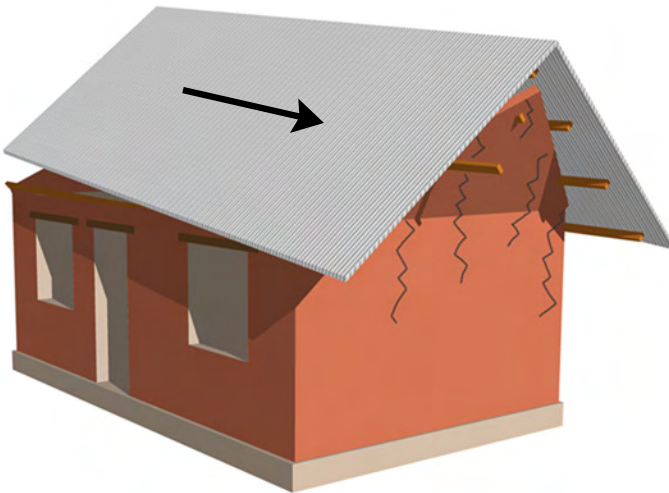
- A** Wall plates are fitted and fixed securely to the walls.
- B** Roof trusses are fitted to support the purlins and secured to the wall plate.
- C** Purlins are fitted securely to the trusses at a spacing of 1200mm (4').
- D** Diagonal bracing is fitted to the underside of the purlins between the ridge and wall plate.
- E** Corrugated Galvanised Iron (CGI) Sheet should be a minimum 28 gauge and fitted with 65mm (2 1/2") Roof Nails. These should be fitted to every second corrugation at the ridge and eaves, and fixing to other purlins to be at each edge and centre of the sheet.
- F** Thatch Roofs to be supported with trusses, purlins, and bracing as with the CGI roof. These elements can be sawn timber, round timber, or bamboo. Rafters and battens are tied securely and thatch is held down with lengths of bamboo stitched to the battens.

## Common problems with roofs

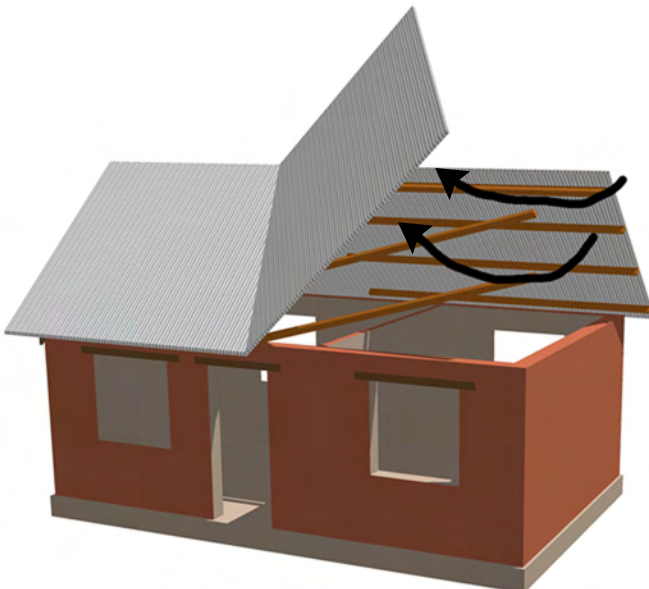
- 1 Roof moves down, pushing walls out



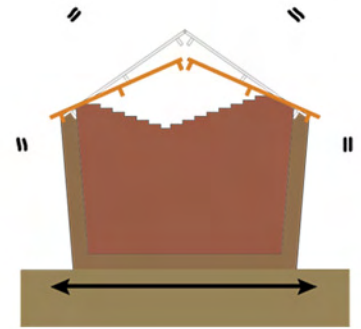
- 2 Roof moves sideways, pushing gables over



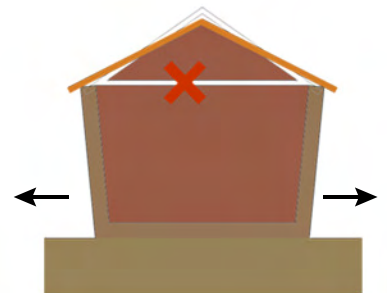
- 3 Roof sheets and structure get blown off



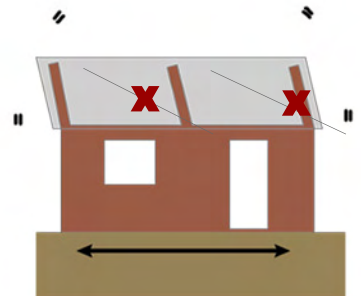
## Common causes



Earthquakes can cause the collapse of walls supporting the roof.



No ties between the rafters causes the roof to sag and push walls out



Where there is no bracing, wind and earthquakes can cause gables to move.



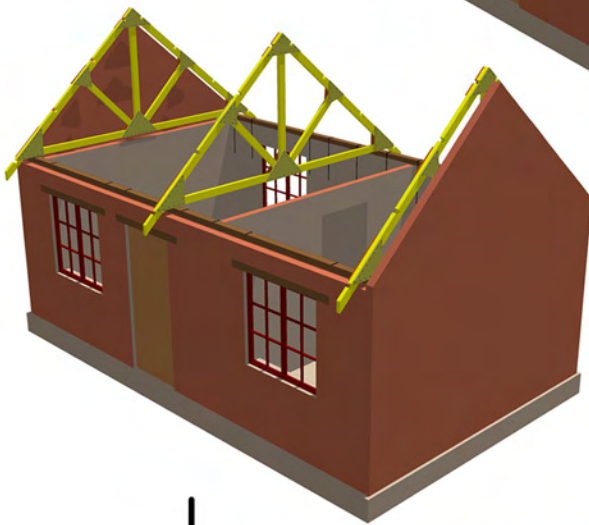
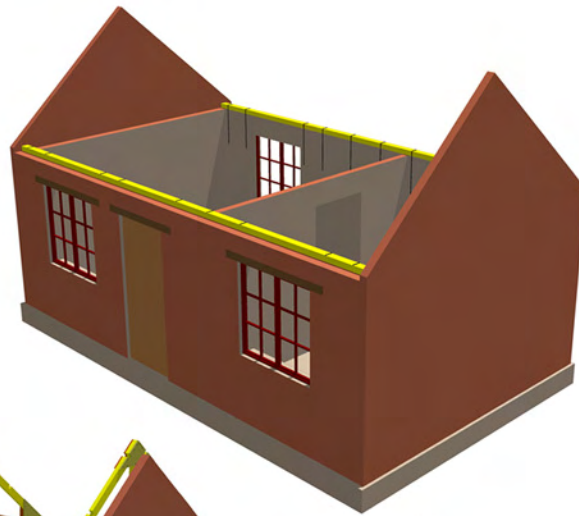
Poor connections will allow damage in high winds.

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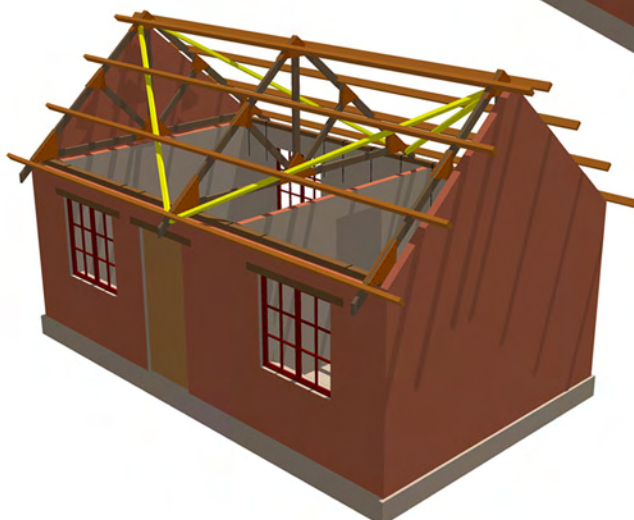
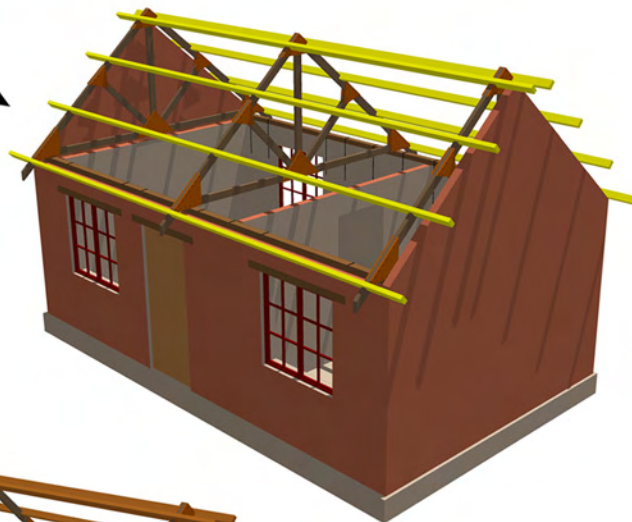
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**STEP 1. WALL PLATE**  
Wall plate fitted and tied to walls at 600mm (2') intervals, at corners and junctions with windows and doors (refer to page 19)



**STEP 2. TRUSSES**  
Roof trusses fitted and connected to wall plates. Gable walls tied to trusses

**STEP 3. PURLINS**  
150 x 50 (6'x2')  
Purlins fitted securely to trusses, with a maximum 1200mm (4') between purlins.



**STEP 4. DIAGONAL BRACING**  
150 x 50mm (6'x2')  
Bracing fitted between trusses, on the underside of purlins.

## 2. Grass roof construction

## Skills and materials

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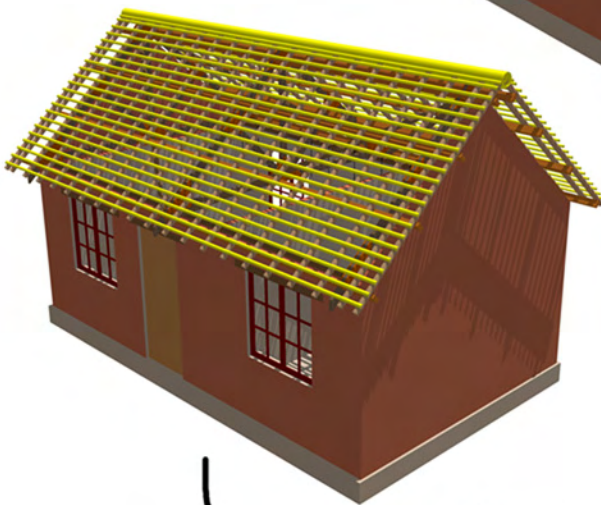
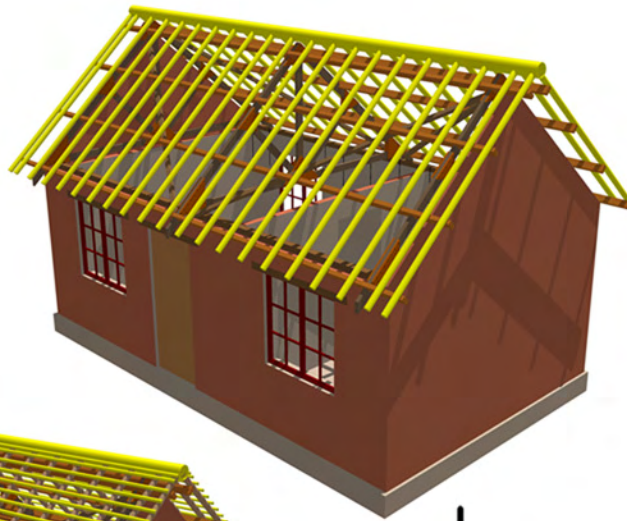
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**COMPLETE ROOF STRUCTURE FIRST**  
(refer to page 14)

### STEP 1. RAFTERS

Round or square section rafters, spaced at 400mm (16") centres and fixed to the purlins.

