Resilient Housing

Guidance for the Maldives

A guide to improve the climate resilience of houses in the Maldives by the Ministry of Construction and Infrastructure.

Ministry of Construction and Infrastructure, Republic of Maldives

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Acknowledgments

The "Resilient Housing Guidance for the Maldives" technical document is the result of extensive collaboration between the World Bank and the Government of Maldives. Recommendations in this Guidance are based on international best practices and engineering design calculations for the Maldives context. They were developed following assessments on existing housing conditions and construction practices and interviews on selected islands and a continuous, consultative process, supported by focus group discussions, stakeholder forums, one-on-one meetings with Island Councils, Local Practitioners and Contractors and Homeowners with regular inputs from the core team at Ministry of Construction and Infrastructure.

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While the comments and inputs to this Guidance have come from many contributors, all shortcomings of the work rest solely with the authors.

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The World Bank is proud to support the government of the Maldives in its commitment to ensuring that every Maldivian has access to safe, affordable, and sustainable housing.

The "Resilient Housing Guidance for the Maldives" offers practical solutions to meet the pressing need for resilient housing in the atolls. In 2022, the Maldives experienced 128 climate-related incidents across 19 atolls, with sea surges being the most frequent, followed by floods and strong winds. Residents in the atolls are not only facing heightened risks from climate change but are also dealing with the high costs of construction materials and labor, along with limited access to technical support for construction.

This guidance offers easy to follow, prescriptive procedures and graphics that promote best practices for the design and construction of safer housing, applicable to both new constructions and the retrofitting and expansion of existing homes. It emphasizes the use of sustainable materials, passive design, and energy efficiency measures.

I would like to congratulate and thank everyone involved in the development of this guidance. During the public consultation sessions, we received tremendous enthusiasm and positive feedback from local councils, communities, and builders. I am confident that this guidance will be useful for years to come. In particular, I extend my deepest appreciation to the Ministry of Construction and Infrastructure for their unwavering commitment and ownership in the development the "Resilient Housing Guidance for the Maldives".

Gevorg Sargsyan
Country Manager of the Maldives and Sri Lanka,
World Bank

Ministry of Construction and Infrastructure, Republic of Maldives

As the Minister of Construction and Infrastructure, I am pleased to present the "Resilient Housing Guidance for the Maldives." This guidance stands as an essential tool for strengthening our communities and protecting our homes against the impacts of increasing climate challenges and natural disasters.

The guidance within this publication reflects our commitment to sustainable development and resilient housing solutions designed to meet the unique needs of our vulnerable islands across the Maldives. It provides practical strategies and best practices in constructing and maintaining safe, sustainable, and resilient homes to empower individuals, families, island communities, and local authorities to create safe and resilient living environments.

As we navigate the complexities of climate change as a nation, it is crucial that we foster a culture of resilience within our communities. I encourage all stakeholders, including government authorities, local communities, and the private sector, to utilize this guide as a tool for collaborative action to foster a culture of resilience throughout the Maldives.

Together, we can ensure our homes are safe and sustainable to safeguard our future while guiding future generations toward resilience and sustainable living.

Dr. Abdulla Muththalib
Minister of Construction and Infrastructure

Disclaimer

This guide provides recommendations to improve houses in the Maldives for increased disaster and climate resilience. It is important to note the following:

- The guide does not provide a full strong wind, flood or earthquake design. In some cases, the application of these techniques in isolation may not lead to a demonstrable improvement in wind, flood or seismic resistance, especially in houses more complex in nature.
- Application of the techniques described in this guide does not mean the building meets building code requirements. There may be strengthening options other than those provided that may be applied to the house for strengthening. Before adopting alternative strengthening solutions or for a code compliant strengthening solution, please consult a registered civil engineer or architect.
- Houses built or improved following this may still experience damage in strong wind storms, floods and earthquakes. The recommendations are not intended for strengthening a home to be a safe shelter to evacuate to during emergencies. Please follow emergency and evacuation guidance from the government and island or city council in the event of an impending disaster.
- Nothing contained in these materials shall create a contractual relationship with or a cause of action in favor of a third party against World Bank and its contractors. Third party use and/or reliance of these materials or the information contained therein is at the third party's sole risk. World Bank shall have no liability or responsibility for changes or alterations to these materials by others.
- The wind data used to define the minimum construction standards was provided by the Construction Industry Development Department in the document "Investigating the Possibility of Using Locally Available Weather Data to Design Structures", February 2023. The seismic data used is from the Multi Hazard Risk Atlas of Maldives, Climate and Geophysical Hazards—Volume II, published by the Asian Development Bank in March 2020.

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Introduction to the Resilient Housing Guidance for the Maldives

1.1 Welcome to the Guidance for Resilient Housing!

What is the guidance for resilient housing?

The guidance is intended to help Maldivians make their homes:

- Stronger and safer against disasters and climate change.
- More sustainable, with lower electricity costs and greener materials.
- Healthier and more comfortable to live in.

Who should use this Guidance?

You should use this guidance if you are:

A homeowner
This guidance will help you to plan and manage resilient housing construction projects.

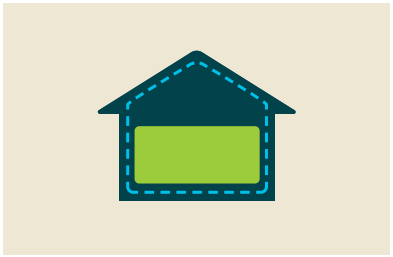
A builder
This guidance will help you to ensure good quality design and construction, and safe building practices.

An island or city council
This guidance will help you to ensure the houses on your island are safe, healthy, and resilient living spaces.

When should the Guidance be used?

You should use this guidance if you want to:

Build a new house
That is one storey and less than 1200sqft.



Improve an existing house
To make it safer and more comfortable, such as by strengthening the roof or improving the natural ventilation.

Add new rooms to an existing house
To add more space to the house, such as another bedroom and bathroom.

Understand the process for building a second storey
A building permit is required to add another storey. This Guidance explains this process.

Applicability of the guidance

This guidance can be used for houses anywhere in the Maldives and is most appropriate for houses which do not require a building permit.

These are:

Sloped roofs made with timber framing and metal sheet (not a concrete slab).

Single storey house with a building area less than 1200 sqft (111 m²).

Houses only (not used as guesthouses, shops or other types of businesses).

Masonry walls, either concrete blocks (planned or existing), or coral stone (existing only).

Source (for all above pictures): Riyan Private Limited (made for this project)

Basis of the recommendations

The recommendations in this guidance are based on the Maldives building codes and standards, as well as international standards (ASCE 7, British Standards, Eurocodes) where necessary to fill any gaps in provisions in the Maldives documents.

The disaster- and climate-resilience aspects that are considered include:

- **Natural and climate hazards:** including strong wind storms; flooding due to heavy rainfall, sea surge and sea level rise; temperature rise; seismic hazard.
- **Energy- and water- efficiency:** including reducing emissions and costs by maximizing natural ventilation, natural light, passive cooling, and thermal mass, and optimizing building orientation, shading, and the sustainability of materials used for construction.

Reference Chapters

This Guidance can help you if you want to...	 **Build a new house** with a lightweight roof	 **Improve an existing house** with a lightweight roof	 **Horizontally expand** an existing house	 **Vertically expand** an existing house
Chapter 3: Check and prepare your site	✓	✓	✓	✓ *
Chapter 4: Choose good quality construction materials	✓	✓	✓	✓ *
Chapter 5: Build your house strong	✓	✓	✓	✓ *
Chapter 6: Make your house stronger		✓		
Chapter 7: Build your house comfortable and efficient	✓	✓	✓	✓ *
Chapter 8: Build your house for the future			✓	✓ *
Chapter 9: Build your house safely	✓	✓	✓	✓ *
Chapter 10: Maintain your house	✓	✓	✓	✓ *

* You can refer to the guidance in this Guidance if you want to add a second storey to your house, but you will also need to get a building permit from the island council. This will require you to hire an architect and an engineer to draw your plans.

Build a new house with a lightweight roof

Typical characteristics:

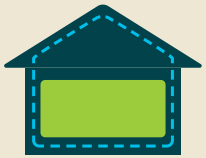
- One-storey house, with one or more volumes on plan
- Masonry walls with concrete blocks
- Strip footings under walls
- Plastered or unplastered walls
- Light roof, with light-weight metal roofing on timber or light steel framing
- Electrical and plumbing systems with possible improvement for solar and rainwater-harvesting system integration

Horizontally expand an existing house

Typical characteristics:

- Existing one storey house
- Masonry walls with concrete blocks or coral stone, plastered or unplastered
- Strip footing under all walls
- Light roof, with light-weight metal roofing on timber or light steel framing
- Existing building services supply

Improve an existing house with a lightweight roof



Typical characteristics:

- One-storey house, with one or more volumes on plan
- Masonry walls with concrete blocks or coral stone
- Foundations may or may not be present
- Plastered or unplastered walls
- Light roof, with light-weight metal roofing on timber or light steel framing
- Existing building services supply

Vertically expand an existing house

Typical characteristics:

- Existing one storey house (may need strengthening to withstand an extra storey)
- No damages to walls related to foundation settlements or soft soil
- Masonry walls with concrete blocks plastered or unplastered
- It is not permitted to vertically expand upon coral stone masonry houses
- Strip footings under all walls
- Light roof, with light-weight metal roofing on timber or light steel framing
- Existing building services supply

Source (for all above pictures): Riyan Private Limited (made for this project)

What is a Resilient House?

...Climate and Disaster Resistant
able to protect against strong winds, earthquakes, extreme heat, and flooding from rain and storm surge.

...Healthy and Secure
with adequate water, sanitation, ventilation, light, access, space, and security.

...Affordable
financially accessible for low- and middle-income households.

...A Financial Asset
that stimulates economic opportunities for families by being adaptable to many uses, and protecting investment.

...Green and Sustainable
built or strengthened using materials and processes that minimise the environmental footprint and mitigate climate change.

...Adaptable
can be expanded and adapted to changing family size or composition, or to embrace emerging technology.

...Locally Appropriate
built using materials, skills, and tools that are available in the Maldives and appropriate for national culture and tropical climate.

...Scalable
can be replicated to meet the needs of thousands of families in the Maldives through a combination of policy, access to finance and technology.

Components of a Resilient House

Naturally cool and well ventilated

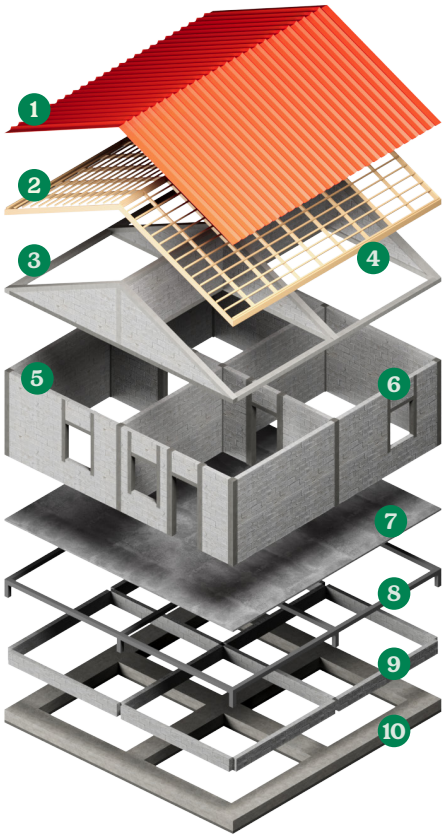
The plot is subdivided to allow for air flow and natural light, and houses are built to minimise exposure of east-west facades with natural shading from vegetation and roof overhangs. The roof is insulated to reduce solar gain and walls are painted with light colours to reflect the light. There are plenty of windows for natural ventilation.

Reinforced walls to resist strong winds and earthquakes

Walls are constructed from good quality blocks and reinforced with confining columns and ring beams. They are plastered and painted to improve water resistance and reduce heat in the home.

Self-sufficient supply of water and energy

Rain water is collected from roofs and stored in tanks to use for irrigation, bathing, flushing and laundry. Solar panels are installed on the roof (or the ground) to reduce the amount of utility provided energy, reducing household costs and having a positive impact on the environment.



