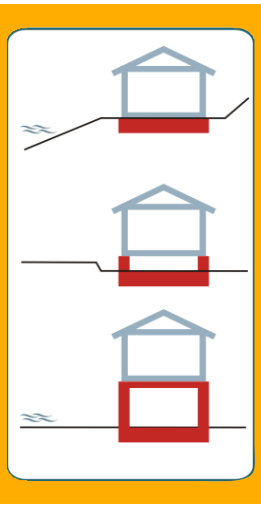


Safe Site

1

It is not always possible to choose where we live, but understanding the site will help you to make the desicions that will help keep your family safe and protect your house from damage.

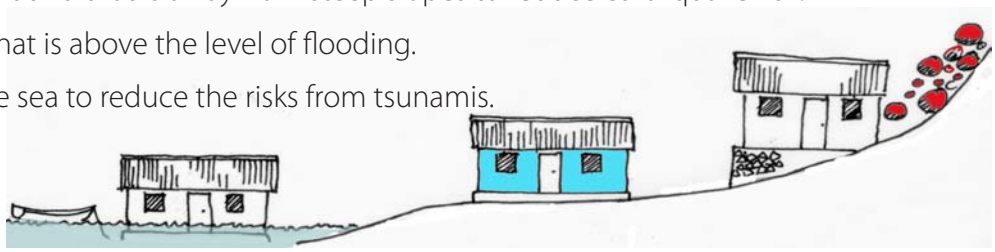
THINK ABOUT THE RISK FEATURES OF YOUR SITE BEORE YOU BUILD.

DESIGN THE HOUSE TO BEST SUIT THE SITE AND REDUCE RISKS.

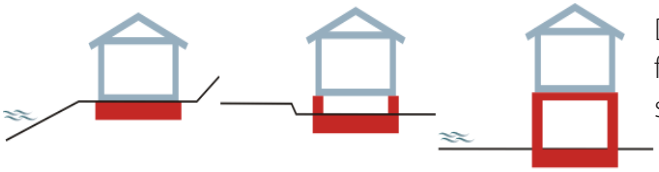
PREPARE FOR SERIOUS DISASTER EVENTS: LOCATION, LAYOUT, ESCAPE.

The 3 requirements for the safest sites are:

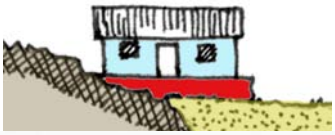
1. On good flat solid ground that is away from steep slopes to reduce earthquake risk.
2. On higher ground that is above the level of flooding.
3. Far enough from the sea to reduce the risks from tsunamis.



If your site does not meet these 3 requirements for safety, then you will have to take measures to reduce the risks to your family and your house.



Different site conditons also require different foundation solutions: low down, on a high sloof, high off the ground.



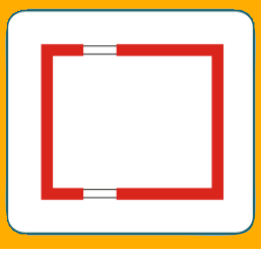
Check the quality of the ground. Build on the area with the most solid ground. Respect the principles of good strong foundations. These are explained on SHEET 4.

If the ground level of the site is lower than surrounding areas, you will need to build up the foundations to raise the floor level above possible levels of flood water.

Planting trees will help protect the house from strong winds and storms.
But do not plant too close to the house or the roots which can weaken the foundations.

Simple Solid and Regular

2



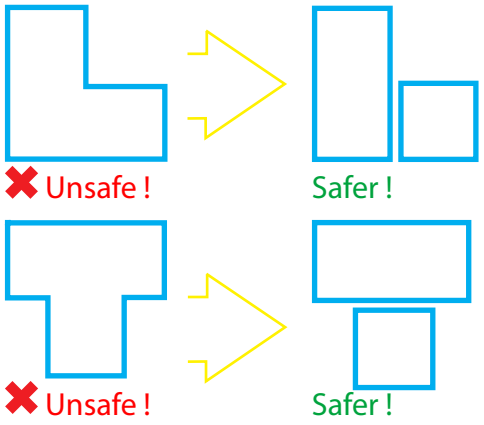
Buildings with a simple regular shape resist earthquakes better.

Simple building shapes present less obstruction to flood waters, and can resist the damage they cause.

KEEP THE SHAPE SIMPLE

BUILD SOLIDLY WITH GOOD MATERIALS

BUILD SO THAT WALLS AND WINDOWS MAKE A REGULAR PATTERN.