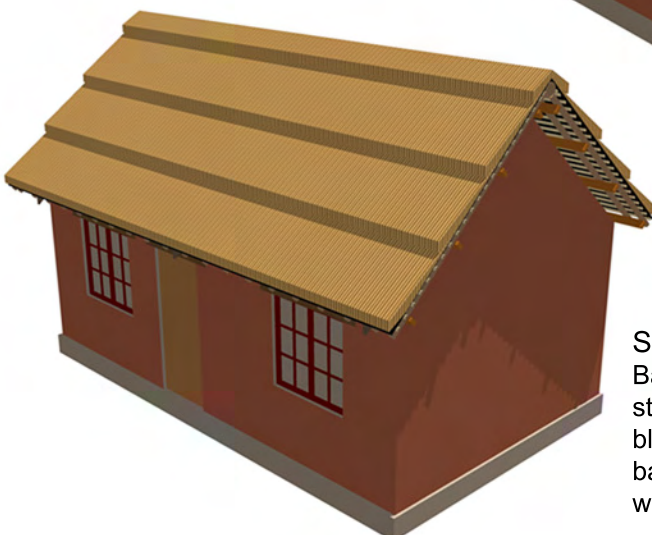


### STEP 2. BATTENS

Spaced at approximately 150-200mm (6"-8") centres or doubled where batten is slimmer. Tie down to the rafters.

### STEP 3. WATERPROOF MEMBRANE

Cover the whole roof with a black plastic membrane, making sure that there are no tears or gaps.



### STEP 4. GRASS ROOF

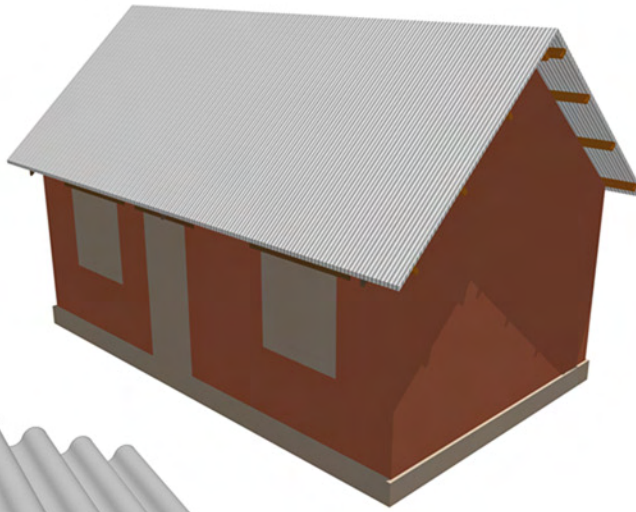
Bamboo poles attached by stitching through thatch and black plastic and tie to battens, to prevent uplift from winds.

#### COMPLETE ROOF STRUCTURE FIRST

(refer to page 14)

#### STEP 1. PURLINS

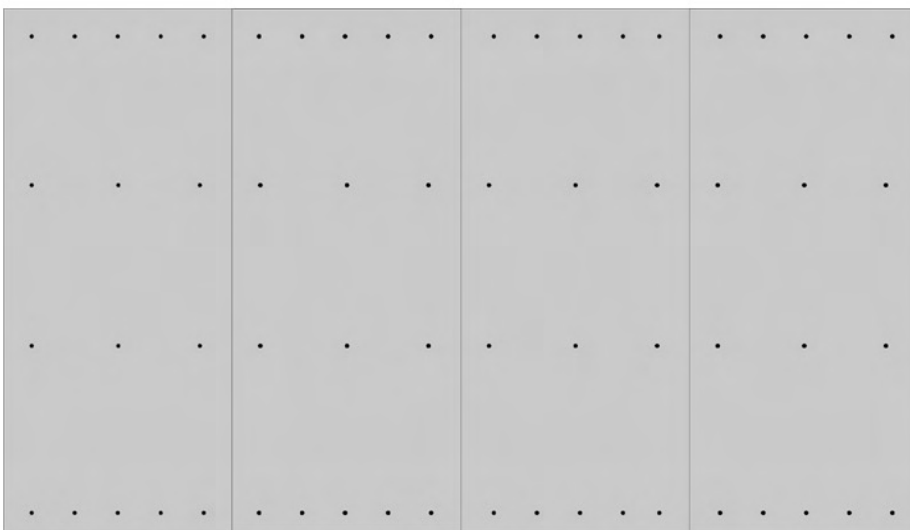
Purlins fitted at 1200mm centres (4'), and CGI sheets fixed onto the purlins. (as shown in step 2 and 3)



**STEP 2. LAPPING**  
CGI sheets to lap over each other by 1.5 'curves'.

#### STEP 3. FIXING PATTERN

Springhead nails fixed through everyother CGI ridge, at eaves and ridge of roof, to prevent uplift from wind (as shown above).  
Sheets fixed with 3 nails to intermediate purlins.



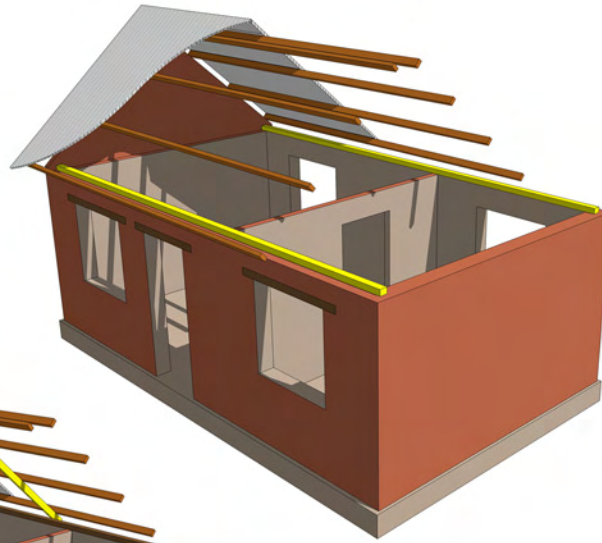
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### STEP 1. WALL PLATE

Fix wall plate to top of wall with wire ties at every 600mm (2') centres, at corners, and junctions with windows and doors.

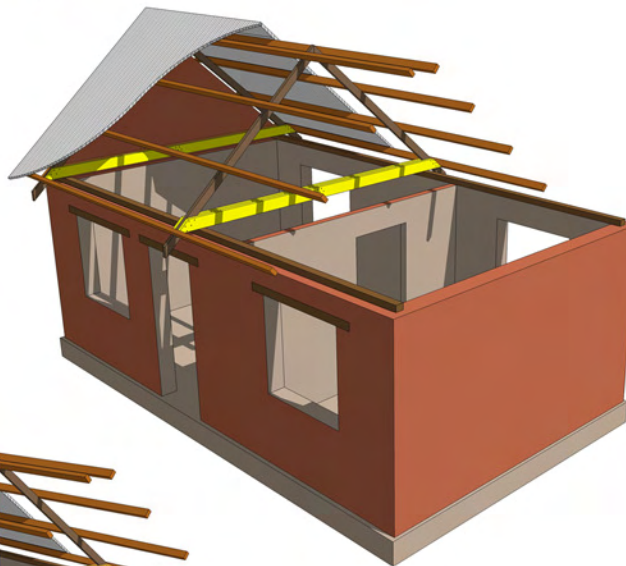


### STEP 2. RAFTERS

150x50mm (6'x2')  
Insert rafters beneath existing purlins and fix to wall plate and purlins.

### STEP 3. TIMBER TIE

2 pieces of 150 x25mm (6'x1') timber attached either side of rafter. Nails fixed at 75mm (3") centres.



### STEP 4. INSERT POST

150x50mm (6'x2') timber cut size and inserted down the centre of the rafters, from ridge to inbetween timber tie. Fixed with nails at 75mm (3") centres.

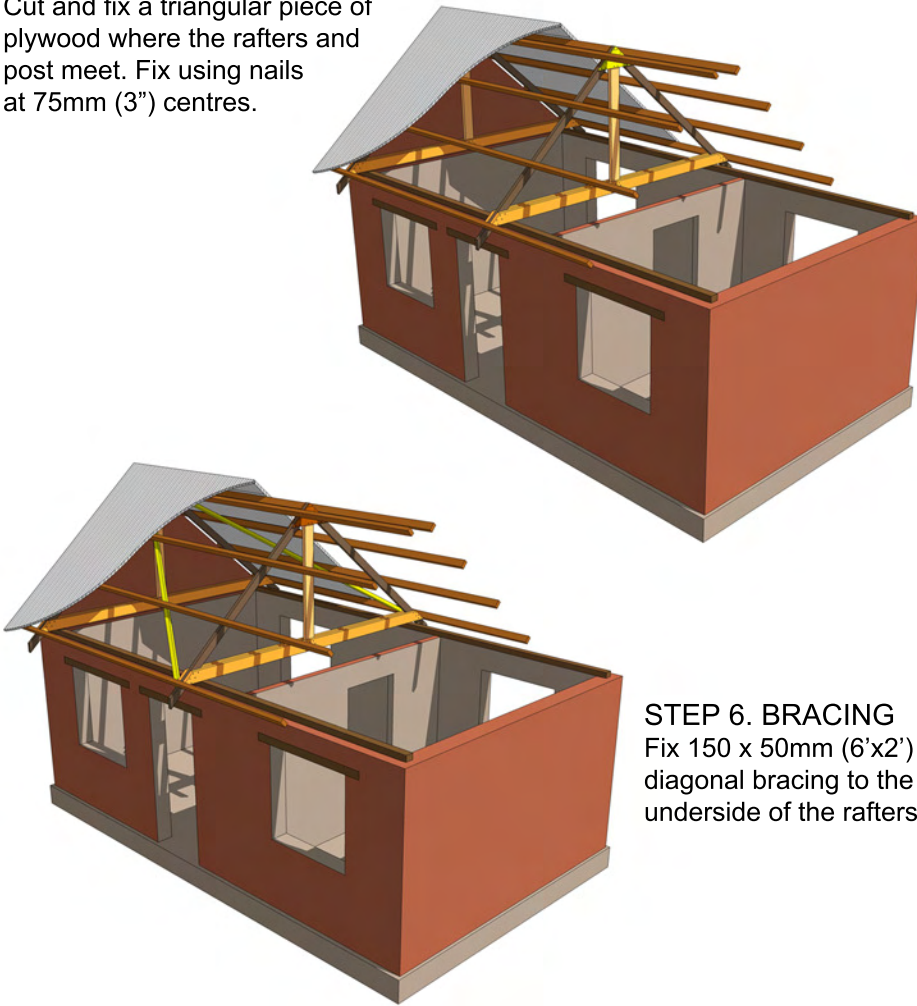
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**STEP 5 - PLY FIXING PLATE**