Low risk site

The plot is allocated as per the island's approved land use plan and there is at least 66ft (20m) of coastal vegetation plus the access road between the coastline and the house. Ideally the house is built on ground higher than the beach that does not flood when it rains.

Strong, raised foundation for flood resilience

The foundation supports the weight of the house and may raise the house 1-2ft (30-60cm) above ground if the site is prone to flooding.

Secure roof to resist strong winds and heavy rain

The roof is balanced and with a recommended slope of 25-30 degrees to withstand strong winds. All the roof elements are very well connected together.

Key to structural components:

1. Light-weight roof sheets, with layers of waterproofing and insulation
2. Timber roof framing with strong connections
3. Gable end walls with confining beams and columns
4. Ring beam above all walls
5. Masonry walls, with reinforced concrete confining columns at intersections and edges
6. Lintels above doors and windows
7. Ground slab raised 1-2ft (30-60cm) above ground.
8. Plinth beam.
9. Masonry knee wall with confining columns.
10. Reinforced concrete strip footing below all walls.

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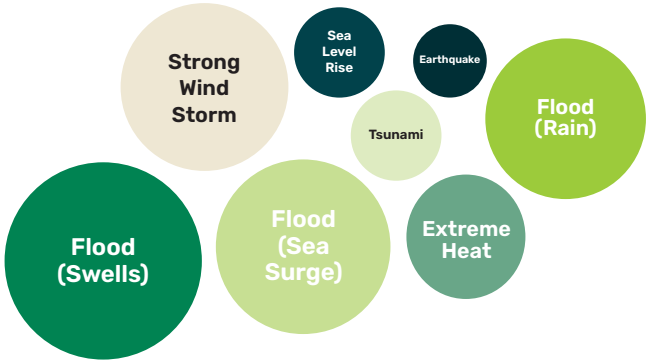
Understand
The natural hazards and effects of climate change in the Maldives

To make your house disaster- and climate- resilient, you first have to understand what the risks are.

Understanding the risks from natural hazards and climate change will guide where, how and what you build.

2.1 Introduction to the natural hazards and effects of climate change

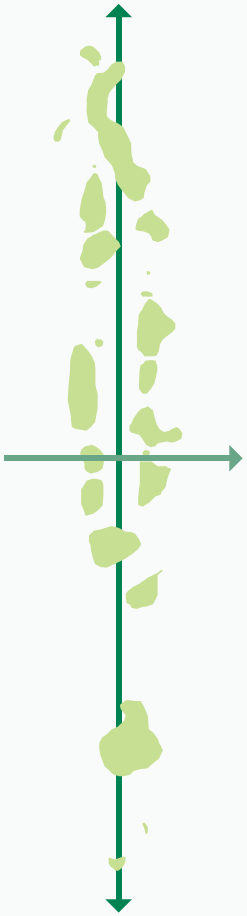
What natural hazards is the Maldives exposed to?



Natural hazards cannot be prevented!

WHAT YOU CAN DO is make your house more resilient so that the damage, disruption and cost of these hazards is reduced.

The first step towards a resilient house is understanding what hazards to design and build for.



Northern Atolls have a higher risk of:

- cyclones
- floods - storm surge

Eastern Atolls have a higher risk of:

- tsunami
- floods - storm surge

Southern Atolls have a higher risk of:

- floods - swells
- floods - heavy rainfall
- earthquakes
- strong wind storms

All Atolls are at risk of:

extreme heat and sea level rise

2.2 Wind Hazard

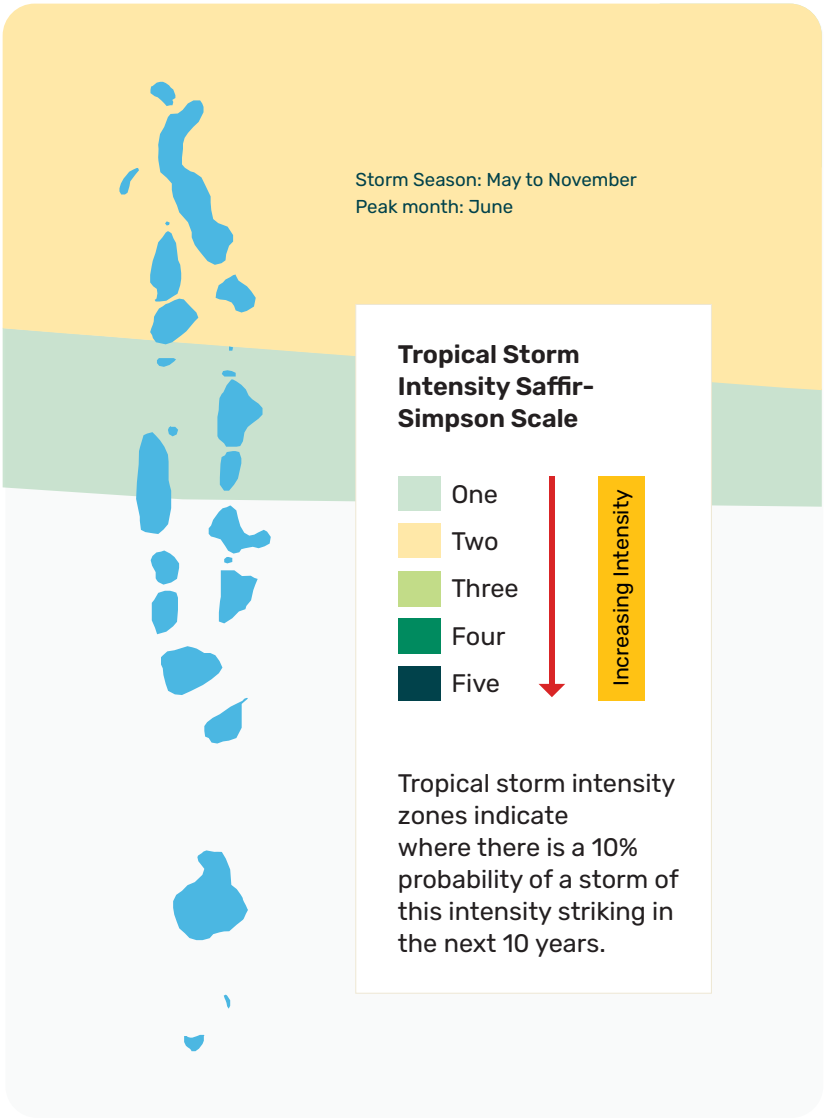
Strong wind storms in the Maldives

All atolls are exposed to strong winds during monsoons, thunderstorms and squalls. Atolls in the North are also affected by tropical storms and cyclones between May to November. Although these storms usually pass further North, Northern Atolls in the Maldives can still experience the very strong winds, heavy rainfall and sea surge associated with these storms. Strong wind storms can cause damage to badly designed and built houses. They can also uproot trees and send dangerous debris flying through the air, increasing the risk of damage to housing.

Source: Maldives National Defence Force

WHAT YOU CAN DO:

Houses can be designed and built to withstand strong winds. Following the recommendations in Chapters 3,4,5,6,10 and 11 will make your house stronger against strong winds during monsoons, thunderstorms, squalls and cyclones.



Source: Based on OCHA/Relief Web (modified)

2.3 Flood Hazard

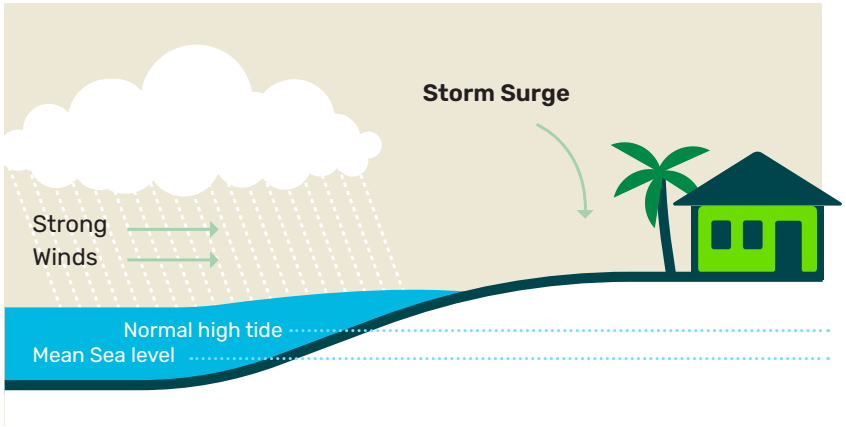
Sea surge and swells in the Maldives

Storm surge is the rising of the sea level during a storm or a cyclone, and water being pushed toward the shore by the force of winds (bodu raalhu - big waves). Swells are a series of waves, with origins in the Southern Ocean, that affect more south and central atolls. Both events can cause extreme flooding in coastal areas, particularly when they coincide with normal high tide, generating water levels sufficient to inundate low-lying, near-shore areas.

Heavy rainfall in the Maldives

Monsoons, storms and the tropical climate that characterise the Maldives can bring heavy rain that can cause floods.

Rainfall varies across the country: the least amount is received by the central atolls. Rainfall is highest in the northern atolls especially from June to August. Both northern and southern atolls experience greater rainfall from September to November.



WHAT YOU CAN DO:

The best prevention from flooding due to sea surge is to build away for the coast – at least 66ft (20m) and to raise your house by a minimum of 1-2 feet. See Chapters 3 and 5 for recommendations for flood resilience.

Source: Maldives National Defence Force

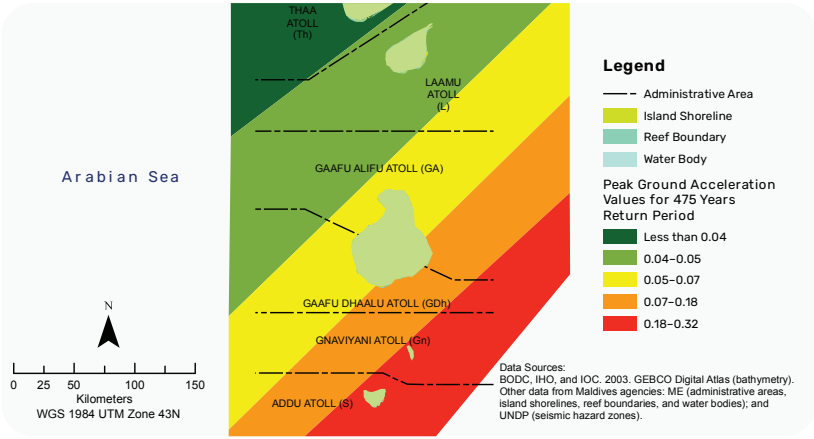
2.4 Seismic Hazard

Earthquakes in the Maldives

An earthquake happens when the earth's tectonic plates push against each other so hard that one of them slips or breaks.

Seenu, Gnaviyani and Gaafu atolls have a moderate seismic hazard, which could cause moderate to high damage to buildings.

Elsewhere in the country the seismic hazard is low.



Source: Multi Hazard Risk Atlas of Maldives, Climate and Geophysical Hazards—Volume II, ADB (March 2020)

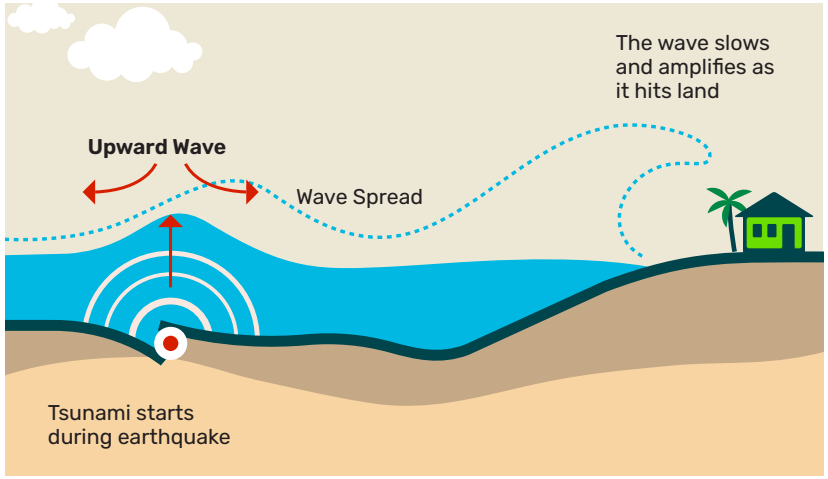
WHAT YOU CAN DO:

Houses can be designed and built to better resist earthquakes. Following the recommendations in Chapters 3-11 will help to keep your house safe.