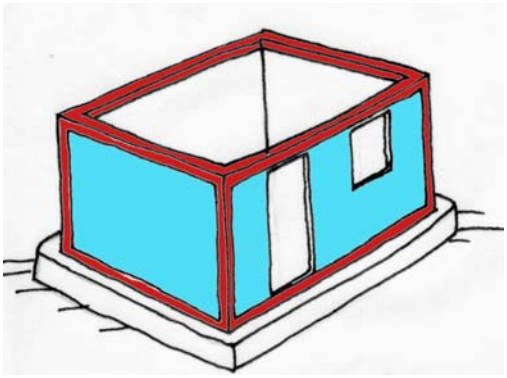


SIMPLE

Buildings with simple layouts are strongest. They resist damage during earthquakes because there is less risk of irregular movement between different parts of the structure.

Many changes of direction in the walls should be avoided.

If the shape of the building is complicated, it should be divided into smaller simpler pieces.

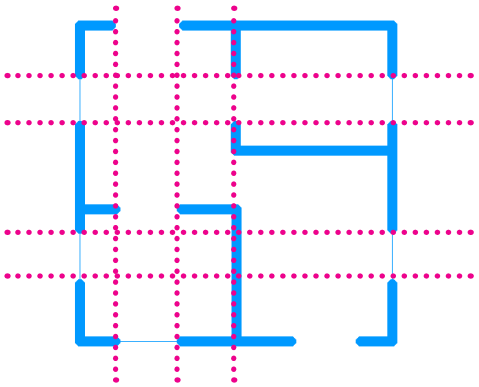


SOLID

To be solid a building needs good quality materials that are strongly connected together.

Walls and columns should be not too thin and not too high.

Solid shaped buildings are those that are well balanced over the ground. The length of one side of the building should not be more than 3 times longer than the other side.



REGULAR

When walls, columns and openings are aligned, the building will be much stronger against earthquakes. The earthquake will create less conflicting movement.

A simple and symmetrical arrangement will always be safer. Keep walls, columns and windows in line as much as possible.

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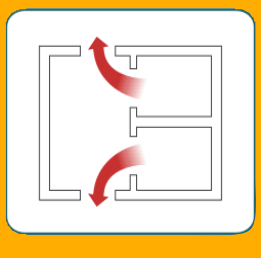
Quick Escape

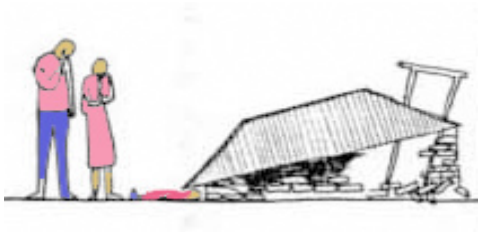
3

When Tsunamis or earthquakes happen, the first thing to do is get out of the building.

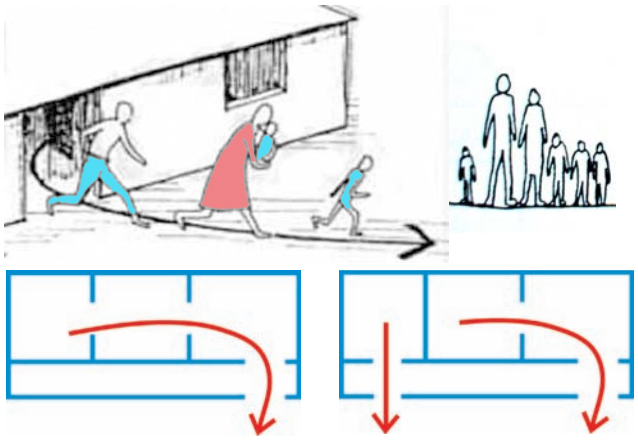


DESIGN BUILDINGS SO THAT ESCAPE IS QUICK AND EASY

PROTECT OPENINGS FROM COLLAPSE



Most immediate victims of earthquakes are killed or injured because buildings have collapsed on top of them.
Quick escape is more important than saving the building.

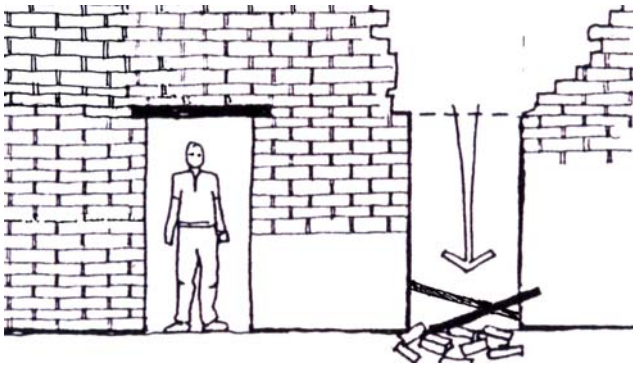


Dangerous escape route!