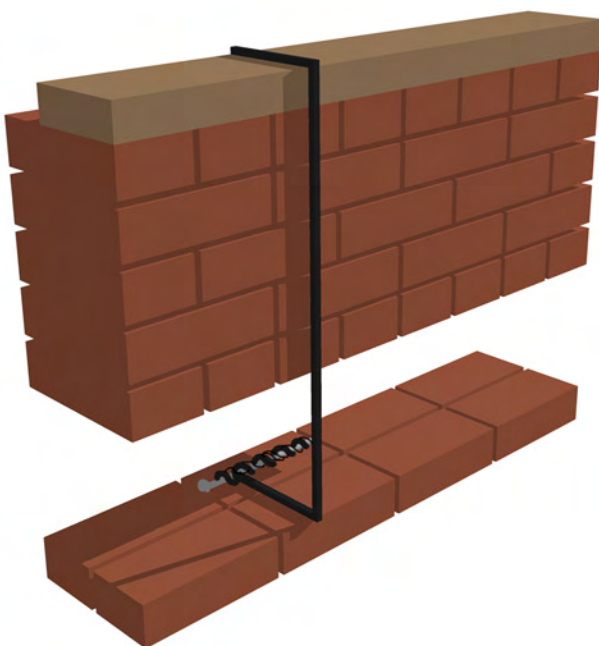
Cut and fix a triangular piece of plywood where the rafters and post meet. Fix using nails at 75mm (3") centres.



**STEP 6. BRACING**

Fix 150 x 50mm (6'x2') diagonal bracing to the underside of the rafters.

**5** Fixing wall plates to brick walls



**STEP 1**

Wind galvanised wire around a nail.  
Rake out a slot in the mortar and bed nail on to brick (external side).

**STEP 2**

Make a hole to feed the wire through the wall and then up the internal wall to fix to the wall plate.

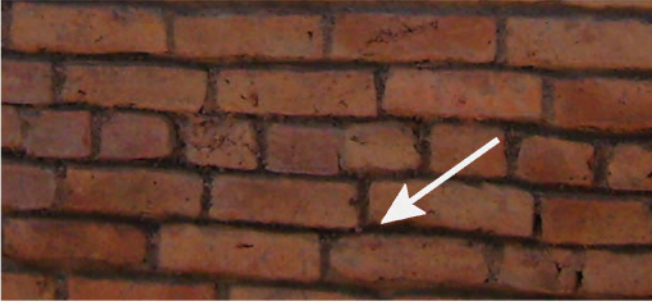
Repeat process at 600mm (2') intervals, at corners, and junctions to windows and doors.



# Bricklaying

## Common Problems

- 1 Brick bonds are not correct



- 2 Brick courses are not correct

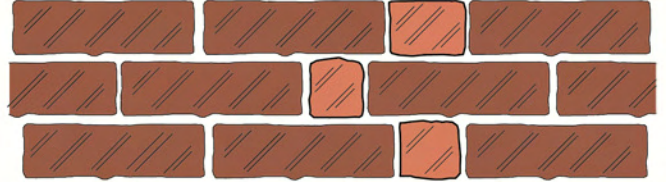


- 3 Weak brick connections and thick mortar beds

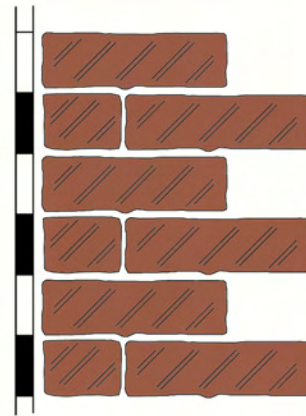


## Workmanship standard

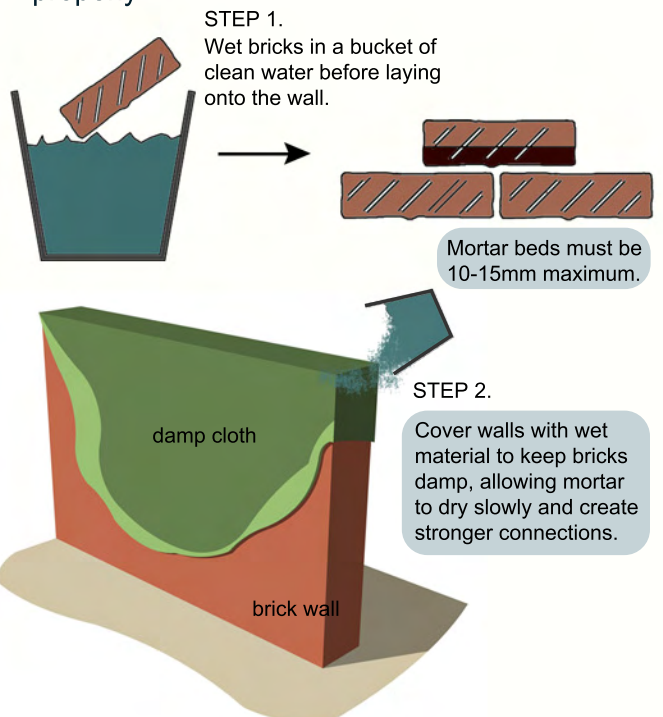
- 1 Use cut bricks to keep an even bond



- 2 Use a gauge rod to keep courses even

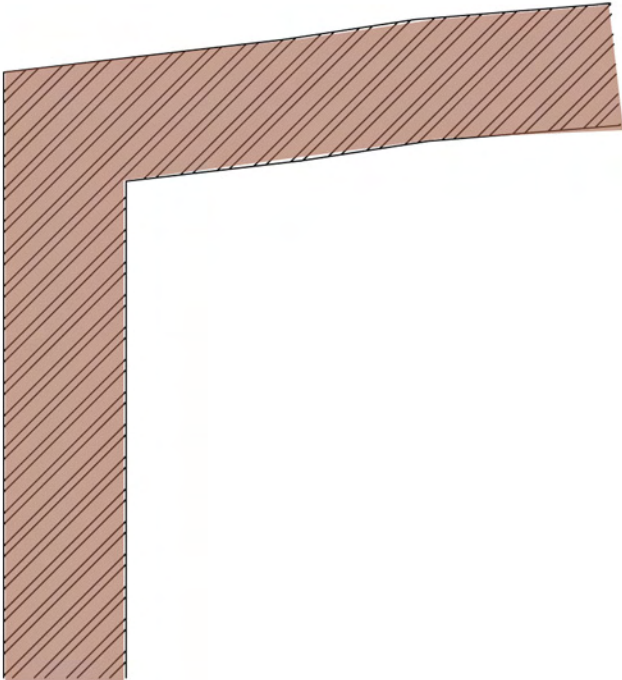


- 3 Cement mortar needs to stay damp to cure properly



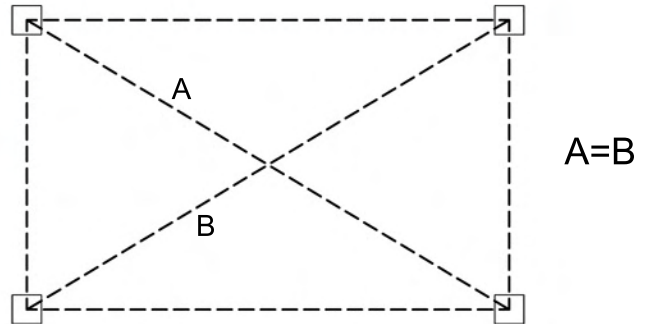
## Common Problems

### 4 Walls are not square

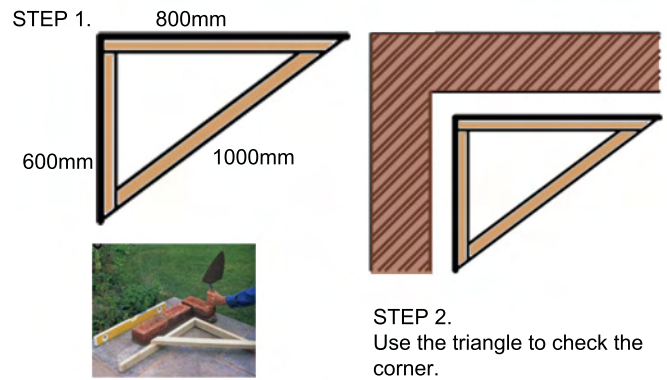


## Workmanship standard

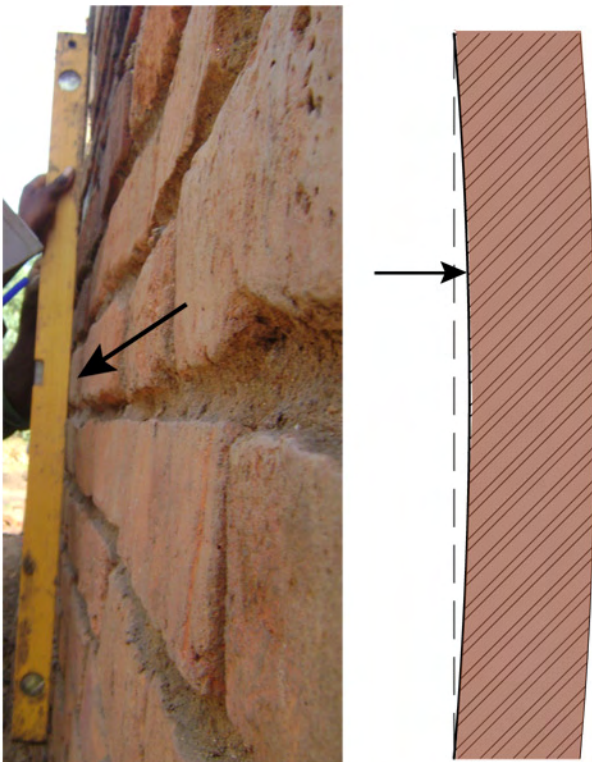
### 4a Check diagonal measurements when setting out