Tsunamis in the Maldives

A tsunami is created by an earthquake under the sea, that causes a big displacement of water in waves that become bigger when they meet the coast.

The tsunami risk is higher on the eastern side of atolls in the Maldives.



2.5 Climate Change Effects

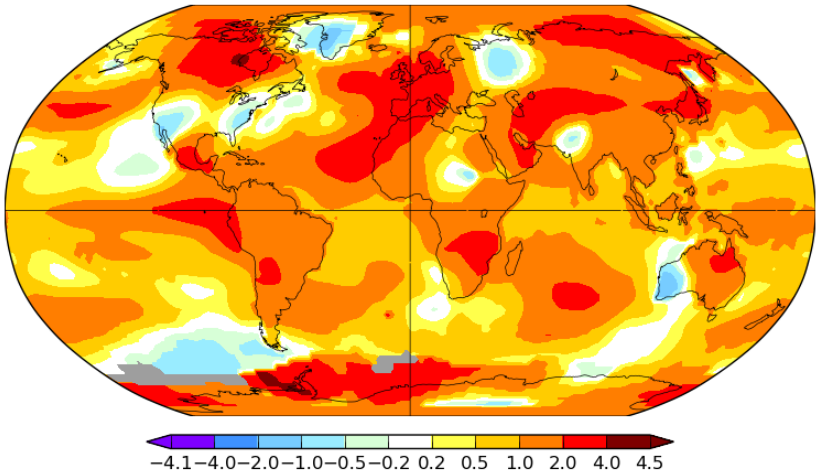
What is climate change?

Climate change is the abnormal changes that result from global warming due to an increased greenhouse effect caused by the vast amounts of greenhouse gases added to the atmosphere by human activities.

In the Maldives, climate change is predicted to cause:

- **Average temperatures to increase**, increasing the potential for discomfort inside houses.
- **Sea level rise**, increasing the existing risks of tsunami and sea surge
- **Increased rainfall** across the whole country, increasing the risk of floods.

"Temperature change in the last 50 years"



Source: NASA, https://data.giss.nasa.gov/gistemp/maps/index_v4.html

Extreme heat in the Maldives

Extreme heat occurs when temperatures are over 30°C with high humidity. Climate change is increasing how often and how intensely extreme heat occurs.

WHAT YOU CAN DO:

Houses can be designed and built to be safer and more comfortable during extreme heat.

Following the recommendations in Chapters 7, 8 and 10 will help to make your house more resilient.

Sea level rise in the Maldives

Sea levels have been rising globally for over 100 years due to warming sea temperatures. The risk from sea level rise is the same throughout the country and depends on the elevation of the island.

WHAT YOU CAN DO:

It is difficult and expensive to design houses for sea level rise. The best protection is to build your house away from the coast line – at least 66ft (20m) and, depending on the existing topography of the site and island, to raise the ground floor at least 1-2ft (30-60cm) above ground level. See Chapter 4 for more details.

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Check and prepare your **Site for Construction**

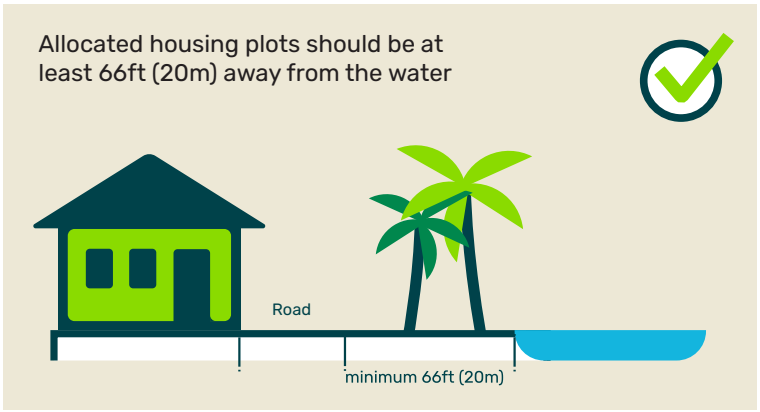
To build in a safe site is necessary for a resilient house.

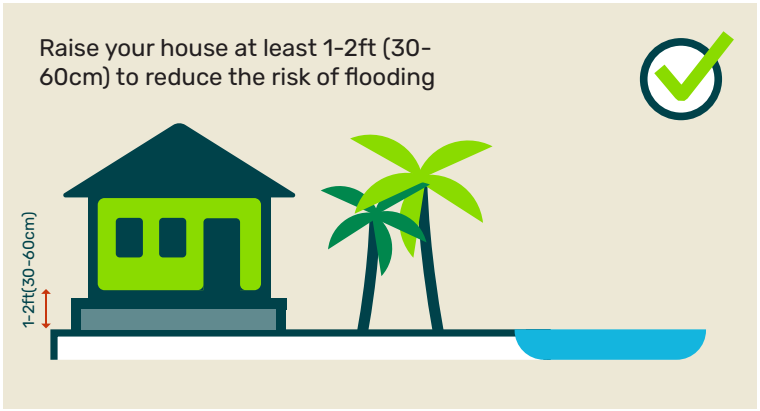
If your plot has been allocated by the island or city council, it should follow the island's approved land use plan. When land use plans are created, they often consider where the safest land on the island is for housing based on the local risk of flooding from heavy rainfall, sea surge, and tsunami.

3.1 New and existing housing: check your plot is in a safe location

- ✗ **Plots should not be allocated close to the shoreline**
- ✓ Check that your plot is allocated as per the island's approved land use plan.
- ✓ Check there is at least 66ft (20m) of coastal vegetation plus the access road between the coastline and your plot.
- ✓ If your allocated plot is on the oceanward side of the island: it is best to be 100ft (30m) away from the coastline (or 160ft (50m) in high exposure islands).
- ✗ **Do not build at the same level as the road.**
- ✓ Raise your house by at least 1-2ft (30-60cm) from road level to avoid flooding.
- ✗ **Plots should not be allocated in areas that are prone to flooding.**
- ✓ If your plot is in an area that is prone to frequent flooding, it is recommended to raise your house further. In this case, dig a trial pit of 1ft x 1ft x 1ft to determine the water table level. If you hit the water table at 1ft, it is recommended to raise your house by at least 4ft from the water level to prevent flooding.
- ✓ Raising your house according to the water-table of your site will further improve the flood-resilience.
- ✓ Even if your plot does not flood, it is better to raise your house. More rainfall is expected every year with climate change, and new roads can change the drainage on the island.

Note: If your island is prone to flooding but fill material is not readily available or is too costly, an alternative way to raise your house is by designing and building a suspended ground slab. It is recommended to seek the advice of an engineer to do so.





3.2 Check your soil conditions – New housing

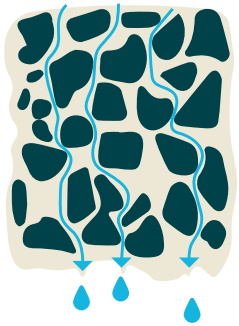
Soil should be well-graded with a mixture of different size particles (sand and stones are preferred because they provide excellent drainage and compaction characteristics), and free of organic matter, debris and pollutants that can decompose over time leading to voids and instability. Soils which contain excessive amounts of fine matter such as silt and clay should be avoided.

✗ Avoid sandy soil that is loose or full of water.

This type of soil is very common and is often found near the beach.

How to identify this type of soil:

- Take a 12mm steel bar.
- Push the bar by hand into the ground.
- If you can push it in more than 1ft (30cm), the soil may not be strong enough to support your house.



✗ Avoid clay soils that are very sticky.

This type of soil is less common, but may be found near the mangroves.

How to identify this type of clay soils:

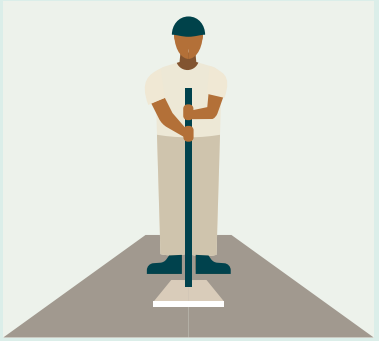
- Smell musty and rotten; contain organic matter such as small fibers or seashells.
- Dry out slowly, shrink as they dry with visible cracks, and break up or crumble easily when dry.
- Stick to your hand or are difficult to wash off when you squeeze it in your hand.

WHAT YOU CAN DO:

If you find either of these types of soils, raise the issue with the island council as you might need to move to a different plot. If moving is not possible you can dig out the soil and replace it with a well compacted fill gravel, construction debris, and soil combined.

How to execute the works:

- Excavate to a level where the soil has the required characteristics.
- Compact the bottom of the excavation with a hand tamper.
- Add a 8in (20cm) (maximum) thick layer of gravel and sand.
- Compact again with the hand tamper.



- Repeat the process with several layers (max. 8in 20cm) until you get to the required level.

WARNING:

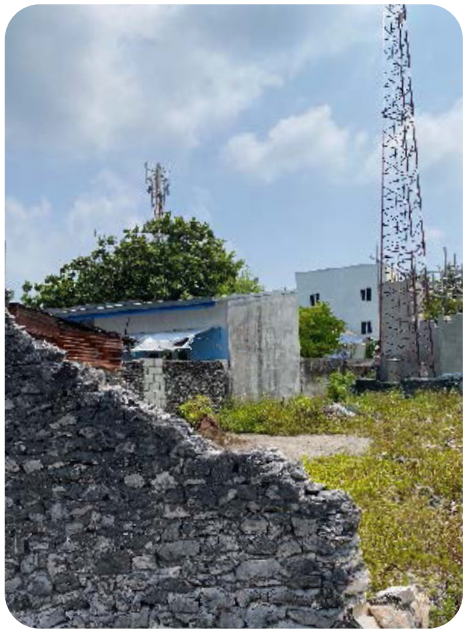
Building on these types of soil might generate serious cracking and damage to walls and structural elements that would compromise the structural integrity and result in costly repairs

3.3 Demolition

Demolition is the process of removing part or all of a building. Often buildings become temporarily unstable and at risk of collapse during demolition, so the work must be carefully planned to ensure the safety of workers and residents, as well as to avoid damage to neighbouring buildings.

When planning for demolition, always consider the following:

- Undertake demolition as directed by and under the supervision of an engineer with site experience.
- Follow Island Council procedures for demolition. A demolition permit might be required, so check with the Island Council. The fee is 100 MVR per submission.
- Contact and follow procedures from utility providers for disconnecting utilities prior to demolition. Prior approval may be required before starting demolition works. There may be a fee involved.
- Refer to safety regulations (such as those specified on page 96).
- Follow the detailed instructions for demolition given in Chapter 11.



Source: Riyan Private Limited (made for this project)

3.4 What activities and costs to expect when preparing your site

1. Trial pits (required)

Trial pits will help you understand:

• What soil you have.

• If dewatering or ground improvement will be required.

• If it is an existing house, existing foundations.

Average size:

2.6ft (80cm) x 2.6ft (80cm) x 3ft (1m) deep

Average cost*:

460-540 MVR each (does not include expert advice).

2. Compacted fill (may be required)

If your site requires ground improvement or is at risk of flooding, compacted fill may be required.

Average cost*:

120-170 MVR/m² (includes fill material and hand tools for compaction).

3. Excavations (required)

Excavations will be required for foundations.

If the excavations are deeper than 5ft (1.5m), they should be protected from collapse with boards and props.

If there is an existing building adjacent to the site boundary, follow the guidance for set- backs provided in Chapter 7.***

Average size:

2.3 ft (70cm) wide x 3ft (1m) deep

Average cost*:

400-500 MVR/ m³ (does not include transport of material away from site, temporary protection).**

4. Dewatering (maybe required)

If you discover water in your trial pits and excavations, you will need to remove it before pouring concrete foundations.