Safer escape route!

For a quick escape outside...

Plan the layout of rooms:
- You should not have to run through several rooms to get outside.
- The greatest risk is when people are sleeping- make sure you can get quickly outside from a bedroom.
- For buildings with more than one floor, direct escape from upstairs to the outside should be possible, preferably using an outside staircase.



Protect your escape routes with strong openings!

Protect your escape!

All doors and windows are possible exits. They must be built with lintels which are strong and well connected to the walls on either side.
See **OPENINGS SHEET 9**

The roof of a porch will block escape if it collapses. Porches must be:

1. Constructed according to Safe Building Principles.
2. Supported separately from the main structure
3. Not constructed from heavy materials.

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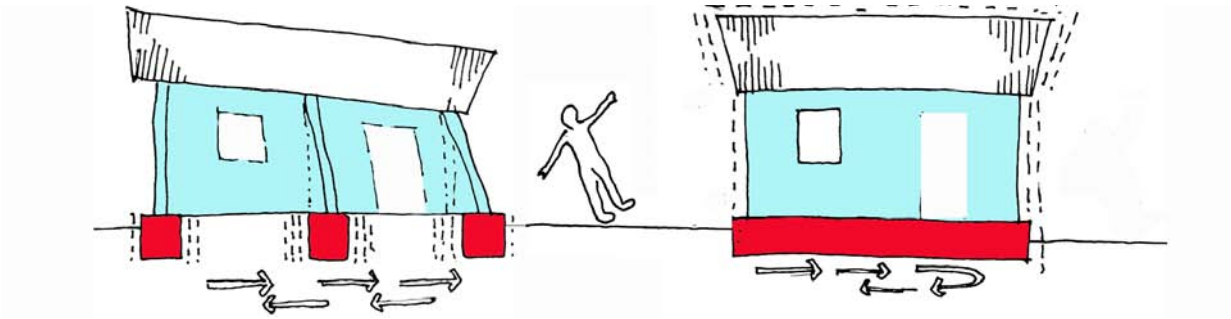
Foundations

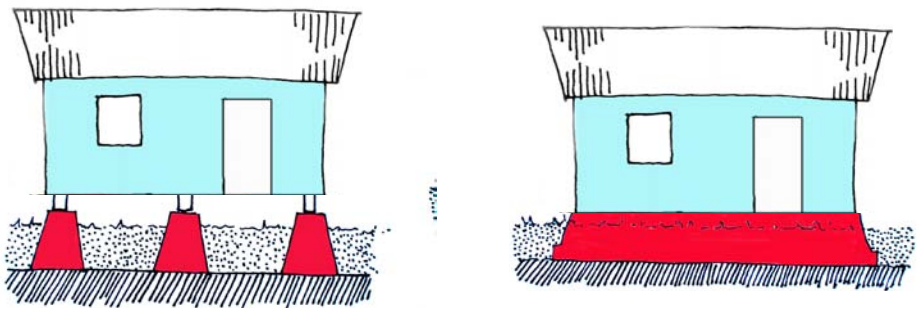
4

The design and quallty of the foundations is the first stage in the safety of every building.

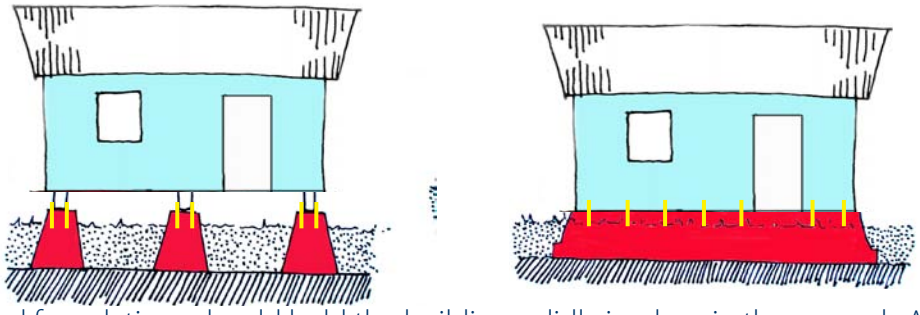
Good foundations spread the weight of the building down onto solid ground, and they hold the building together.



CONTINUOUS FOUNDATIONS ARE STRONGEST! Good continuous foundations will help to protect the building from damage caused by the ground moving during an earthquake.