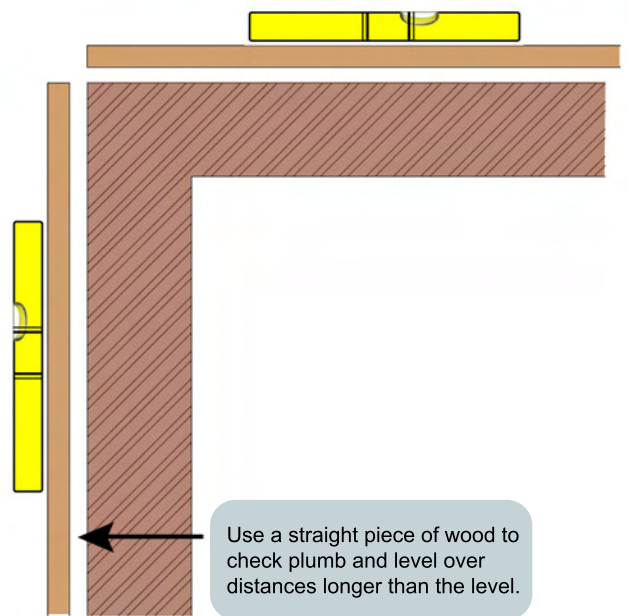
### 4b Make a triangle out of wood using the dimensions given below;



### 5 Walls are not plumb and level

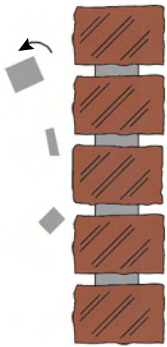


### 5 Check plumb and level over longer distances

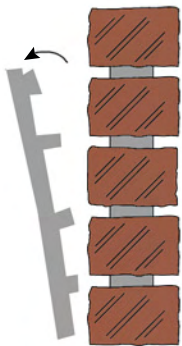


## Common Problems

### 6 Pointing and render falls out



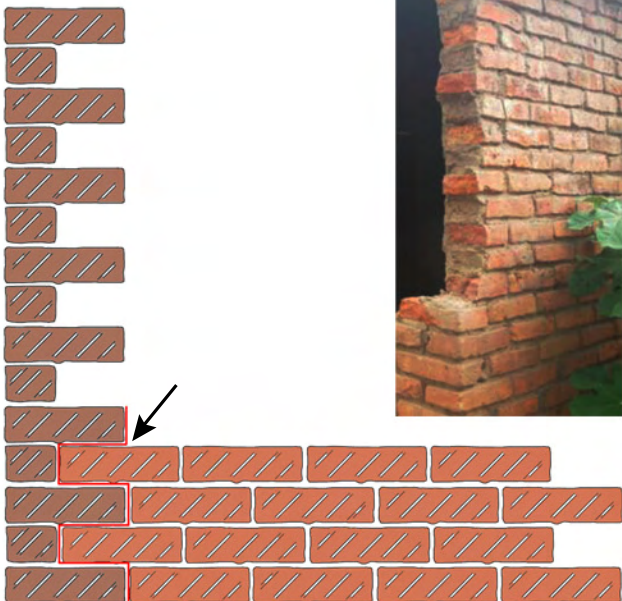
Pointing has a poor connection due to not enough 'key' and the mortar drying too quickly.



Render has a poor connection due to not enough 'key' and the mortar drying too quickly.

### 7 Walls built from 'toothed' corners are weak

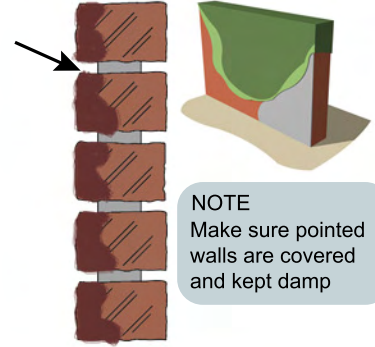
Walls built from 'toothed' corners are likely to cause structural damage during earthquakes, or high winds.



## Workmanship standard

### 6a Rake out and re-point joints

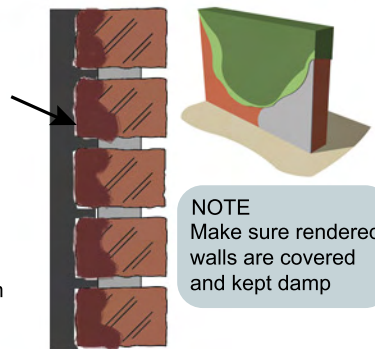
Rake out joints to a minimum of 20mm and soak with water prior to pointing.



NOTE  
Make sure pointed walls are covered and kept damp

### 6b Rake out and render joints

Rake out joints to a minimum of 20mm and soak with water prior to rendering.

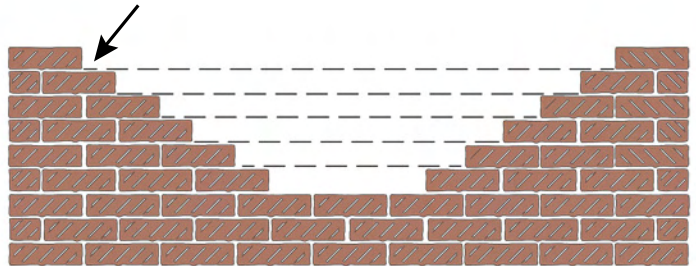


NOTE  
Make sure rendered walls are covered and kept damp

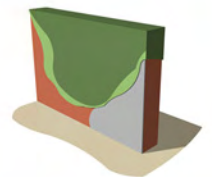
Render over brick should be a minimum 15-20mm thick.

### 7 Stepped corners are stronger

Stepped corners are strong because a proper mortar connection is made and the bricks can be wetted



NOTE  
Make sure brick walls are covered and kept damp



## Common Problems

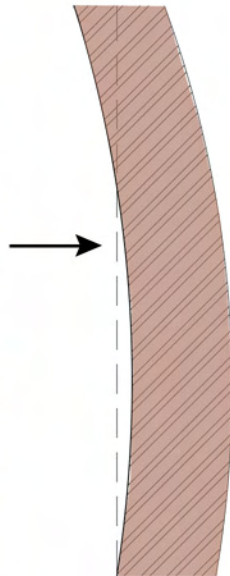
### 8 No lintels over windows and doors



Windows and doors without lintels are likely to form large cracks in the brickwork during an earthquake or when there are heavy loads on the roof.

This weakens the walls and can lead to structural collapse.

### 9 Leaning or bulging walls



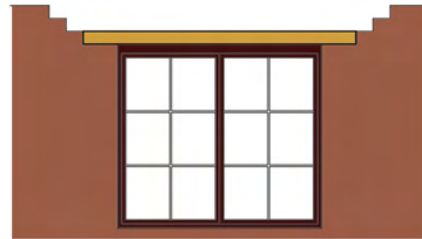
Too much load from above will cause the walls to lean or bulge.

## Workmanship standard

### 8 Retrofitting a lintel to a window or door



STEP 1.  
Take down bricks in steps to window/door height

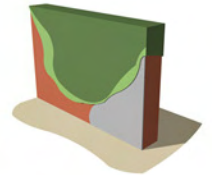


STEP 2.  
Fit lintel (timber or reinforced concrete). Ensure there is a 200mm bearing either side of window.



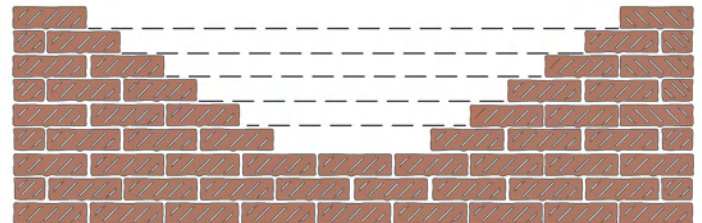
STEP 3.  
Build back bricks to wall plate height.

NOTE  
Make sure brick walls are covered and kept damp

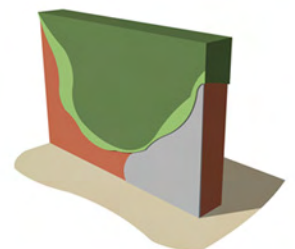


### 9 Rebuilding damaged walls

Take down damaged walls in steps and rebuild. Make sure corners are properly stepped.

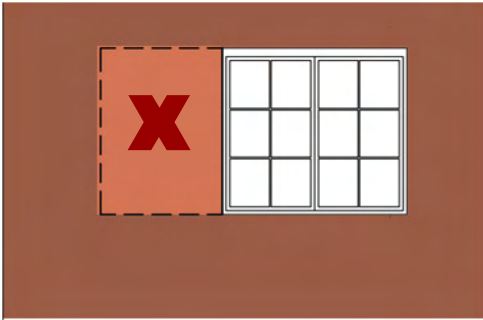


NOTE  
Make sure brick walls are covered and kept damp



## Common Problems

### 10 Filling a hole in a wall without a brick bond



Filling a hole without a brick bond creates a weak spot in the wall.

### 10 No ties/lags provided for doors and windows

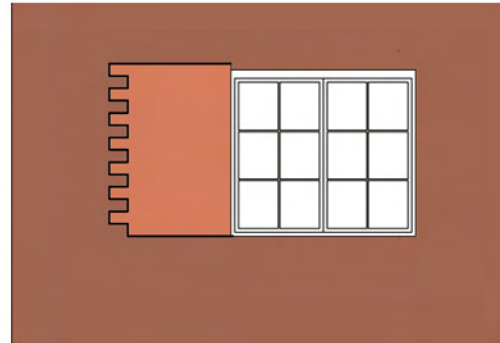


No ties/lags are fixed to the window and door frames into the brickwork.

Or, nails are used to create an anchor. This type of fixing is inadequate.