A dewatering permit is required by the Utilities Regulatory Authority – available online. There is a fine of 40,000MVR/ day for dewatering without a permit. An administrative fee of MVR 100 is required for the permit. After that, the average costs are explained below.

Average cost*:

500 MVR/day for the first 28 days; 1,000 MVR/ day, 1,500 MVR/day, and 2,000 MVR/day for the first, second and third extensions respectively.

Refer to URA regulations and website for permit and inquire from the Island Council for island specific procedures on dewatering

5. Site drainage (may be required)

If your site is prone to flooding when it rains, it might help to add site drainage by creating long pits filled with gravel.

Average size:

2ft (60cm) wide x 2ft (60cm) deep

Average cost*:

550-600 MVR/m

Source (for all pictures in this page): Riyan Private Limited.

* All costs are indicative and based on 2023 commercial prices.

** In Male' a permit is required for excavation, with an associated fee.

This is calculated as 100 MVR plus 20 MVR/ft2 of excavation.

*** If setsbacks are not possible and excavation must be carried out in close proximity to an existing building, it is advisable to consult a professional engineer as the excavations and foundations will need to be protected. All operations should be undertaken under the engineer's supervision.

4 /

Choose good quality **Construction Materials**

A house will only be as strong as the materials that it is made of: using weak construction materials will make a weak house.

It is important to:

- Purchase good quality materials for your home
- Store them correctly
- Prepare good mixes following correct proportions and procedure

This chapter provides guidance on how to choose good quality materials. It also gives fundamental guidance in selecting sustainable construction materials, that have a lower impact on the environment and help to preserve it.

4.1 How to choose good quality materials

Concrete blocks

Strong walls are the first line of defence in a storm, a flood or an earthquake. If possible, check to make sure blocks are sourced by an approved supplier. If blocks are made locally, try to see how they are made. Buy from a block maker that is using the correct materials and techniques to make strong blocks.

Good quality blocks are:

- **Intact,** with no cracks and no chips
- **Smooth**, without a coarse or overly porous texture
- **Minimum 5in (12.7cm) thick** (note: walls made with 5in blocks must be plastered)
- **Grey** in colour
- Hollow blocks should have a thickness of 1in (25mm)

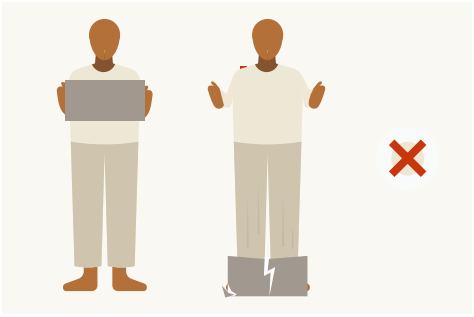
6in (15cm) wide blocks.

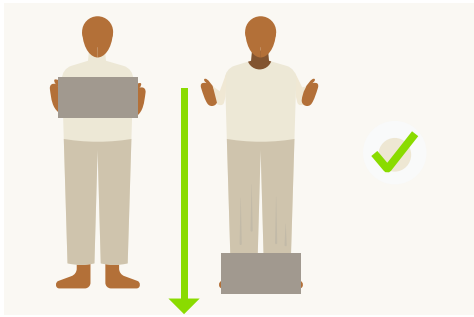
4in (10cm) wide blocks

Chipped blocks

How to test block quality:

- Before buying all the blocks you need, test them: drop 5 blocks from shoulder height on to hard ground (not sand).
- If two or more blocks break, they are not good quality and you should look for stronger blocks somewhere else.





WARNING: Using poor quality blocks will result in a higher chance of cracking and consequent water seepage, peeling and falling of plaster.

Gravel

Gravel is used in important reinforced concrete structural elements such as plinth beams, tie columns, ring beam and slabs.

Good quality gravel is:

- Crushed and angular (not round or smooth)
- Clean and free from mud
- Not mixed with rubbish, wood debris, or roots
- Not larger than 1in (2.5cm) thick for reinforced concrete beams and columns.

Crushed gravel

Rounded gravel

Mixed sand & gravel

How to test gravel quality:

To check that the gravel is clean and does not contain mud: Put a cup of gravel in a plastic bottle, add water, shake it up, and let it settle for 4 hours.

If the water is clear, the gravel is good. If the water is cloudy, the gravel is not so good.

WARNING:

What about coral aggregate?

Although some older houses were built with coral aggregate, it is no longer permitted to be used in construction. Using coral aggregate in concrete is a dangerous practice because it is typically too smooth to form good concrete, it contains salt which corrodes steel reinforcement, and it is porous, which significantly weakens the strength of concrete.

Furthermore, removal of coral has detrimental effects on reefs and the overall marine environment. Its extraction contributes to the degradation of these delicate ecosystems, threatening marine life and biodiversity.

A dangerously unsafe reinforced concrete beam that was made with coral aggregate.

Sand

Sand is used for many important parts of construction, including reinforced concrete foundations, beams and columns, as well as in mortar between blocks, and plaster over walls. It is very important the sand is good quality.

Good quality sand is:

- **Grey** in colour.
- **Clean** and free from mud, not mixed with rubbish, wood bits, or roots.
- **Not too fine** (particles are not too small).

River sand

Beach Sand

How to test sand quality:

To check that the sand is clean and does not contain mud: Put a cup of sand in a plastic bottle, add water, shake it up, and let it settle for 4 hours.

If the water is clear, the sand is good. If the water is cloudy, the sand is not so good.

WARNING:

What's the problem with beach sand?

Beach sand contains salt, which corrodes steel.

If beach sand is used for reinforced concrete, the steel will rust and expand, causing the concrete to crack and eventually crumble. This makes the concrete very weak and dangerous. Additionally, the salt in beach sand can cause concrete leaching and stains which can be difficult to contain.

Beach sand may be used in blocks and plaster, but if you can, it is always better to use imported river sand.

A wall plastered with plaster made from beach sand that has badly deteriorated.

A dangerously unsafe concrete slab made using beach sand

Water

The water must be colourless and clean in appearance, free from oil samples, acids, salts, organic materials and other substances that may cause damage to concrete or reinforcement.

Sea water must not be used for construction. Preferably, the water should come from the public supply. If you use ground water or rainwater, make sure it meets the description above.

Timber

Timber used for roof framing must be sawn, free of knots or cracks, and thoroughly dry before use.

It is better to use lumber harvested from a certified source, to protect the environment.

All timber that is directly exposed or open to weather, like rain, wind, and sun, should be protected with paint or varnish.

Good quality timber is:

- Straight grained
- Free from excessive knots
- Free from warps and moisture
- **Pine, Red Meranti, or Balau**

Cement

There are two different types of cement available:

TYPE I PORTLAND CEMENT

Portland cement: hardens and cures fast, making it better for use in concrete elements, such as the plinth beam, columns, and ring beam. If Type 1 Portland cement is used for the masonry, it must be used rapidly after mixing as it dries quickly.

HIGH SULPHATE RESISTING CEMENT

Sulphate resistant cement: still a Portland cement but with a revised chemical composition to improve its resistance to sulphate (salt) attacks. It is particularly good for use in elements exposed to a higher risk of bar corrosion (for example in foundations, exterior walls exposed to rain and floods).

To ensure the quality of cement, make sure you buy a certified cement product from a reliable supplier. Follow the specifications of that cement product with accurate measurements and correct ratios to ensure construction quality.

WARNING:

Coconut Lumber

Coconut lumber is less durable and has lower capacity than industry standard hard woods for structural construction. It is recommended to use C20-C30 grade hard wood for roof framing to ensure structural stability.

Steel reinforcement

Bars should be new and ribbed to make a good bond with the concrete. Avoid reusing steel from old buildings, since it is likely to be rusty, bent, and less ductile.

Any light rust should be removed by cleaning the bars with a wire brush before use in construction.

Ribbed bars

Smooth, rusted bars

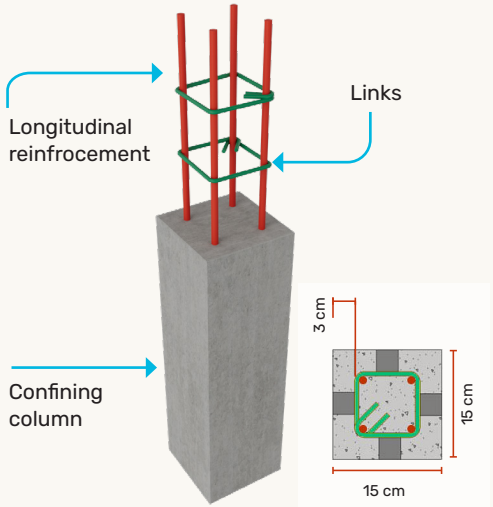
Recycled bars

When to use different bar sizes:

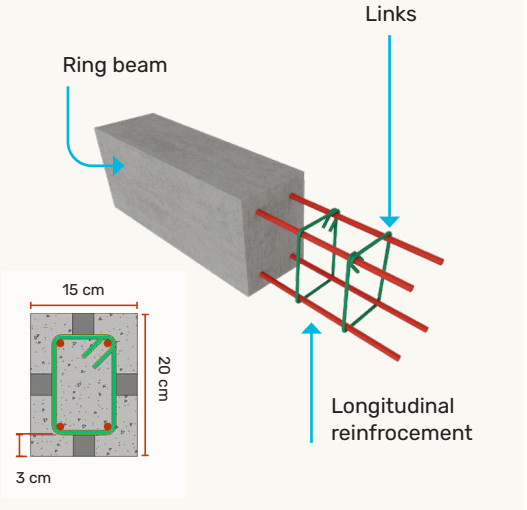
Bar diameter	Typical use in construction
¼ in (6mm or #2)	Links or hooks in confining columns, ring beams
⅜ in (10mm or #3)	Longitudinal reinforcement of columns and ring beams; slab reinforcement; links or hooks in suspended beams or columns
½ in (12mm or #4) ⅝ in (16mm or #5)	Longitudinal reinforcement of columns (especially when isolated) and beams (especially when suspended).

WARNING: If reinforcement in columns is left exposed due to prolonged construction period/phased construction, it will lead to heavy rusting which cannot be removed and potential deterioration of the columns. So, it is recommended to apply a zinc coating on exposed reinforcement in such cases. Alternatively, the exposed bars can be covered with a weak mortar mix that can be easily removed.

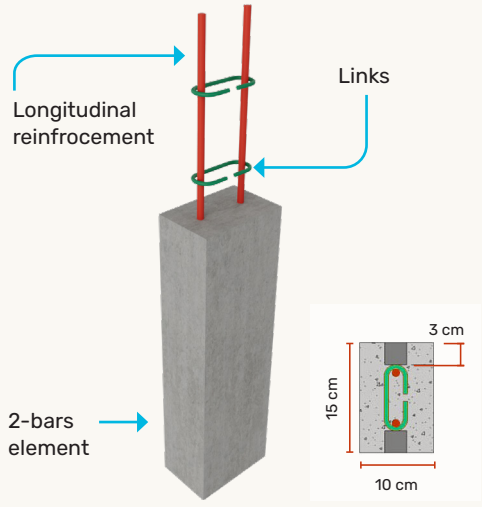
Confining columns



Ring beam



2-bars column or lintel



4.2 How to store your materials

- **Sand and gravel** should be stored in a clean, dry, covered area, free from flood water or rain, where it cannot mix with soil and plant material.
- **Cement bags** should be stacked in piles, maximum 10 bags high. Each stack should be raised above the ground on pallets and moved away from the walls. Cement should always be well covered to prevent it from getting wet.
- **Steel rebar** must be stored in a protected place, covered with plastic to prevent it from rusting due to humidity and salt spray.
- **Timber** should be neatly stacked and well covered to prevent exposure to rain or moisture that will cause it to expand or soften.
- **Dismantled doors and windows** that have been temporarily removed must be stored with care. They should be arranged in a clean space, away from sources of moisture that could damage them. Try not to store them on the construction site to avoid accidental damage.