DIG DEEP! All types of foundations should be built deep enough in the ground where it becomes solid and difficult to dig. If the ground is soft, then make the foundations bigger, wider and deeper.



CONNECT! Good foundations should hold the building solidly in place in the ground. All foundations should have very strong connections to the rest of the house above. This will make the house much safer against earthquakes and floods.

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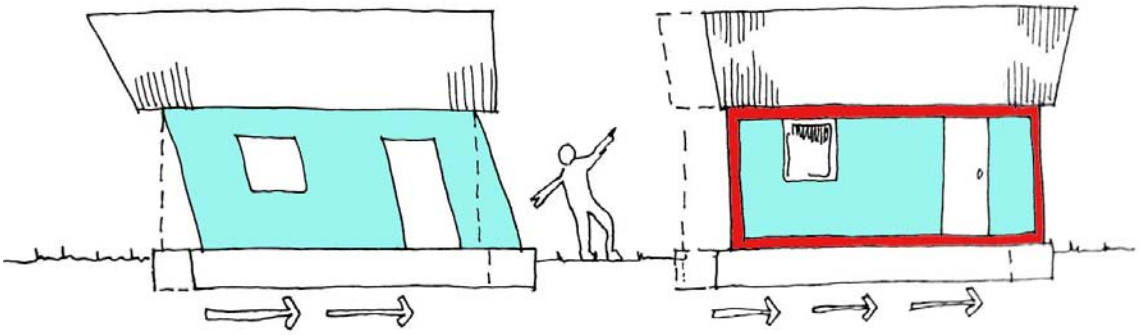
Rigid Frames

5

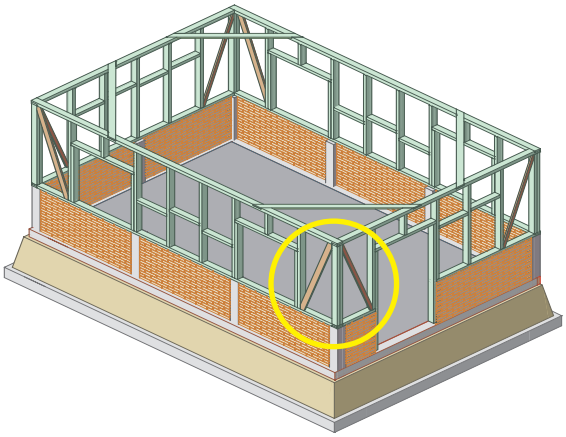
All houses should have strong rigid frames to prevent the house from collapsing in an earthquake and to resist the strength of moving water during strong floods.

TIMBER FRAME WALLS NEED GOOD TRIANGULAR BRACING.

CONCRETE FRAME WALLS NEED STRONG STIFF COLUMNS.



Rigid walls hold their shape in earthquakes. This will reduce damage to the house and reduce the risk of the roof collapsing.

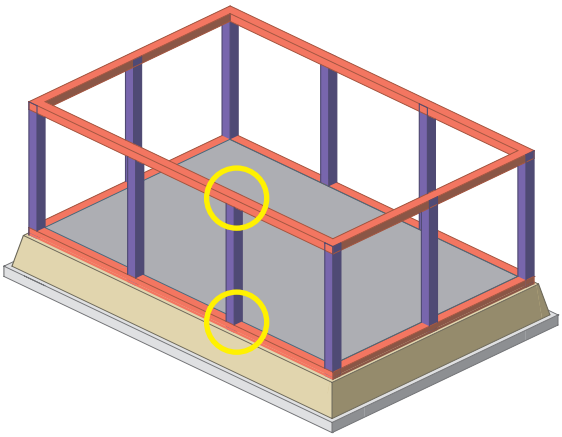


Making Timber Frames Rigid

For houses built with a timber frame, the walls must have vertical bracing in the walls - especially at the corners.

The longer the braces are, the stronger the wall will be.

Triangular bracing will do more for the strength and safety of timber frame walls than any other protection.



Making concrete frames rigid

The most important parts of a concrete frame for making the walls and the building rigid and safe are the columns.

Columns must be properly constructed and the reinforcement bars must be well covered with concrete.

The columns need to have good strong connections down to the sloof and foundations below, and up to the ring beam above.

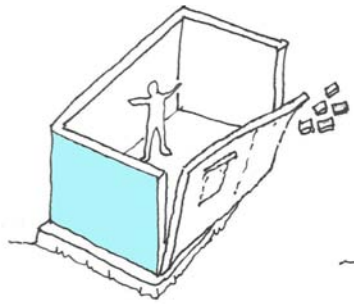
Ring Beams

Ring beams are a major safety feature against earthquake damage.