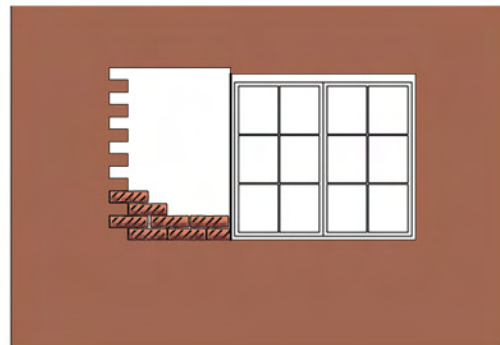
## Workmanship standard

### 10 Tooth out the bricks in the hole

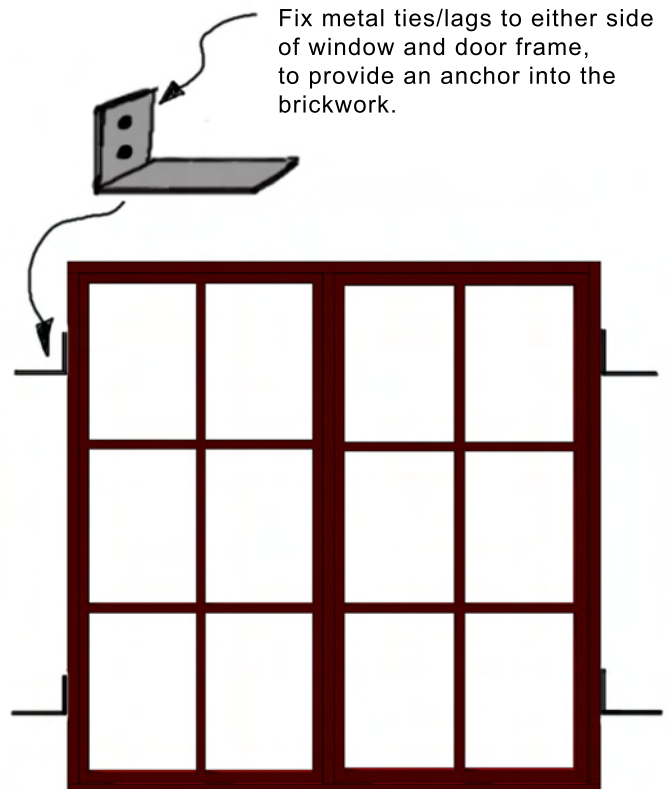


STEP 1.  
Tooth out the brick in the hole, to ensure a stronger connection

STEP 2.  
Re-build back the hole in the wall



### 10 Fixing brackets to doors and windows

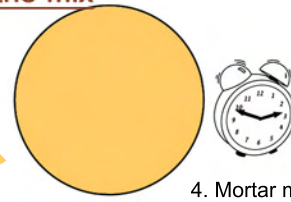


## Common Problems

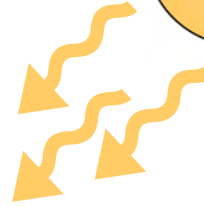
### 12 Mortar is not prepared properly, weakening the strength of the mix



Mortar is prepared directly onto the ground. This allows impurities to contaminate the mortar and weaken it.



4. Mortar mixes are not used quickly enough and dry out in the sun, weakening the mix



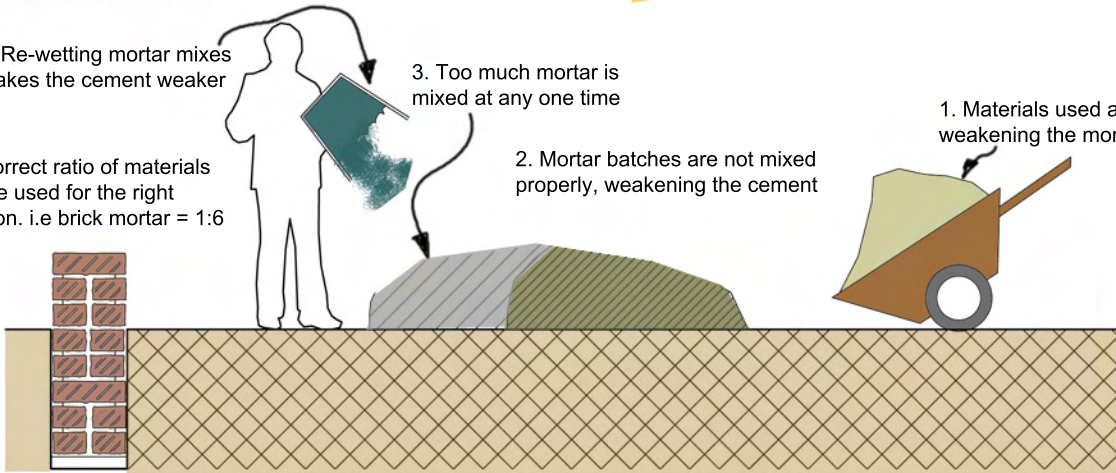
5. Re-wetting mortar mixes makes the cement weaker

3. Too much mortar is mixed at any one time

1. Materials used are dirty or old, weakening the mortar.

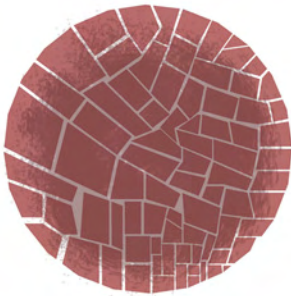
6. The correct ratio of materials should be used for the right application. i.e brick mortar = 1:6

2. Mortar batches are not mixed properly, weakening the cement



## Workmanship Standard

### 12 Preparing mortar mixes correctly



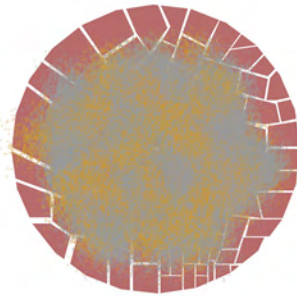
#### STEP 1.

Construct a preparation area on the ground using broken bricks and grout them together.

An approximate preparation area would be 1500mm diameter.

This is to ensure that each mix is clean and regulated i.e no impurities from the ground.

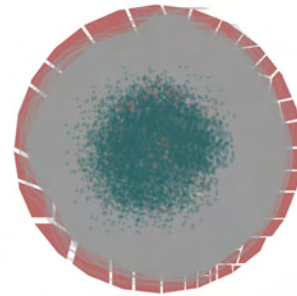
Preparation area to be 'wetted' before use.



#### STEP 2.

Put the accurate measures of sand and cement (and any other material required) onto the preparation area.

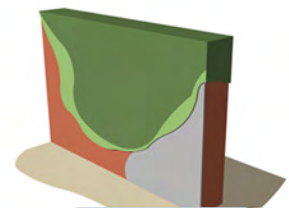
Mix together dry until there is an mix of all the materials.



#### STEP 3.

Create a well in the middle of the dry mix, add clean water, and begin blending in the water to make the mortar.

Once the mix is ready cover it with a damp cloth to prevent the mortar from drying. Use with 1-2 hours.



**NOTE**  
Make sure mortar mix is covered and kept damp



# Carpentry

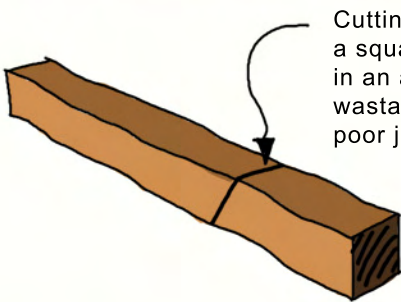
## Common Problems

### 1 Timber is not cut to the right length



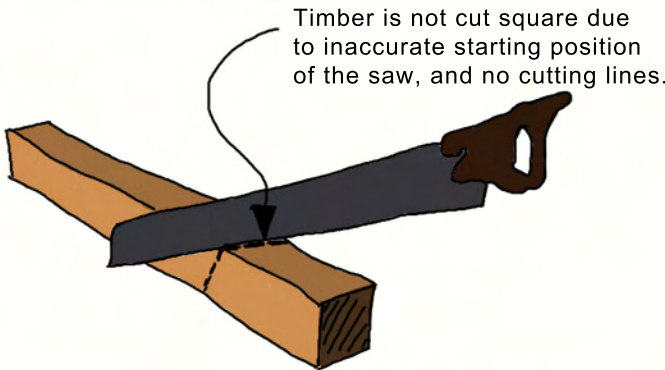
Timber not cut to the right length will result in wastage, and weakening of the structure where timber is spliced together.

### 2 Timber cutting lines not drawn square



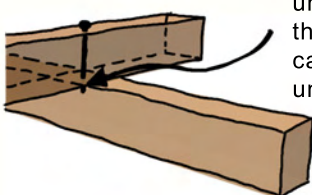
Cutting line made without a square, and resulting in an angled cut, with wastage to timber and poor joinery.

### 3 Timber not cut square



Timber is not cut square due to inaccurate starting position of the saw, and no cutting lines.

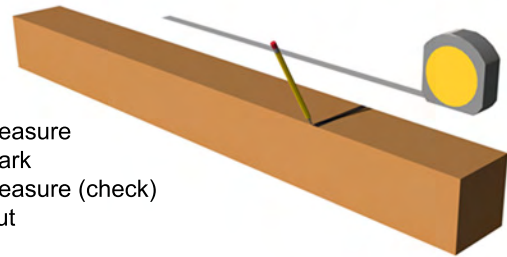
### 4 Nails not connecting properly with timber



The nail is too short and is unable to connect properly to the timber beneath, and will cause timbers to collapse under load

## Workmanship standard

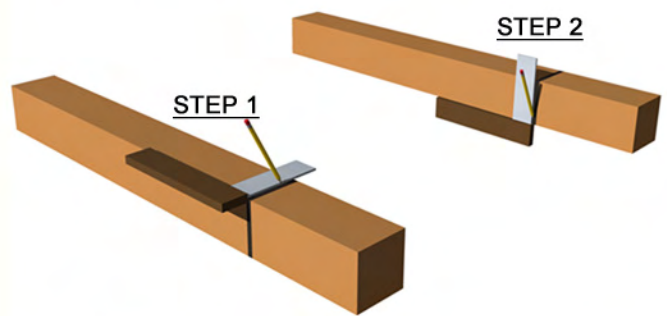
### 1 Cutting timber to the correct length



1. Measure
2. Mark
3. Measure (check)
4. Cut

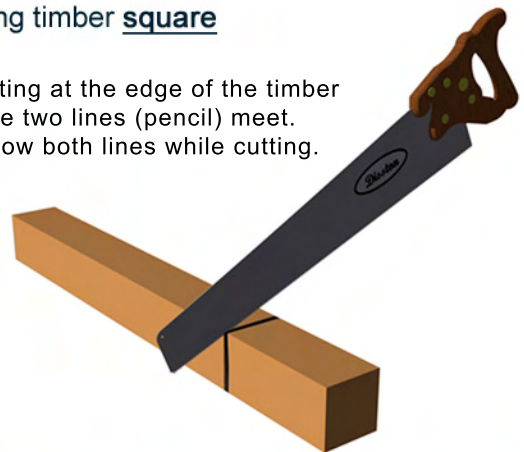
"Measure twice, cut once"

### 2 Always use a square to mark two sides

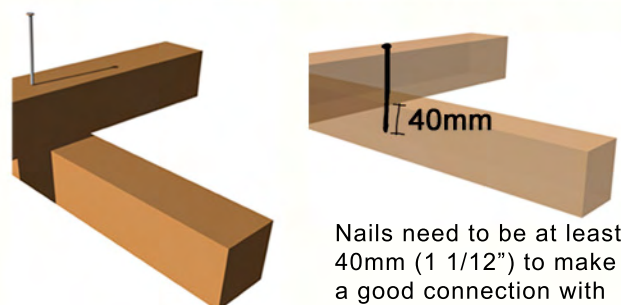


### 3 Sawing timber square

Start cutting at the edge of the timber where the two lines (pencil) meet. Then follow both lines while cutting.