WARNING:
Unless stored properly, materials will not maintain their quality and will deteriorate quickly, resulting in weaker structures and financial losses

4.3 Why it is important to choose more sustainable construction materials

The manufacture, use and disposal of building materials can greatly impact your health and the environment you live in.

Using sustainable or “green” building materials can provide you with a range of benefits:

- Reduces energy consumption and costs;
- Reduces maintenance costs for your house;
- Improves indoor air quality and reduces exposure to harmful chemicals found in some materials;

Why it is important to choose more sustainable construction materials

Sustainable building materials are typically made using renewable resources that have less of a negative impact on the environment.

They may have the following qualities:

- Made using recycled content
- Produced locally using plentiful resources that supports the local economy and reduces transportation needs
- Renewable content that rapidly replenishes naturally in the environment like certain wood species
- Durable, materials with long life expectancies
- Manufactured in a more efficient manner that requires less or no fossil fuels in their production
- Low or non-toxic: Materials that emit few or no chemicals that may negatively impact human health, or only require simple, non-toxic methods of cleaning and maintenance

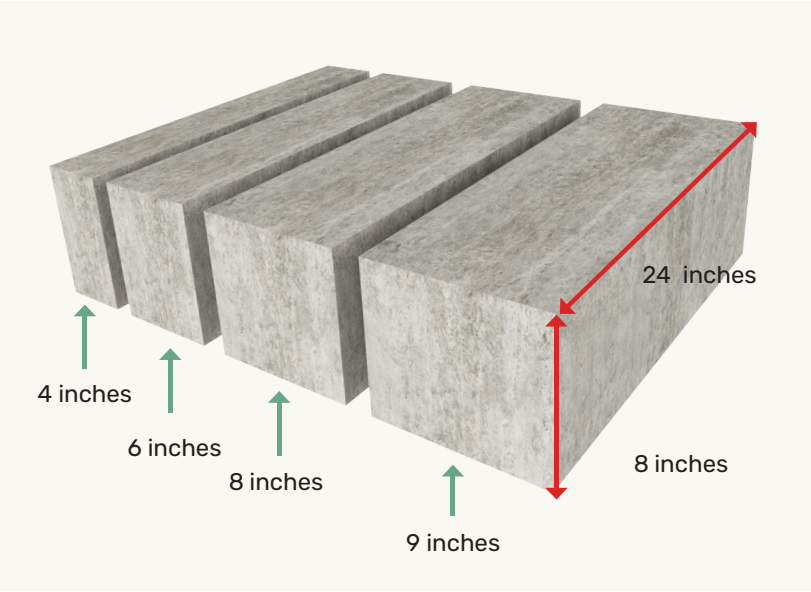
Choosing more sustainable materials

Autoclaved aerated concrete (AAC) blocks

Replace commonly used concrete blocks with AAC blocks.

These blocks are imported and available in the Maldives. Compared to standard concrete blocks, AAC blocks provide better:

- **Thermal insulation**, helps lower the temperature inside your home, which reduces the need for air conditioning and related costs
- **Acoustic insulation**, reduces noises from outside which improves the comfort in your home
- **Transport and construction process**, as they weigh less and are easier to handle



Source: https://renacon.in/renacon-aac-blocks/

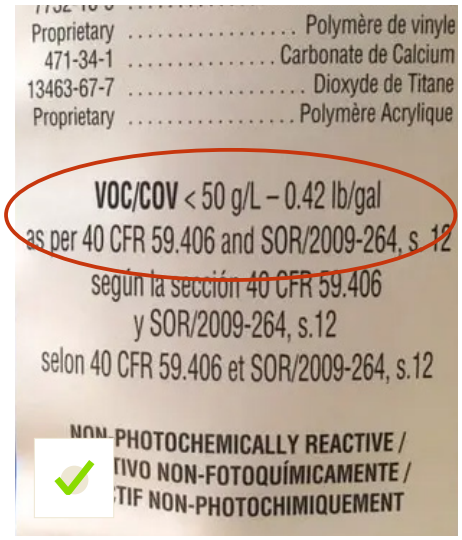
Paint

Paint your walls a light colour. Light coloured paint helps reduce the solar gain in the walls, hence reduces the need for AC energy to reduce the temperature in the house.

Make sure to use paints with low VOCs (volatile organic compounds)

Low VOC paints are less harmful for your health. VOCs are solvents that get released into the air as the paint dries. Breathing in VOCs has been associated with an array of health problems including allergies, asthma, cancer, cardiovascular disease, and reproductive issues.

Check the label for VOC content, and always buy less than 50g VOC per litre.



VOC ≤ 50 grams/litre

VOC > 50 grams/litre

5 /

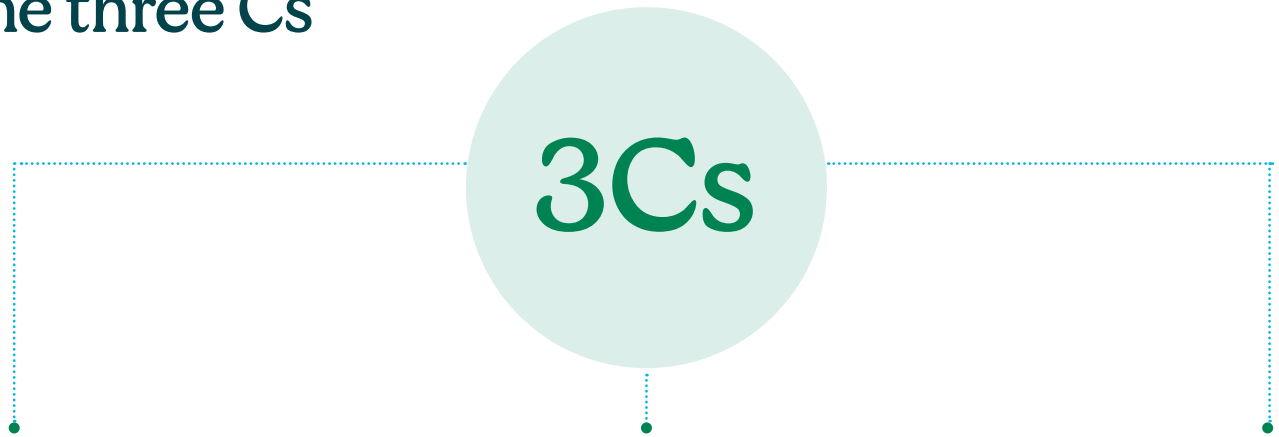
Build your house **Strong**

Natural hazards such as floods and strong winds cannot be prevented…

… but they don’t have to be disasters. You can prepare by building a strong and safe house to reduce the risk of damage and collapse.

This chapter provides construction solutions to build your new house strong. See also Chapter 7 for recommendations on how to make your house comfortable and efficient.

5.1 Introduction to the three Cs



Configuration

Configuration is the building's shape. For example, its plan shape, number of storeys, wall distribution, and wall height. The simpler, the better.

WHAT YOU CAN DO to achieve good configuration:

- **Plan shape:** best if square or rectangular
- **Distance between walls:** 15ft (4.5m) maximum
- **Height of walls:** 10ft (3m) maximum
- **Height of gable walls:** 6ft (2m) maximum
- **Doors/windows sizes and distribution:** Minimum 3ft (1.0m) of solid, continuous wall in each exterior wall and 5ft (1.5m) in each interior wall.

Connections

All elements should be tightly connected to be stronger together – particularly the roof elements, roof to walls, and walls to foundation.

WHAT YOU CAN DO to achieve good connections:

Build strong connections between:

- **Roof elements**
- **The roof and the walls**
- **The walls and the foundations**

Construction Quality

Building quality depends on the quality of the materials, the design and the construction workmanship.

WHAT YOU CAN DO to achieve good construction quality:

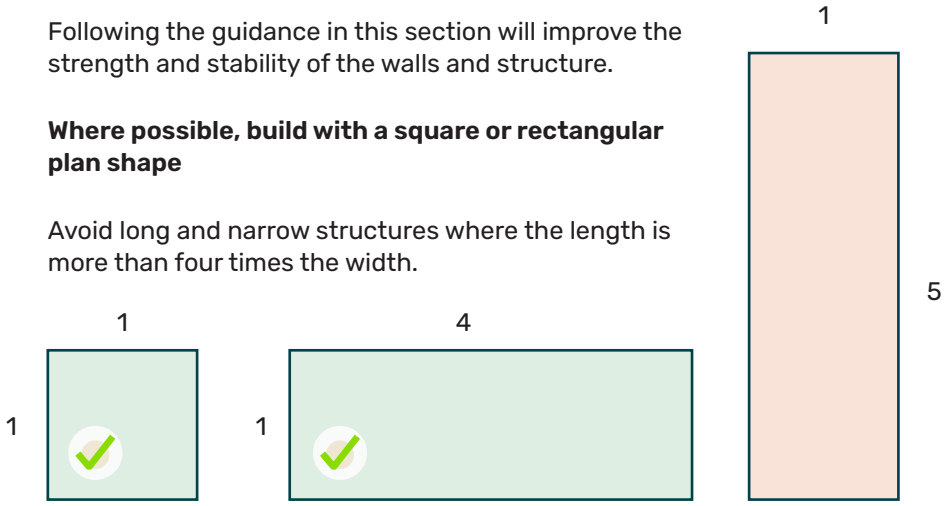
- **Choose good materials, and use them well:** (see Chapter 4)
- **Build strong** foundations, walls, gables walls and roofs (see Chapter 5)

5.2 Configuration

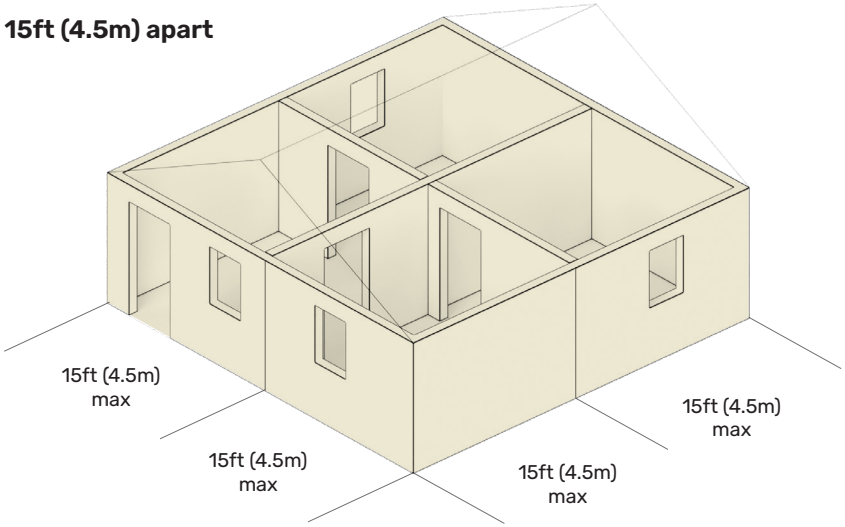
Following the guidance in this section will improve the strength and stability of the walls and structure.

Where possible, build with a square or rectangular plan shape

Avoid long and narrow structures where the length is more than four times the width.