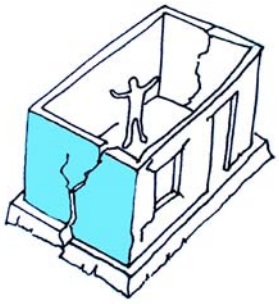
Ring beams tie the walls and the foundations together.

RINGS SHOULD BE:

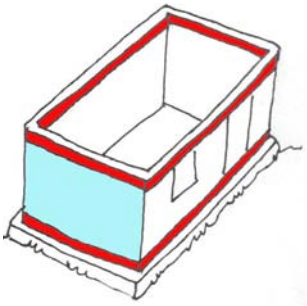
- **STRONG - ESPECIALLY AT THE CORNERS!**
- **CONTINUOUS**
- **WELL FIXED TO THE STRUCTURE ABOVE AND BELOW THE RING BEAM.**



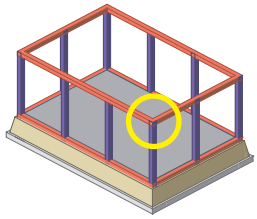
Without a top ring beam the walls will collapse in an earthquake!

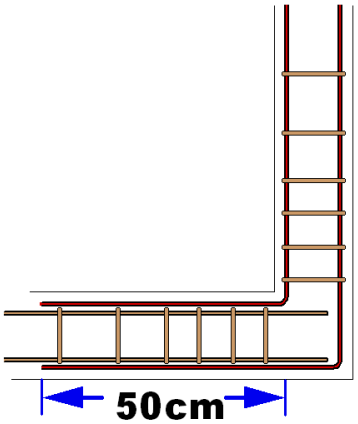


Without a sloof the foundations are much weaker!



A safe house has ring beams at the top and bottom of the walls!



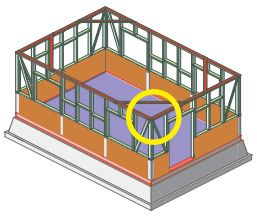


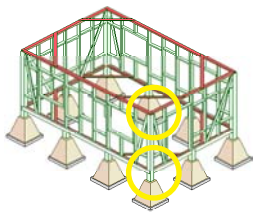
Concrete Ring Beams:

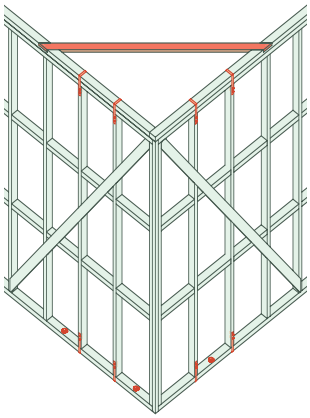
1. STRONG CORNERS! The bars in the concrete should always be bent around the corners.

2. CONTINOUS! Make sure that all the bars are overlapped by at least 50cm.

3.STRONG CONNECTIONS! The sloof need to be well fixed to the foundations. Ring beams should be well fixed to the top of all the columns.







Timber Ring Beams

1. STRONG CORNERS! Diagonal bracing must be fixed to the ring beam. If the house is on timber posts, do this below the floor as well!

2. CONTINUOUS! Make sure the timber pieces are properly joined together all the way around the house.

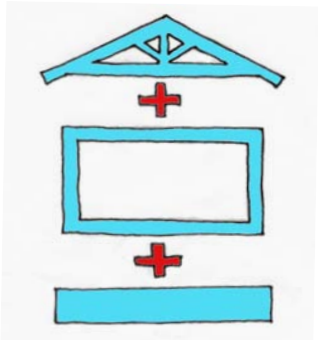
3. STRONG CONNECTIONS! Use bolts, metal straps and good joints to fix ringbeams to posts.

Strong Connections

7

To be strong and safe, all houses must be built with care and good quality. Even the best quality materials will be wasted if the different parts of the house are not strongly connected to each other.

ALWAYS MAKE SURE THAT ALL THE SEPARATE COMPONENTS THAT GO TOGETHER TO MAKE A HOUSE ARE CONNECTED TO EACH OTHER AS STRONGLY AS POSSIBLE.