### 4 Nails to be min. 40mm (1 1/2") into the wood

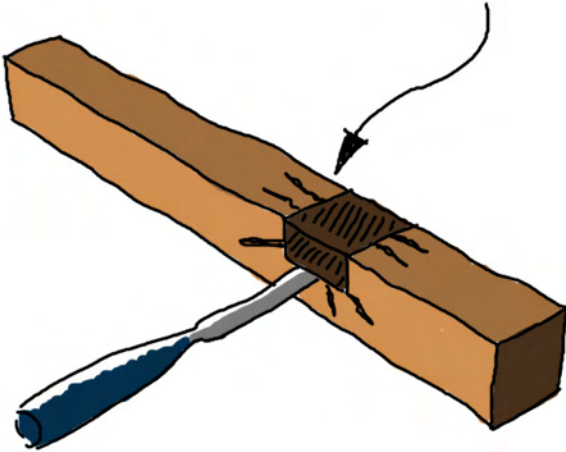


Nails need to be at least 40mm (1 1/2") to make a good connection with the timber.

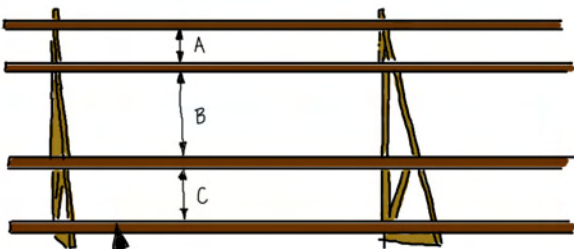
## Common Problems

### 5 Notches are not cut correctly, causing splitting

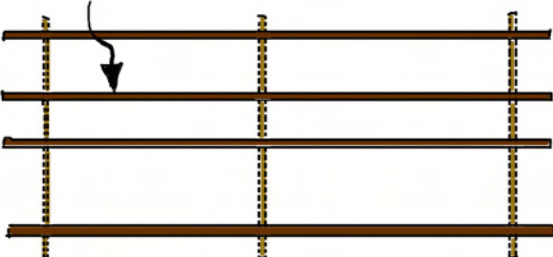
Cracking and splitting will occur if timber is not notched out using the correct method. This will weaken the timber.



### 6 Purlins are unevenly spaced, weakening the structure of the roof.



Purlins that are unevenly spaced will weaken the structure of the roof, and make it difficult to have consistency in fixings for the roof covering.



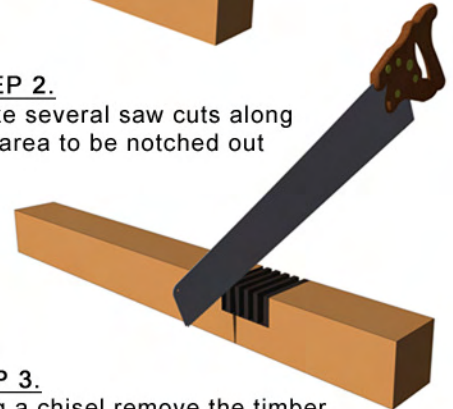
## Workmanship standard

### 5 Cutting notches in timber correctly

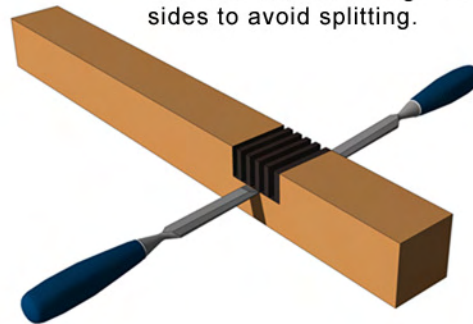
**STEP 1.**  
Using a tape measure and square mark the position of the notch



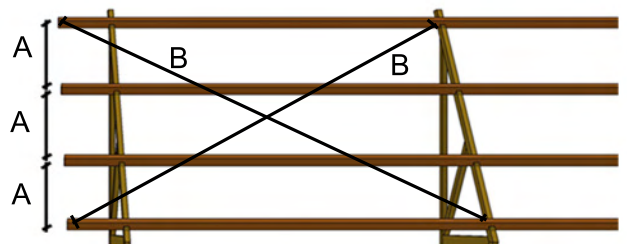
**STEP 2.**  
Make several saw cuts along the area to be notched out



**STEP 3.**  
Using a chisel remove the timber from the notch working from both sides to avoid splitting.



### 6 Correctly spacing purlins on the roof, providing structural integrity.



A = Purlins should be evenly spaced at a maximum of 1200mm intervals.

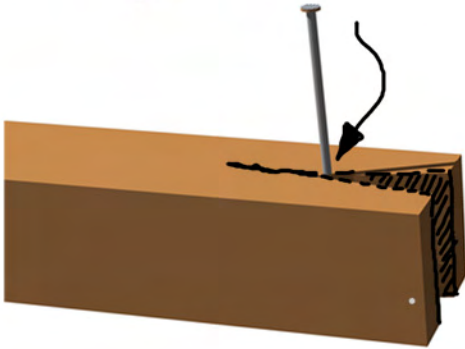
B = Check the diagonal measurements to sure the roof is square. (B=B)  
This is important to remember to ensure the roof sheets can be fitted square.

## Common Problems

### 7 Nails not connecting to timber

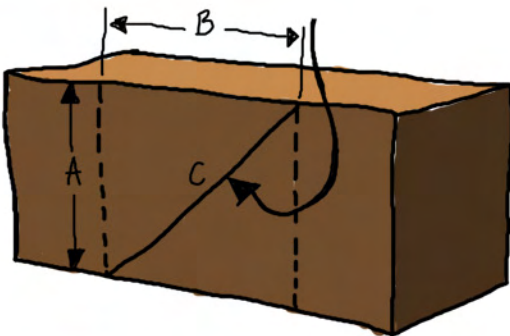


Nailing near the end of timber will cause splitting, and weaken the strength of the timber and its useable length



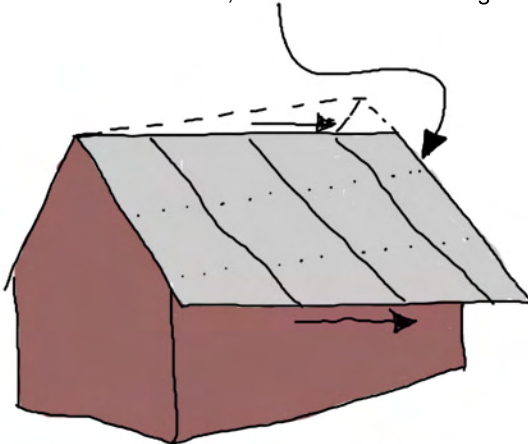
### 8 Timber scarf joints not cut to 45 degree angles

Measurement 'A' and 'B' are not the same, so angle 'C' is not 45 degrees. This will result in bad joinery due to inconsistencies, leading to weakening of the structure.



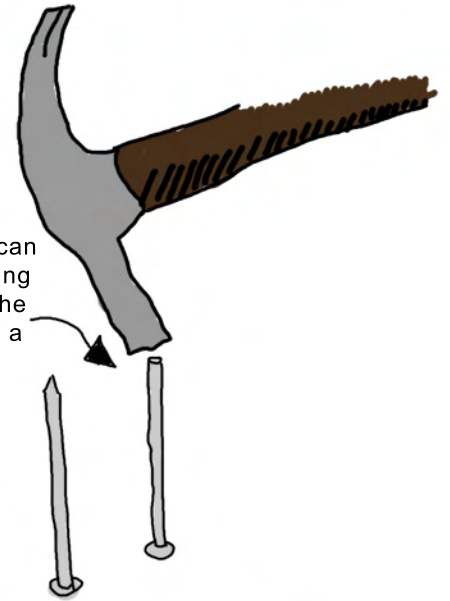
### 9 CGI roof sheets are not fitted square

Roof sheets that are not fitted square, will result in material, cost and time wastage.



## Workmanship standard

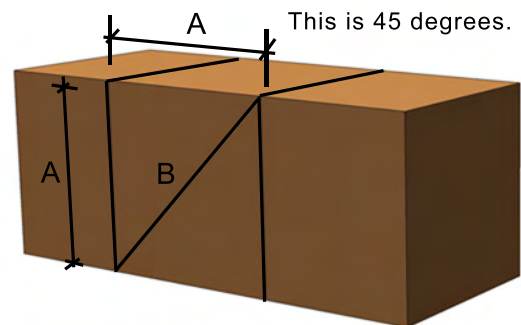
### 7 Blunting nails to prevent splitting at ends



The risk of splitting can be reduced by blunting the nail - by hitting the point of the nail with a hammer.

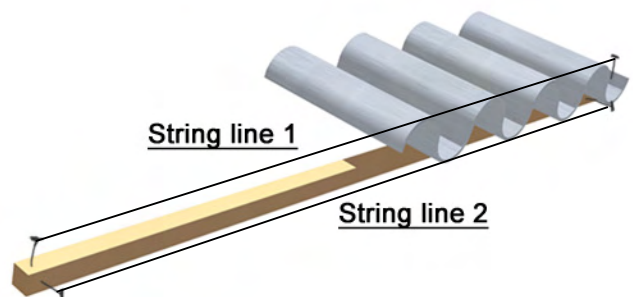
### 8 Marking a 45 degree angle for a cut

Make two marks equal to the depth of the timber ( $A=A$ ). Mark the diagonal (B)



This is 45 degrees.

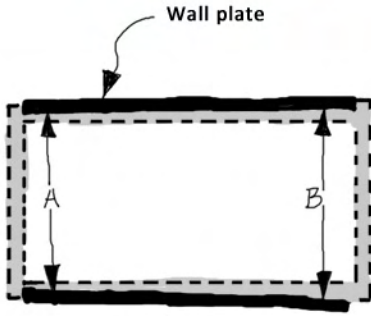
### 9 Fitting CGI roof sheets square



Attach string line no. 1 to keep the nails in line. and, attach string line no. 2 to keep the roof sheets in line.

## Common Problems

### 10 Wall plates are not parallel to each other

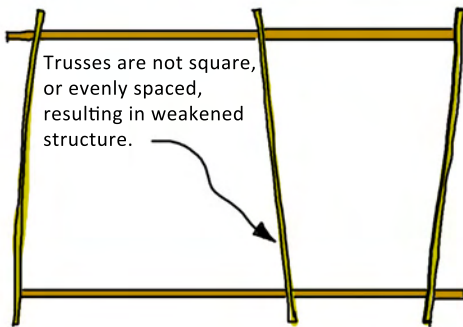


Plan View of wall plates

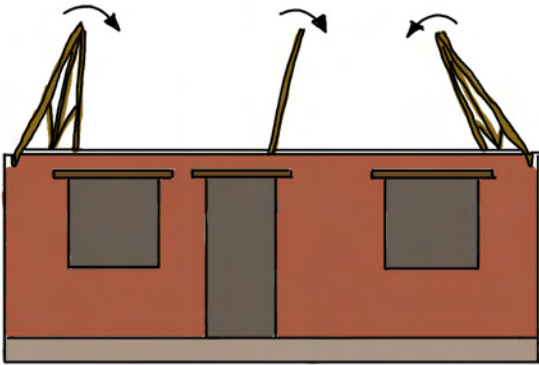
The wall plates are placed on obscure angles, so that they are not parallel.