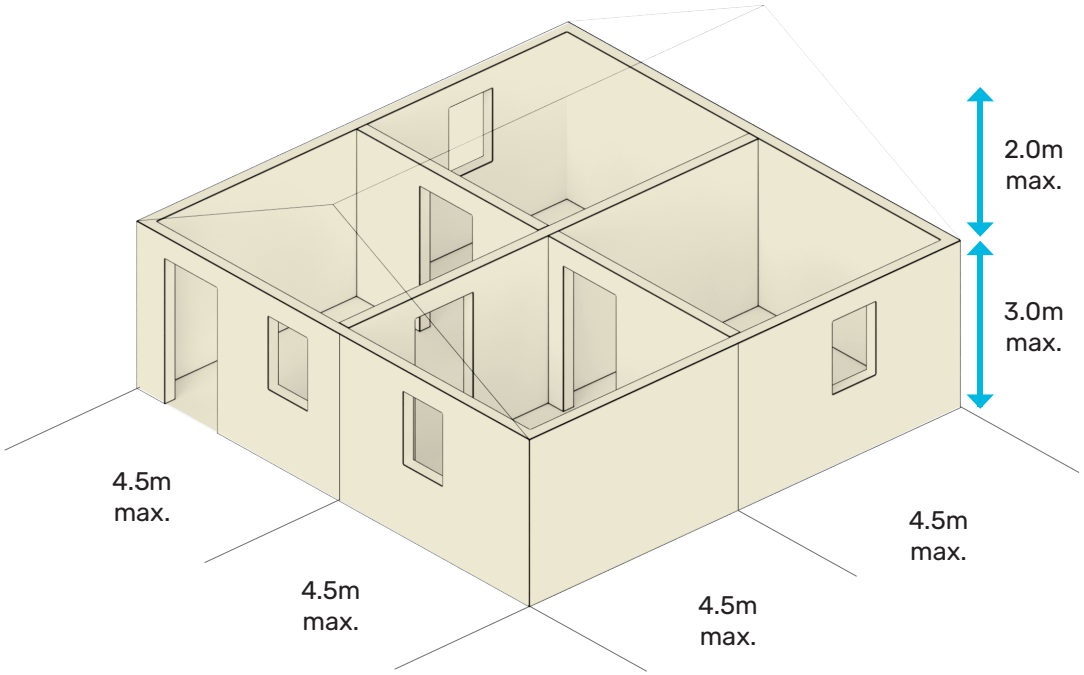


Space walls no more than 15ft (4.5m) apart



Note: 5in blocks MUST be plastered to build walls up to this distance

Limit: wall height to 10ft (3.0m), gable wall height to 6ft (2.0m)

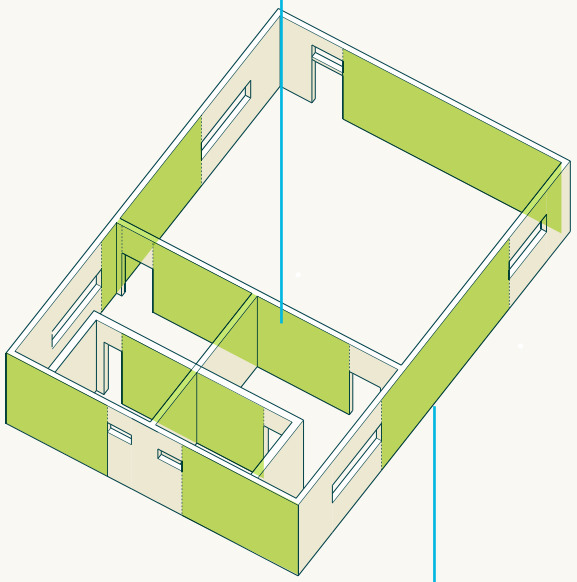


WARNING: If you live in **Addu** or **Gnaviyani Atoll**, you must have a minimum solid length of 10ft (3.2m) in exterior walls and 12ft (3.7m) in internal walls. If you live in **Laamu, Gaafu Alifu** or **Gaafu Dhaalu Atoll**, you must have a minimum solid length of 6ft (2.0m) in exterior walls and 8ft (2.5m) in internal walls. These lengths do not need to be continuous. They can be divided into two or three different segments with a minimum length of 3ft (1.0m) each.

Don't put too many openings in a wall

Make sure you have at least 3ft (1.0m) of solid, continuous wall in each exterior wall and 5ft (1.5m) in each interior wall.

Each internal wall must have at least one section of at least 5 ft (1.5 m) without openings

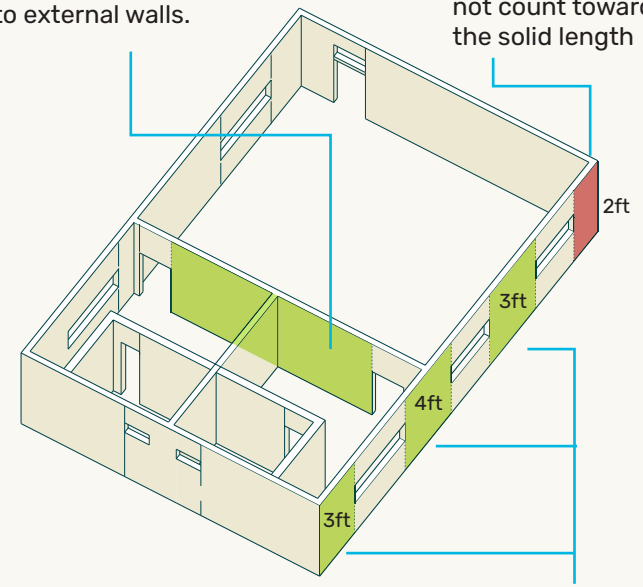


Each external wall must have at least one section of at least 3 ft (1.0 m) without openings

Avoid having too many door and window openings

For Addu/Fuvahmulah, the internal walls must have a minimum solid length of 12 ft (3.7m) and for Laamu/Gaafu Alifu/Gaafu Dhaalu the minimum solid length is 8 ft (2.5 m). This can be achieved in segments similar to external walls.

Wall segments less than 3 ft (1.0 m) will not count towards the solid length

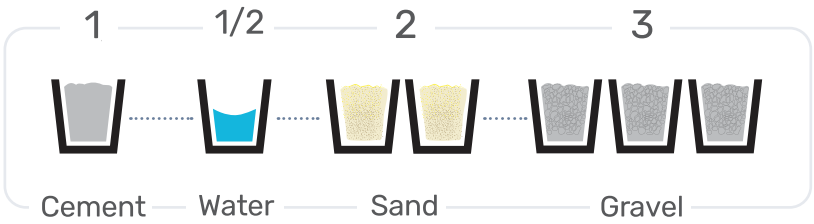


For Addu/Fuvahmulah, the external walls must have a minimum solid length of 10 ft (3.2 m) and for Laamu/Gaafu Alifu/Gaafu Dhaalu the minimum solid length is 6 ft (2.0m). This length can be obtained using solid wall segments of at least 3 ft (1.0 m)

5.3 Construction quality

Concrete Mix

Recommended mix:



WARNING:

Do not add too much water to your concrete mix.

Adding too much water makes the concrete very weak. Try adding water slowly, and always thoroughly mix the mix before adding more water.

Never add more buckets of water than buckets of cement. For example, if you add two buckets of cement, you should add one bucket of water (or similar, as needed to obtain the consistency shown in the picture). Never add more than two buckets of water.

WARNING:

Do not use bags to measure for the mix as this will result in an inaccurate mix ratio. Use a container instead.

1

Make the mix on a clean surface, free of debris or organic matter.

2

Measure using buckets a ratio of 3 gravel, 2 sand, 1 cement and 0.5 water.

3

Thoroughly mix the gravel, sand and cement, at least 3 times from side to side.

4

Add water, and mix until you get an even, consistent paste.

5

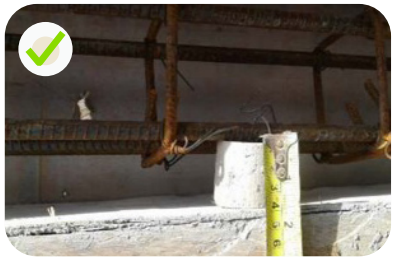
Do not add too much water into the mix.

6

After 30 minutes, do not use the mix.

Concrete spacers

Concrete spacers are needed to separate the steel reinforcement from the formwork so that there is enough space for the concrete to cover the steel and protect it from the environment. If the steel is not covered up by concrete, it will get rusty, lose strength, and cause cracking in the concrete. Using a concrete spacer also helps to straighten out the bars. Cover to bars should be 1¼ in (3cm) minimum.



WARNING:
Do not substitute concrete spacers with other materials such as timber or PVC pipe sections. This will compromise the quality of concrete.

How to make concrete spacers:

Option 1: Use a PVC pipe

Mark a PVC pipe with the measurements of the 1¼ in (3cm) thickness required for the spacers.

Cut the tube at each mark, obtaining small cylinders that are cast with mortar.

When the mortar is half dry,insert tie wire into each spacer and wait for it to dry completely.

Cut the tube at each mark, obtaining small cylinders that are cast with mortar.

Option 2: Use timber planks

Use timber planks to make a mold of minimum 1¼ in (3cm thickness. Fill it with mortar.

When the mortar is half dry, cut it to create the spacers.

When the mortar is half dry, insert tie wire into each spacer and wait for it to dry completely.

When the mortar is totally dry, extract the spacers.

Concrete formwork

- Buy plywood that is good quality, straight and unwarped. Minimum ½in (1.2cm) thick.
- Use a spirit level to check the forms are straight and level.
- Use 1¼ in (3cm) concrete spacers below and to the sides of reinforcement cages to ensure there is enough cover between the rebar and the formwork.
- Make sure the forms are well nailed with no gaps at joints to prevent leaks of wet concrete.
- Make sure the formwork is properly braced or tied together to maintain position and shape.
- Before pouring, make sure the forms are clean and free from sawdust, leaves, waste, standing water.
- For newly constructed masonry walls, install the column formwork after the wall construction is complete.

Concrete pouring

- Wet the formwork and reinforcement before casting the concrete.
- Pour the concrete maximum 30 minutes after mixing.
- Vibrate the concrete with a rod and a hammer as the element is being cast to ensure all voids are filled.
- It's best to cast the whole element at the same time. If a suspended beam cannot be poured at the same time, make the joint at 1/3 of the span.
- Make sure that the concrete is level and even before curing.

Concrete curing

Ground slab

• Wet with abundant water for **3 days, 5 times a day.**

Beams above masonry and wall columns

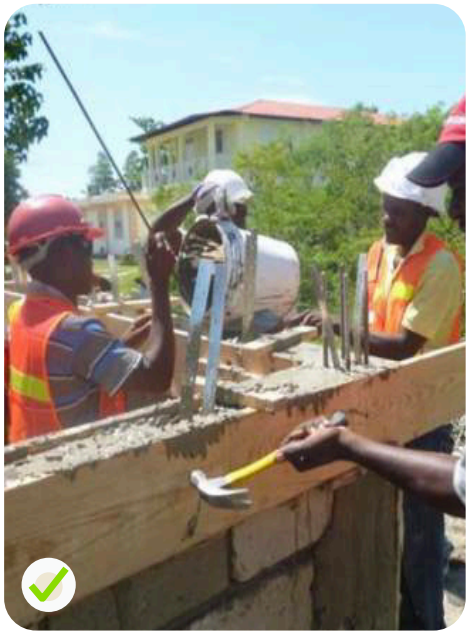
• Sprinkle with water for **3 days, 5 times a day.**

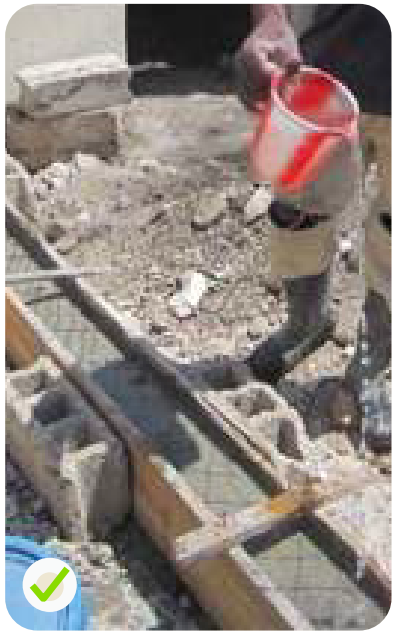
• **Wait 3 days** before removing formwork or adding masonry.

Suspended beams and isolated columns

• **Wet for minimum 7 days** using goani (hessian bags).

• **Wait 14 days before removing formwork and shoring.**





Foundations

Excavations

Step 1: Excavate to the appropriate depth and along straight lines. The bottom surface should be flat and leveled.

Step 2: Remove water, organic material, and debris from the bottom of the excavation.

Step 3: Pour 2in (5cm) of lean concrete (1 cement: 2 sand: 6 gravel) into the bottom of the excavation to create a well-levelled working surface.