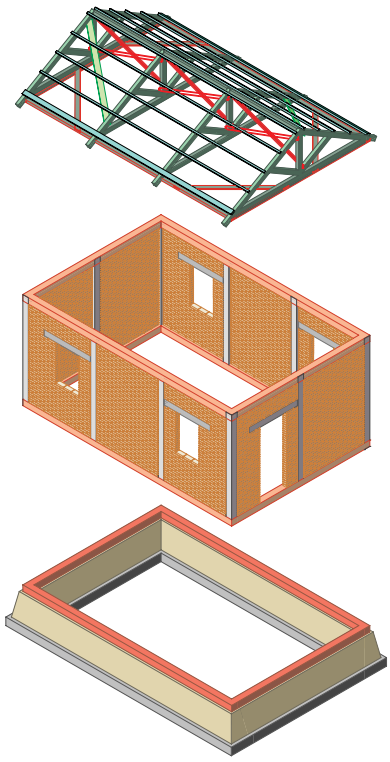
Connecting the Main Elements

The roof must be well fixed to a ring beam at the top of the walls.

The ring beam at the top of the walls should be well fixed to the wall below.

The walls need to have strong connections down to the foundations

Every house has 3 main sections. FOUNDATIONS, WALLS and ROOF. It is the connections between these that are the most important and should be given much attention when building the house.



Connecting the Small Elements

ROOF

All the parts that make up the roof frame must be strongly connected together using diagonal bracing and nail plates and bolts.

WALLS

In concrete, the Re-bar connections at corners and between columns and beams must be strong.
Masonry should be straight and level, have good bonding, and regular sized joints.
Timber pieces should be well jointed and strengthened with good fixings.

FOUNDATIONS

Stonework in the foundations needs frequent stones that go right through the width of the foundation (through stones). Mortar joints should be regular with no big gaps.

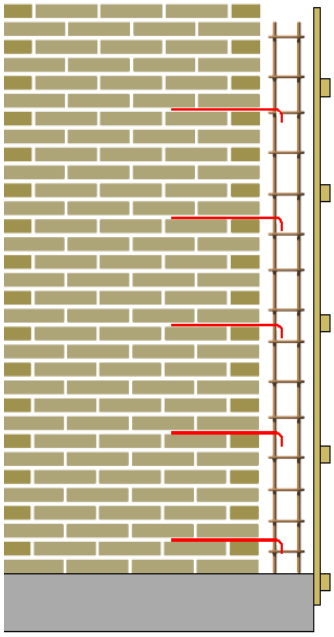
What defines quality workmanship in buildings? Making good strong connections between all the small parts that make up each element of the house.

Anchors

8

USE METAL ANCHORS TO FIX WALL PANELS TO THE BUILDING FRAME AND TO STOP WALLS FROM FALLING SIDEWAYS.

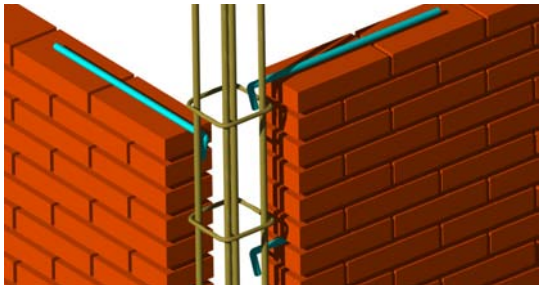
Use of infill wall panels is common in Aceh for buildings of timber frame and concrete frame construction. These panels can be strongly shaken in an earthquake. If they are not fixed to the frame they will fall out causing damage and injury.

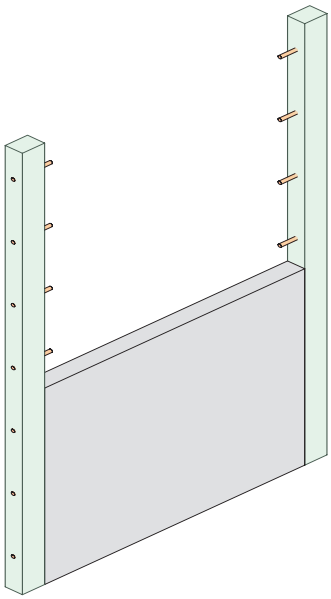


ANCHORS FIXING BRICK OR BLOCK INFILL PANELS TO REINFORCED CONCRETE FRAMES

Anchors should be at least 40cm long.

Anchors should be placed every 6 courses of bricks.





ANCHORING CONCRETE INFILL TO TIMBER FRAMES.

Anchors can be made from a variety of materials - including pieces of re-bar or long nails.

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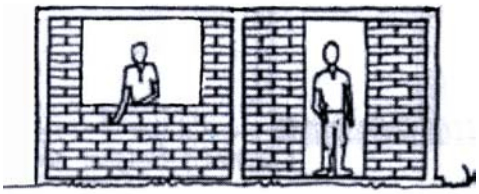
Openings

RESPECT THE 3 PRINCIPLES FOR OPENINGS:
SIZE - PROTECT ESCAPE ROUTES - POSITION

Walls with openings are weaker than solid walls.