Length 'A' is different to length 'B'. This will mean that the whole roof structure will not align square and loads not distributed evenly to the ground, causing the potential for structural failure.

### 11 Trusses are not square and equally spaced



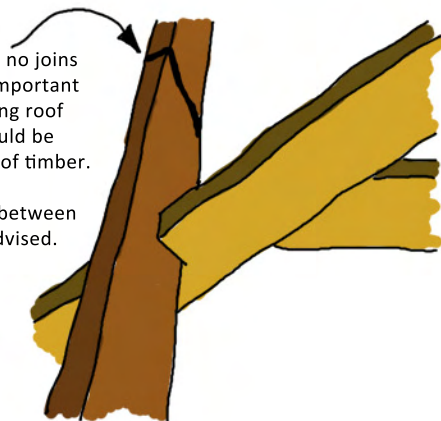
Trusses placed without temporary bracing will collapse from their own load or from wind loads.



### 12 Joins in purlins are not connected properly

Ideally there should be no joins in purlins, due to the important part they play in carrying roof loads, and a purlin should be one continuous length of timber.

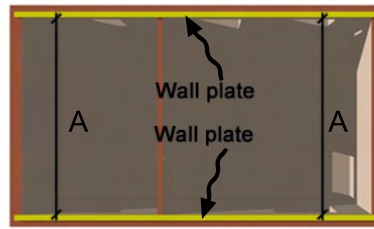
Any splicing of purlins between rafters would not be advised.



## Workmanship standard

### 10 Wall plates should be parallel to each other

Distance A = Distance A



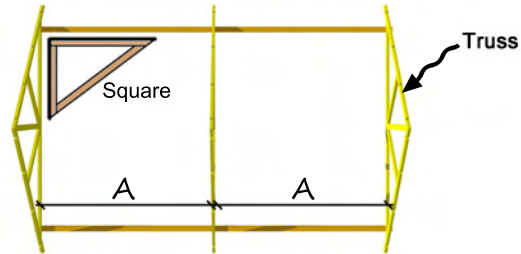
Plan View of wall plates

When fitting wall plates to brick walls, remember to set the wall plates parallel to each other.

To do this, use a tape measure to check the distance between both ends of the wall plates.

### 11 Trusses must be square and equally spaced

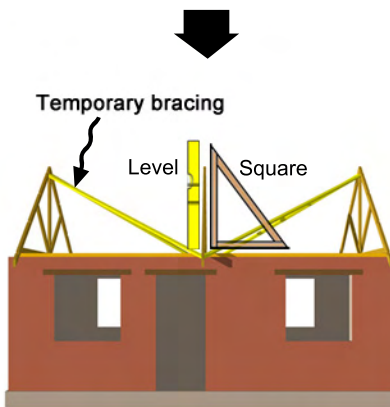
Distance A = Distance A



Plan View of truss arrangement

Trusses should be plumb (level) and square, and fixed to the wall plate.

Temporary bracing should be attached to hold the trusses in position before fitting the purlins.

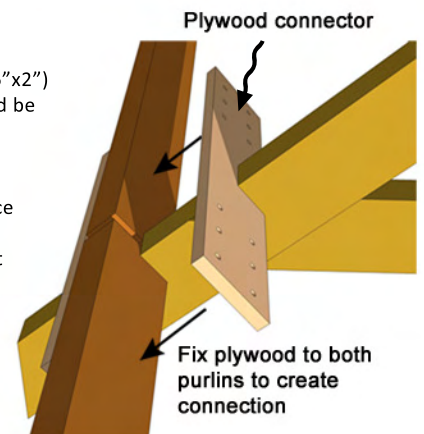


Elevation showing trusses & temporary bracing

### 12 Connecting two purlins using a correct join

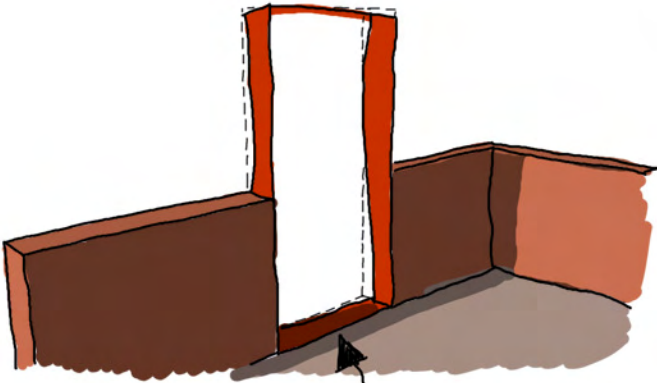
Purlins should be 150x50 (6"x2")  
Notches over trusses should be 50mm (2").

Purlins should be joined on the truss with a joining piece of timber on both sides.  
i.e x2 pieces of plywood cut to shape.



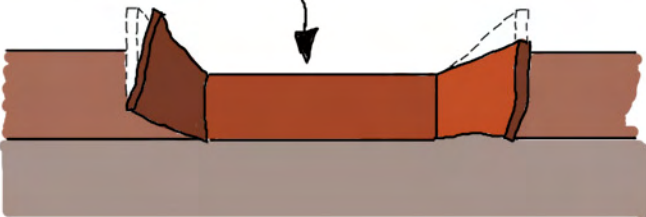
## Common Problems

### 13 Window and door frames twisting during construction of walls

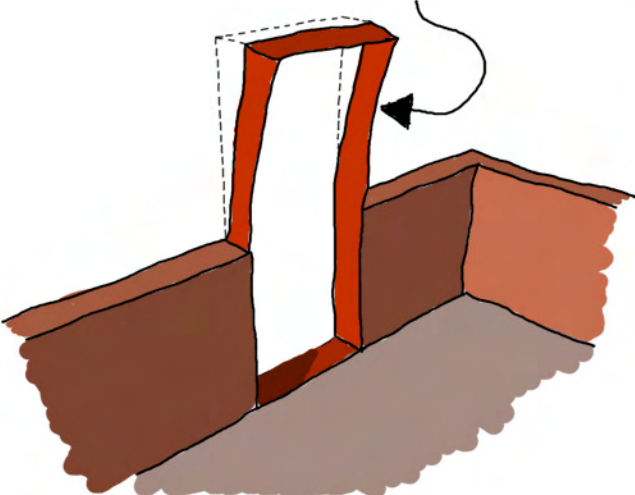


Door and window frames fitted without infill bracing and diagonal support will twist under the pressure of masonry walls. This means that joinery and glazing will not fit square into the frames, causing extra time, expense and wasted materials.

A plan view showing the twisting of a door frame when there is no bracing in place.



The absence of a vertical prop, means that the door or window frame could twist and not remain vertical.



## Workmanship standard

### 13 Installing window and door frames

#### STEP 1.

Check the door head is level and the frame is plumb on both sides of the frame



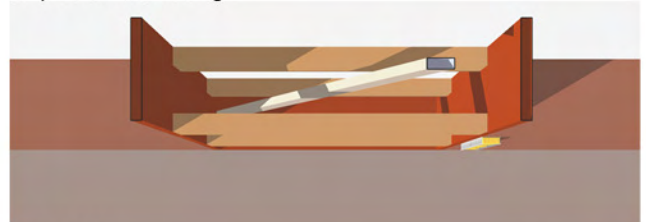
#### STEP 2.

Fit timber spacers and diagonal bracing to keep the door frame square and to stop it twisting



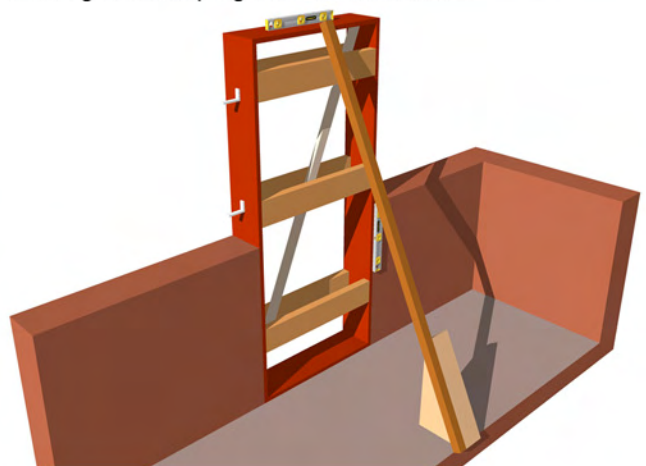
#### STEP 3.

Door spacing to be fitted to both sides of frame to prevent twisting.



#### STEP 4.

During construction prop the frame to prevent twisting and keeping the frame vertical.



# Tools

## Carpentry - basic hand tools list



Claw Hammer



Tape Measure



String Line



Square



Chisel



Hand Saw



Spirit Level

## Bricklaying - basic hand tools list



Mortar Hawk



Lump Hammer



Line Pins



String Line



Wood Float



Bucket



Trowel



Bolster Chisel



Shovel



Tape Measure



Plugging Chisel



Spirit Level

# Materials

## Common Problems

- 1 Dirty sand is used for construction, weakening mortar mixes.



This jar test shows dirty sand, as the water is muddy and not clear. This would be unsuitable for construction. It should not contain any appreciable quantity of clay lumps, shale and salts, or organic matter, sea shells etc..

- 2 Selection of correct sand for the right application



### Mason Sand

A fine, silty sand with some grit and should be used for cement mixes

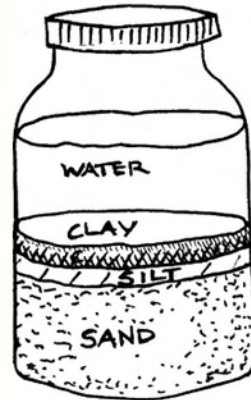


### Concrete Sand

A fine, coarse, sand and should to be used for mixing concrete

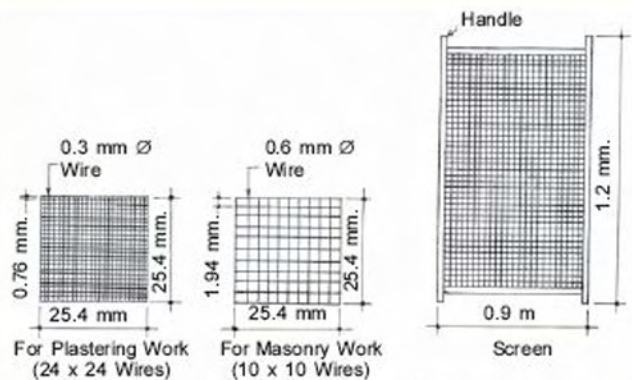
## Workmanship standard

- 1 Clean sand should be sourced for construction



A simple test for sand, involves putting a sample of sand in a jar and filling with water. The results should look something like the images above, with similar ratios of material. The maximum acceptable quantity of silt (fine sand) is 7% of the volume.