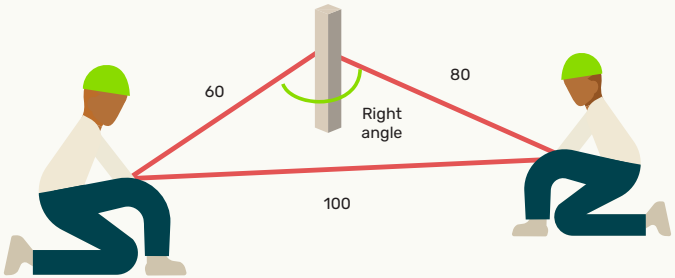
WARNING:

Excavating too close to a neighbouring building can destabilize and damage the structure. Avoid excavations within 3ft (1.0m) of a neighbour's wall, and never excavate below the foundation of a neighbouring building.

If set-backs are not possible, talk to a professional engineer and make sure they supervise any foundation-related construction activities, like making sure that excavations and foundation are well protected.

WHAT YOU CAN DO to help ensure the foundation excavations are straight:

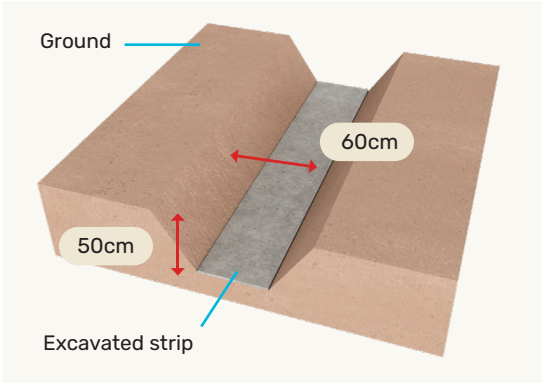
- Cut three strings: one 2ft (60cm) long, one 2.6ft (80cm) long, one 3ft (100cm) long.
- Take the shortest string (2ft - 60cm) and fix it along the line of one wall you want to build.
- Take the 2.6ft (80cm) long string: fix one end with the first string that you already placed (the one that is 2ft -60cm long); fix the other end to the 3ft (100cm) long string.
- Move the end till the 3ft (100cm) string is straight. In this way you have generated a right angle.



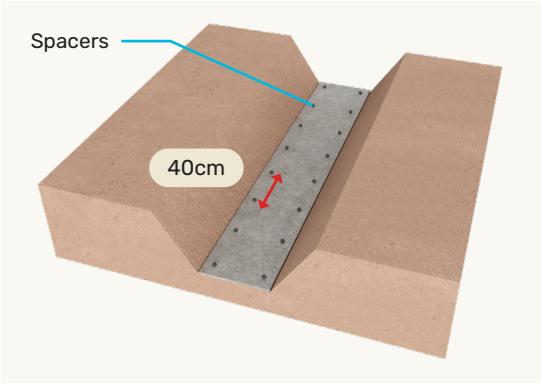
Source (for all images in this page): Build Change.

Foundations to be built under all walls

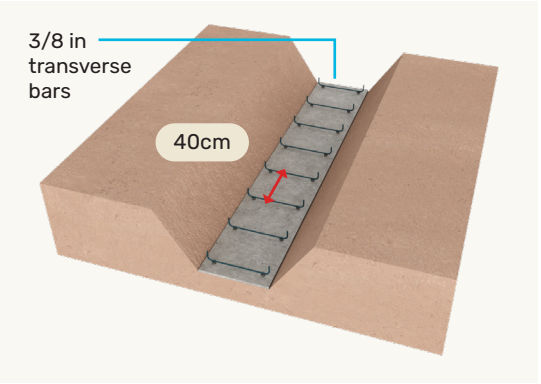
Construction process:



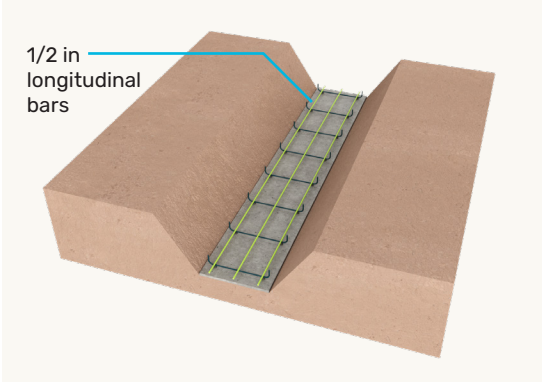
1. Excavate a strip, 23in (60 cm) wide, 20in (50cm) deep.



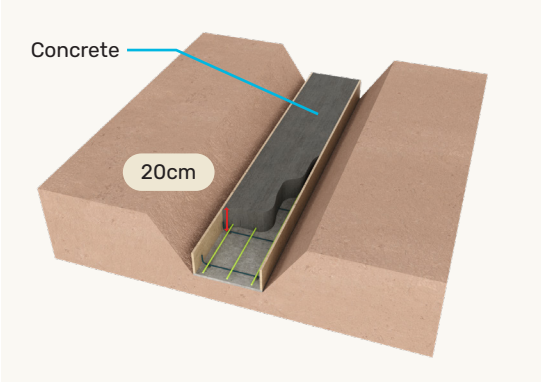
2. Position 2 lines of spacers, 3in (7.5cm), every 16in (40cm).



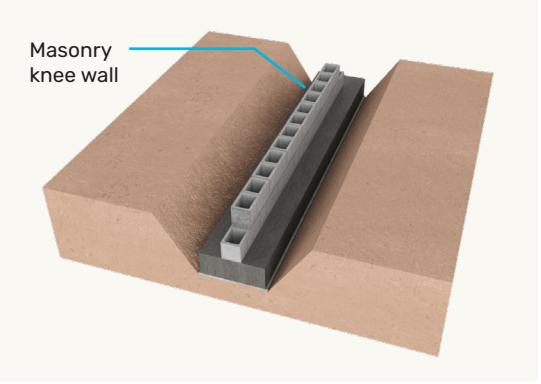
3. Position transverse bars every 16in (40cm) above spacers. Use ⅜ in (10mm) bars.



4. Position longitudinal bars. Use ½in (12mm) bars. Bars should be tied with wire.



5. Pour concrete - 8in (20cm) thick. Allow to cure for minimum 3 days (see Chapter 5).



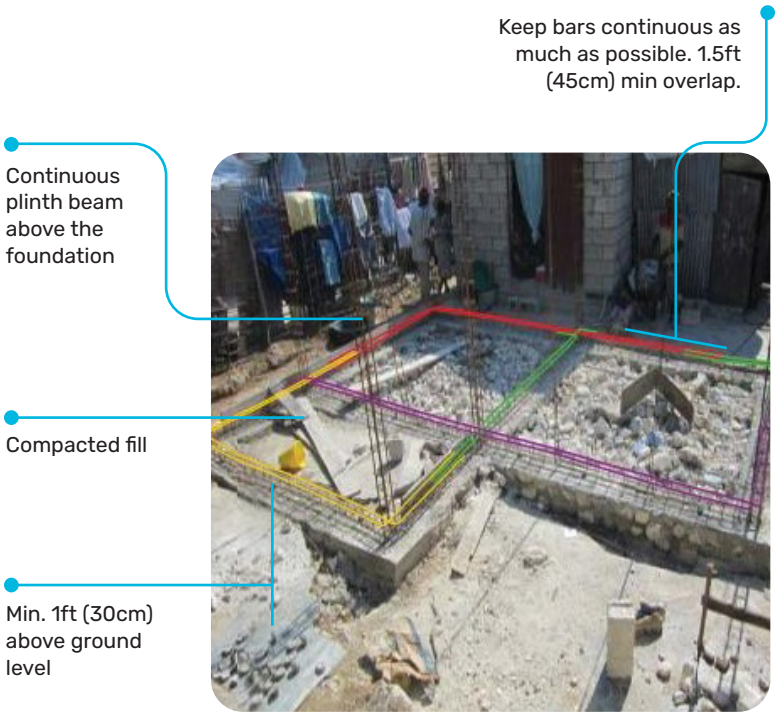
6. Build a masonry knee wall using 6in (15cm) thick blocks. Use either solid blocks, or hollow blocks filled with mortar.

Plinth beam and the ground slab

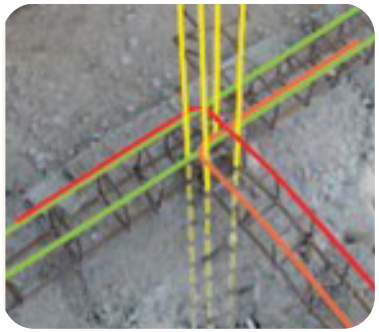
Building 6in x 8in (15cm x 20cm) plinth beam above knee wall:

Provide: Four ⅜in (10mm) diameter horizontal bars and ¼in (6mm) diameter links every 6in (15cm).

See Section 5.3 for how to form, pour and cure beams.



At corners, bend bars as shown below:



Backfilling the raised foundation:

Raising the level of your house is recommended to help protect against future floods. It is recommended to raise you house by at least 1ft (30cm).

The back fill should be:

- Hard, dry material (can be reused from the foundation excavations).
- Placed in horizontal layers, maximum 8in (20cm) thick.
- Each layer should be very well compacted using a hand tamper (see Chapter 5) or mechanical means.

The ground slab should be:

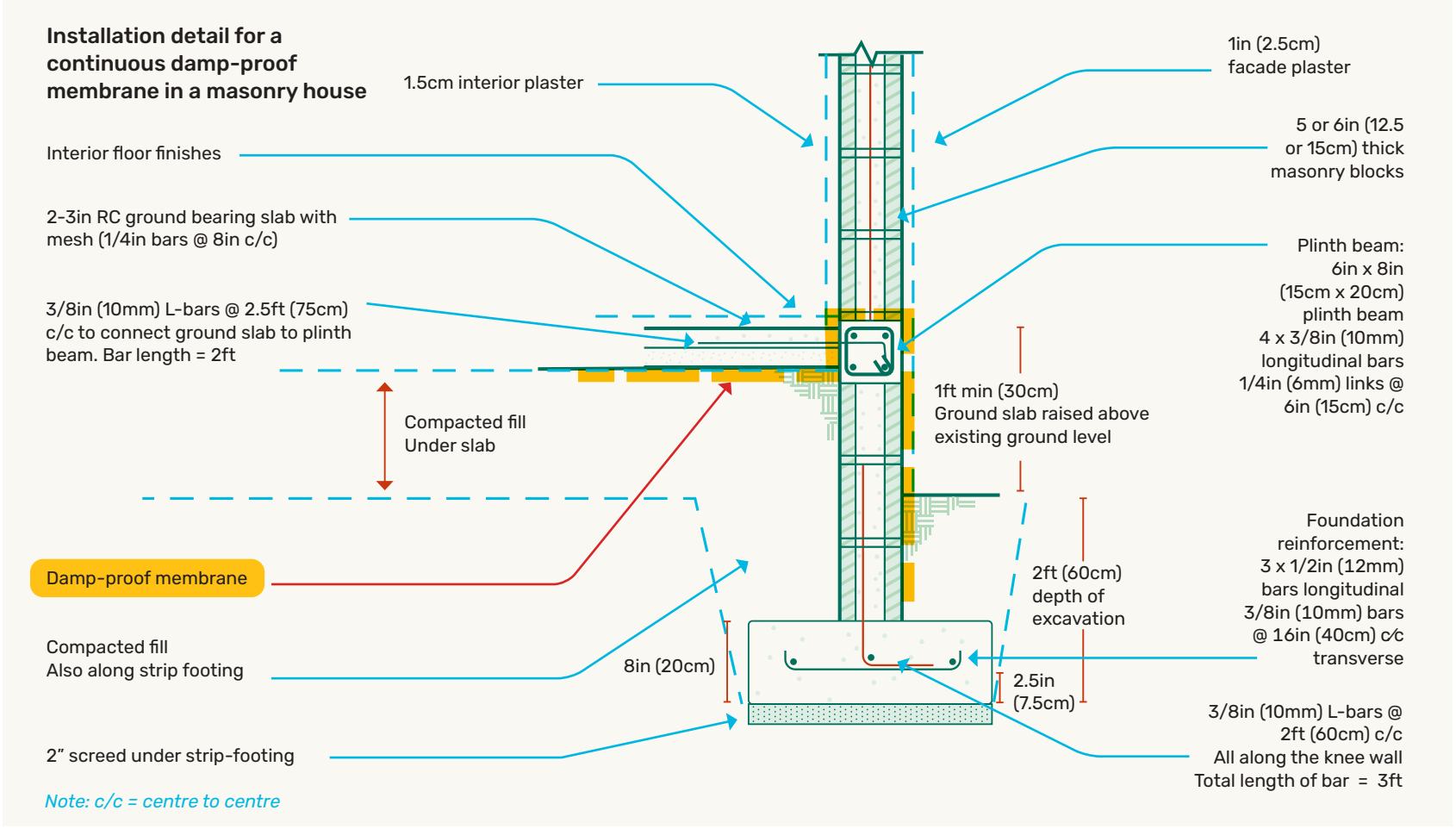
- Minimum 2in (5cm) thick, but 3in (7cm) is recommended.
- ¼in (6mm) reinforcement at 8in (20cm) spacing in each direction or you can use wire mesh.
- Poured above a damp proof sheet.