Openings are the escape routes out of a building. Protect them!

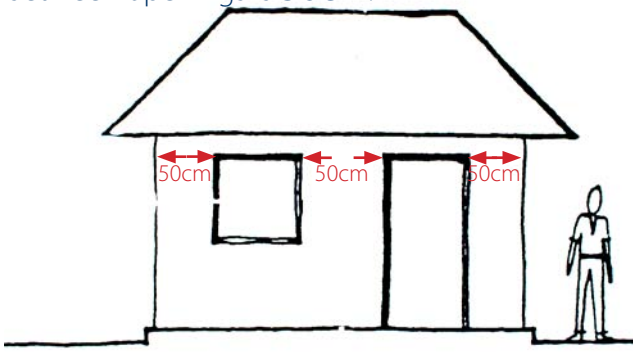
To be safe, all openings for doors and windows should be designed according to the 3 principles below.



SIZE

Smaller openings are safer.
Walls with large openings are weaker.

The recommended minimum distance between openings is **50cm**.



Walls are strongest when openings are away from corners and have space between them.

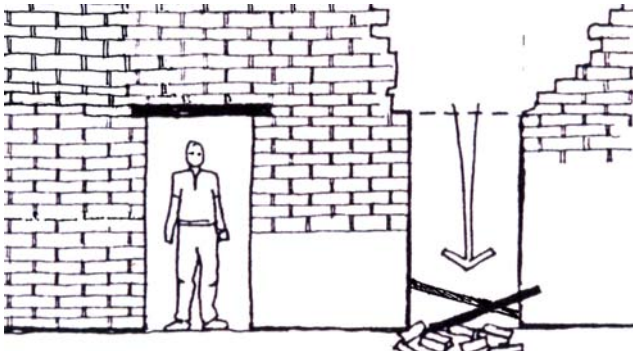
POSITION IN WALLS

Do not position openings too close to each other. The recommended minimum distance is **50cm**.

Windows should be regularly spaced.

Do not position doors and windows too close to corners. The recommended minimum distance is **50cm**.

Openings should be evenly distributed not concentrated on one wall.



During an earthquake, weak lintels can break in the middle or come loose from the wall. A failed lintel makes escape much more dangerous and difficult!

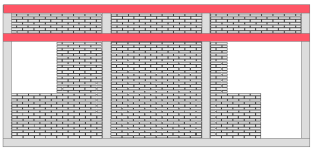
PROTECTION FOR ESCAPE

Good lintels protect escape routes and prevent the wall above from collapsing.

Use strong lintels that are well fixed into the wall on each side of the opening.

It is safest to use a ringbeam as a lintel.

Openings can be placed at corners if the ring beam is used as a lintel.



Roofs

10

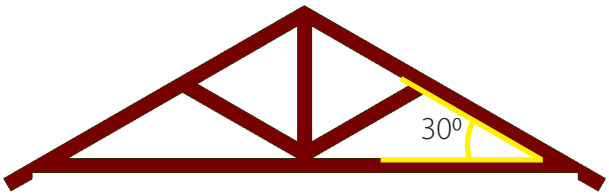
Roof angle should be between 25⁰ and 30⁰ to prevent wind damage

Roof frames must always have diagonal bracing and strong connections

Roof frames must always be firmly connected to a ring beam

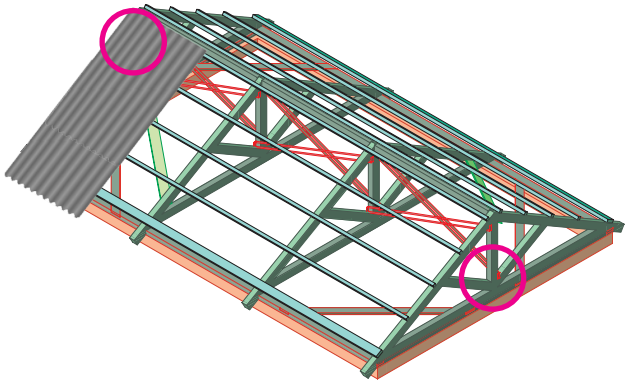
Firmly connect the roof covering to the roof frame

Roofs with large overhangs are more likely to be damaged in strong winds



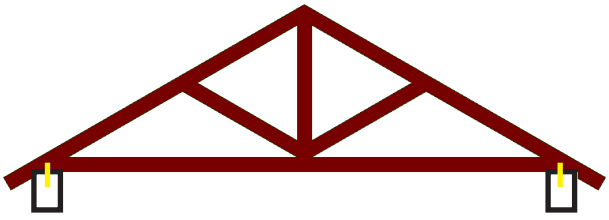
GUIDELINES FOR BUILDING SAFE ROOFS.