- 2 Sand should be graded for correct use



DETAILS OF SCREENS FOR SAND

Sand for masonry work should be coarser than sand for plaster work, and should pass through a screen with 4 wires per cm length of screen. An example of wire screens are shown above. Sand should be tested on site, or graded prior to delivery.

## Common Problems

### 3 Old or impure cement is used for construction, weakening the bond between bricks



Bags of cement older than 6 months are no longer fresh and inadequate for use.

Bags that have been torn and exposed to air and potential ingress of dirt and other impurities should be considered inadequate for use.

Old cement and cement with impurities will lose its inherent strength and will implicate the structural integrity of a building.

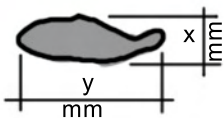


### 4 Concrete & mortar mixes are not the correct ratio for the right application in construction.



It is important to make sure that the right ratio of mixes of cement, sand and gravel/stone are used for the right applications. Otherwise, there will be the potential for structural failure

### 5 Gravel or stone is too big / small or not sharp enough



Particles of stone or gravel that have an elongated shape, more than one rounded side, and are flaky, should be considered inadequate for use.

Particles of this nature have less strength and durability over correctly sized and graded stone/gravel

## Workmanship standard

### 3 Cement bags should be checked for quality



A site supervisor in the field should check the quality of the cement bags per delivery

#### Checklist

1. The stitching of the bag should be intact and original.

2. Check the grade of cement and specification.

3. Check the date of manufacture. The date should not be older than 3 months. Cement older than 6 months is not adequate for use.

4. No lumps should be present. The cement should feel silky and cool to touch.

5. When a pinch of cement is dropped in water it should float before sinking.

6. Weight 5 bags, the average weight should be 50kg.

### 4 The correct ratio of mixes for concrete & mortar should be used for the right application.

Application	Cement	Sand	Gravel / Stone
Foundations	1	3	6
General Use	1	2.5	5
Reinforced	1	2	4

Table above showing concrete mixes

Application	Cement	Sand
Brick work	1	4
Render	1	3
Screed	1	2

Table showing Mortar mixes

### 5 The right aggregate should be used for mixing concrete



Gravel / stone aggregate should be cubic, with sharp edges (angular), and not flaky or elongated. It should be granite or similar.

Gravel / stone with rounded edges should be crushed before use to provide sharp edges.

## Common Problems

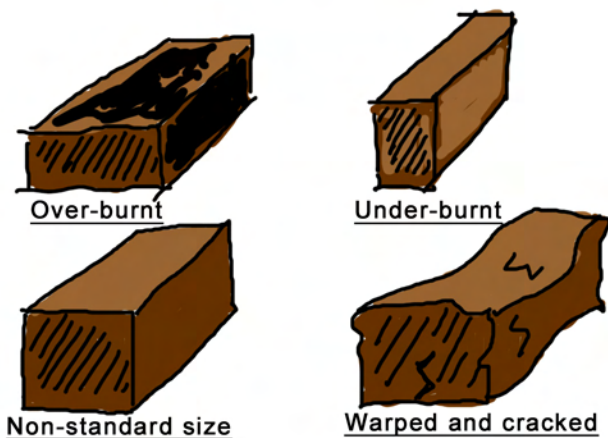
- 6 **Bricks are not made properly, resulting in structurally weak walls**



Poor manufacture of burnt or mud bricks will result in structural failure due to lack of compressive strength, incorrect sizes and erosion of bricks due to over or under burning.



Burning bricks requires wood. Unsustainable methods of burning bricks will result in continuing deforestation.



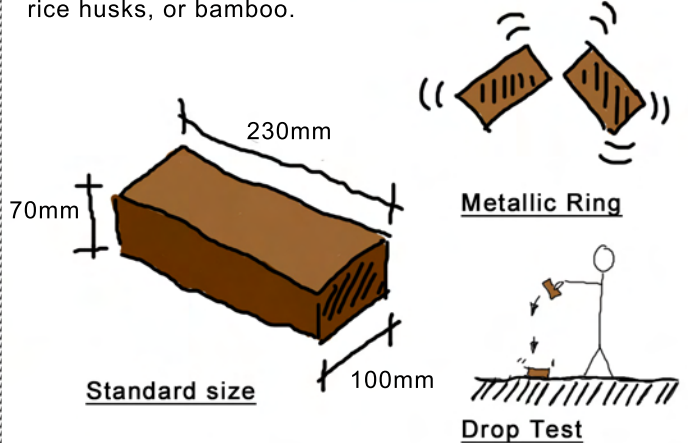
Warped, cracked and non-standard/uneven sized bricks are unsuitable for use.

## Workmanship standard

- 6 **Bricks should be checked for their strength, size and quality**



Burnt bricks should be fired using wood that is sustainable, such as coppiced wood, wood waste, rice husks, or bamboo.



Burnt and mud brick should be made to standard sizes, 230mm x 100mm x 70mm. Care should be taken when creating the moulds, and minimum amount of water used to prevent shrinkage.

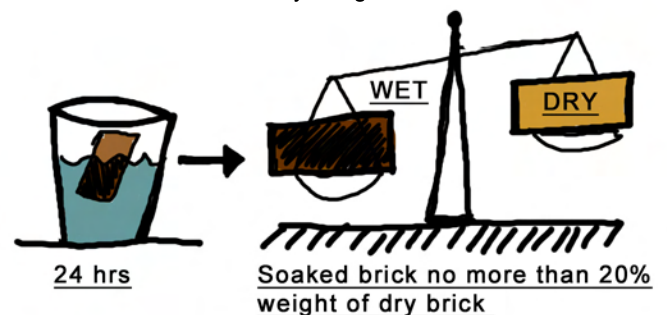
Bricks should be free from cracks, chips or signs of warpage.

There should be a clear metallic ringing sound when two bricks are knocked together.

Bricks should not be over-burnt or under burnt.

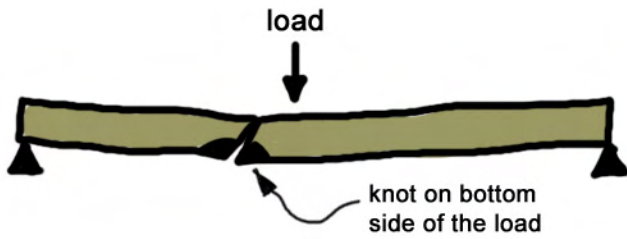
Perform a drop test from waist height. If the brick shatters then too much sand has been used in the brick.

When soaked in clean water for 24 hours, a brick should not exceed 20% of its dry weight.



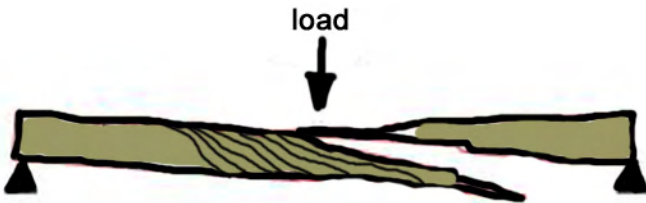
## Common Problems

- 7 **Poor quality timber** has defects, is warped, or inadequately sized



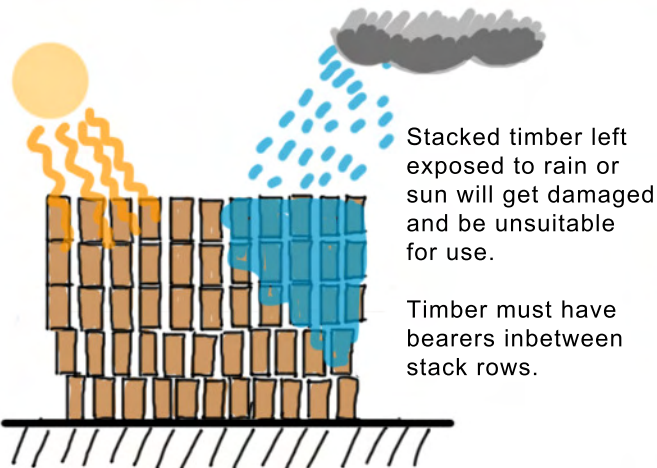
Poor quality timber will have a too many knots and defects, and will fail under load.

Twisting and splitting is also a common characteristic of poor timber, and should not be used during construction.



### Common Defects

- 8 **Timber not stacked properly** will get damaged

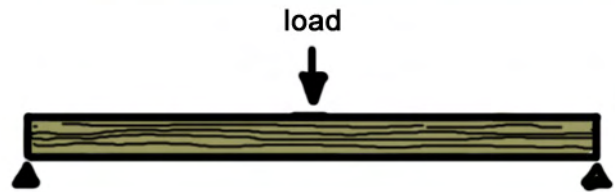


- 9 **Timber not treated against termites** will get eaten by termites and cause structural failure



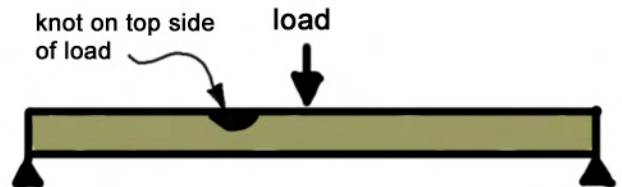
## Workmanship standard

- 7 **Good quality timber** should be selected for construction.



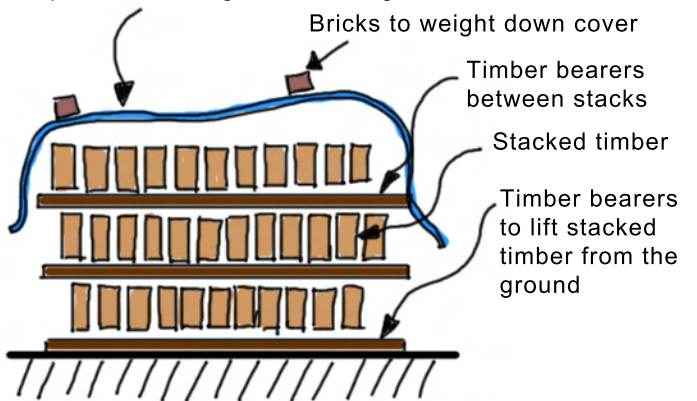
Timber should be observed for the following characteristics;

- Straightness of timber with no twisting.
- No splits and shakes
- No large knots on the outside of the timber, if there is then the ensure the knot is place on the side of the load.
- The grain runs along the length of the timber and not to the side.



- 8 **Stacked timber should be protected from the weather**

Tarpaulin or corrugated sheeting



- 9 **Timber should have appropriate treatment to prevent termite infestations**



Timber should be treated with anti-termite solution