Roofs should have an angle of between 25⁰ and 30⁰ to prevent wind damage.
Flatter roofs are easily destroyed by suction from strong winds

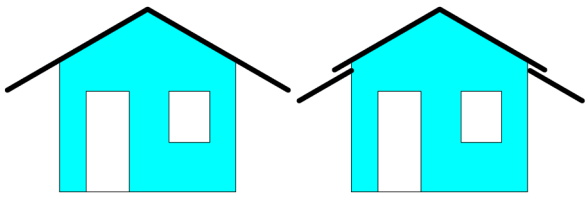


Roof frames must always have diagonal bracing and strong connections.

Firmly connect the roof covering to the roof frame .



Roof trusses must always be firmly connected to a horizontal ring beam.



Separate roof overhangs from the main roof

Roofs with large overhangs are more likely to be damaged in strong winds.

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Extensions

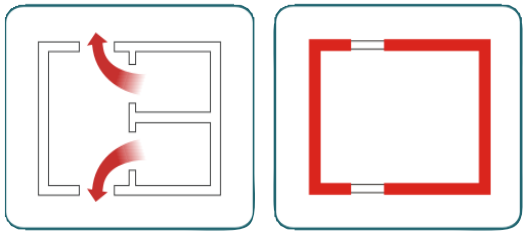
11

Extending an existing house must be done safely.
If the extension does not respect basic rules such as 'simple shapes' then the existing house *and* the extension can be damaged by an earthquake.

Keep the building shape simple and do not touch the existing structure.

Extend outwards by building separated rooms or buildings.

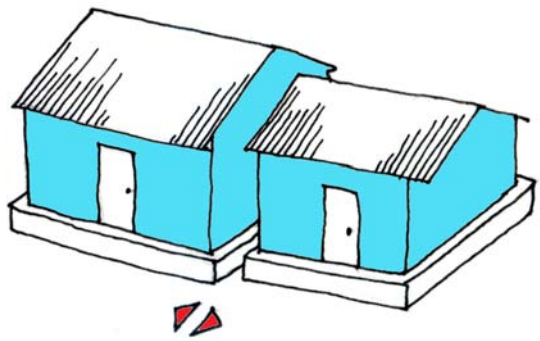
Only extend upwards if the existing structure is designed for this.



Respect the principle that the building shape must be simple and symmetrical

It is essential to maintain quick escape routes to outside- see **SHEETS 2 and 3.**

Extending outwards



The principle is that the new room or building must have structural independence - this means that the new structure should not touch the existing building.

The gap between the old and new building can be very small.

Do not damage the existing structure when making an extension. Any alterations should be done in a way that only makes the building stronger.

Extending upwards

Only extend upwards on top of an existing structure if this structure has been designed to take the extra load of an additional storey.

For this reason, extending a timber frame structure upwards can be easier, because the ground floor structure can be made stronger to carry the extra load.

Although people often add extra floors on concrete frame structures, this is often very unsafe, and should be avoided.

Maintain & Protect

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During earthquakes, damage and casualties occur in buildings which are badly maintained and have been allowed to deteriorate. The building is not as safe as it was.

Lack of maintenance has a serious effect on the safety of a building :

- Connections can weaken or become loose,

- Timber, concrete and masonry can all decay because of water, insect attack and bad design.

PRINCIPLES OF HOME MAINTENANCE

Inspect the structure regularly

Regular inspection helps to find problems before they become serious and expensive.

The longer a building is left unmaintained, the higher the cost of repairs will be.

Lack of maintenance leads to weaker buildings.

Identify the problems
What is causing the damage?

First the problem must be identified so that the same problem can be prevented from happening again.

Common causes of deterioration are:

- Leaking of the roof causes water on RC and timber structures.

- Rusting re-bar reduces concrete strength

- Movement of foundations in the ground.

- Timber decay close to the ground and under roofs where water can collect.

- Constant exposre to flooded ground.

Repair and Protect

Eliminate the cause of damage; then repair or replace damaged components.
Regular repair extends the life of all buildings.

After an event (earthquake, strong wind, flood)

Always inspect the building for damage after any significant event. Weaknesses caused by one event increase the risks of collapse or serious damage the next time if they are not dealt with.