Ground slab and damp proof membrane

Concrete and masonry are not fully waterproof, so a damp-proof membrane is needed as an extra barrier to prevent moisture from entering your home. Moisture can come from the ground, from humidity in the air, or from rain or floodwater, so it is very important the damp proof membrane is continuous below the ground slab and up the lower sections of walls.If you do not include a damp proof membrane, or the damp proof membrane is not continuous, moisture is more likely to enter your home.

This can lead to:

- Mold growth, which can be extremely dangerous for human health.
- Cosmetic damage, such as peeling paint, stains, discoloration, and warping.
- Structural issues: Prolonged exposure to water can weaken the structural integrity of the wall or floor slab.



Masonry walls

Construction process:

Masonry walls should be built **before** the columns. Add a ring beam above walls following the same construction process as for the plinth beam.

It is recommended to use solid blocks for external walls to prevent water ingress.

1. Ensure that the wall is in line with columns and foundations.

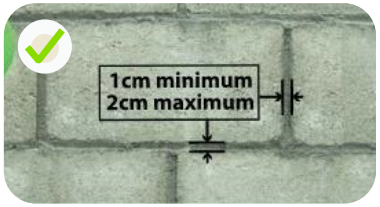
2. You can use strings to help you defining the straight lines.

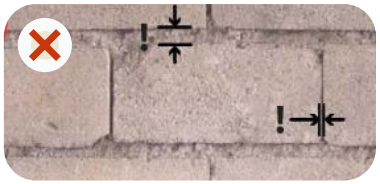
3. The string also helps you to check the levels of the blocks.

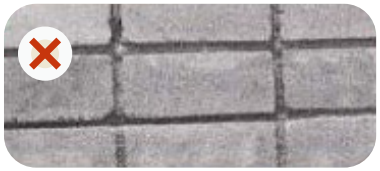
4. Place blocks checking they are levelled and correctly staggered with respect to blocks below.

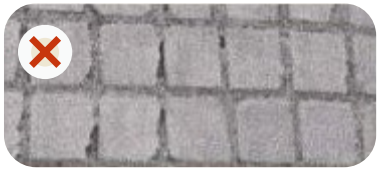
How to check a good quality masonry wall:

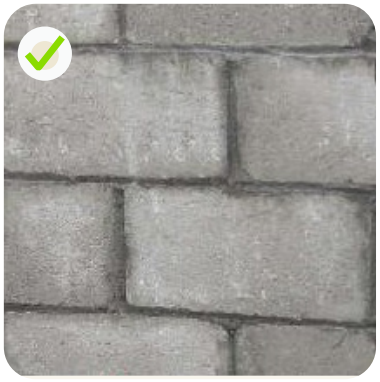
- Blocks should be laid with half a block staggered
- All joints, horizontal and vertical, should be full filled with mortar
- Mortar joints should be approximately ½in (between 1-2cm)
- Blocks should not be damaged









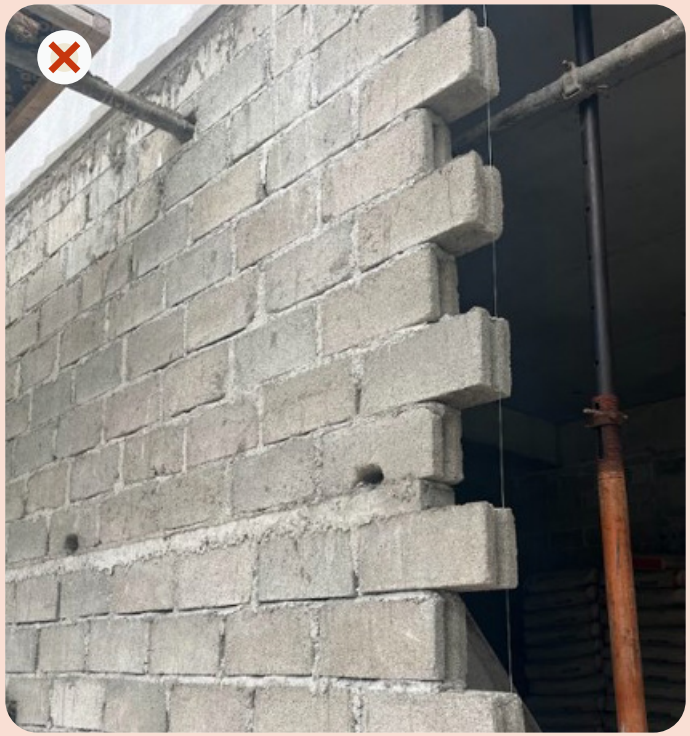


Masonry walls

WARNING

Scaffolding holes in masonry

Creating holes in the masonry for scaffolding will severely reduce the strength of the wall, and makes it easier for water to leak into your house.



Option 1: Do not use scaffolding that punctures the wall

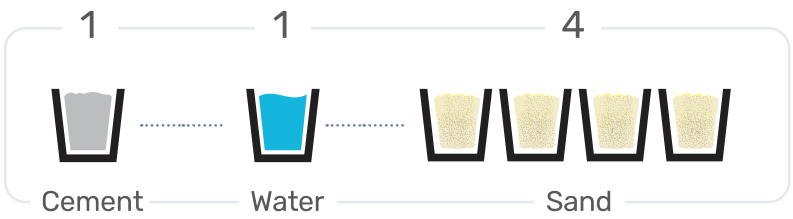
Instead of using scaffolding that goes through the wall, use scaffolding that is an independent structure.

Option 2: Fill the holes before plastering

If there are no other scaffolding options available, break the blocks and use scaffolding that goes through the wall. Once the scaffolding has been removed, fill the holes with a high strength mortar (1 bucket cement : 3 buckets sand).

Mortar for masonry walls

Recommended mix:



WARNING:

Do not waste mortar and use it wisely when laying blocks

Furrow bed joints so that mortar is concentrated under the face shell of blocks. This will eliminate waste and ensure that mortar is placed where it is really needed.

1

Make the mix on a clean surface, free of debris or organic matter.

2

Measure using buckets a ratio of 4 sand, 1 cement and 1 water.

3

Thoroughly mix the sand and cement, at least 3 times from side to side.

4

Add water, and mix until you get an even, consistent paste.

5

Do not add too much water into the mix.

6

After 30 minutes, do not use the mix.

Plaster for masonry walls

Wall Plaster

- Plaster can be used on the walls to minimise heat gain and help manage humidity.
- Plaster on internal walls should be ⅝in (1.5cm) thick minimum.
- On external walls, there should be two coats of plaster, with a total thickness of ¾in (2cm) minimum.
- Waterproofing admixtures will increase the performance of exterior walls.

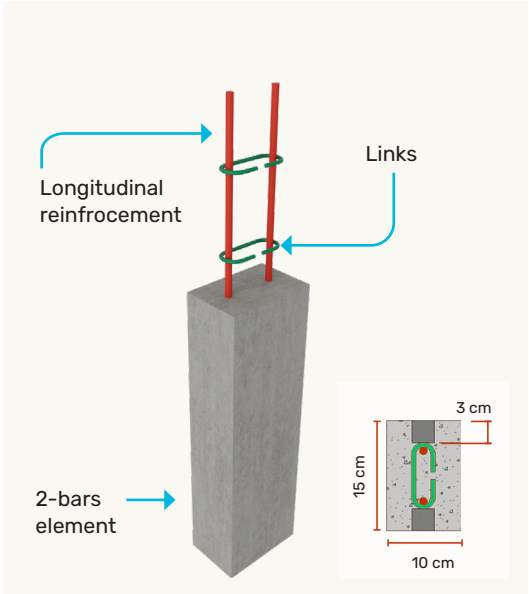
WARNING:

Using fiberglass for waterproofing buildings is a dangerous practice. Spraying fiberglass on exterior walls poses health hazards during application as well as potential long term impacts on those living in adjacent buildings. Additionally, according to the Land-Use Planning Regulations, fiberglass works can only be undertaken a minimum of 150 feet away from residential areas. Hence, fiberglass **must not be used** for buildings in residential areas.

Window and door openings

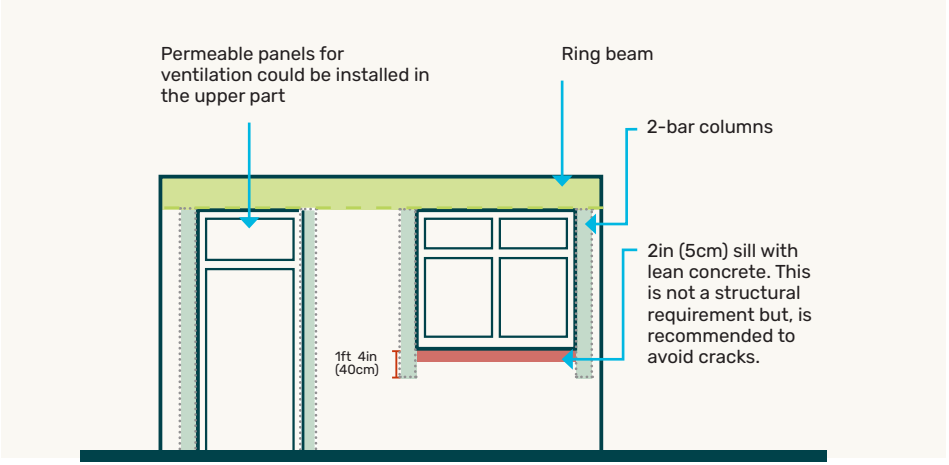
Window and door openings should be constructed with lintels, sills and 2-bar confining columns to avoid cracks. Any masonry above jaalis must be placed above a lintel beam.

Lintels and confining column



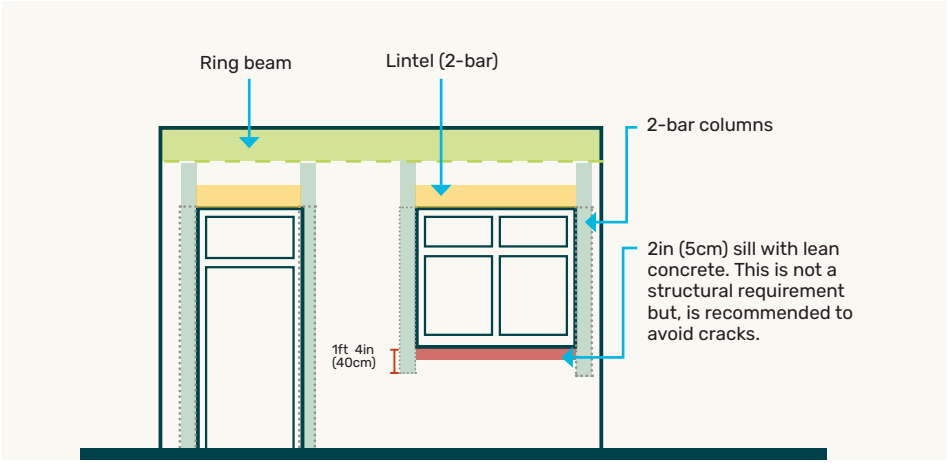
Option 1:

Use the bottom of the ring beam as a lintel and construct the openings like so. This will avoid the need for an additional concrete lintel and will save cost.



Option 2:

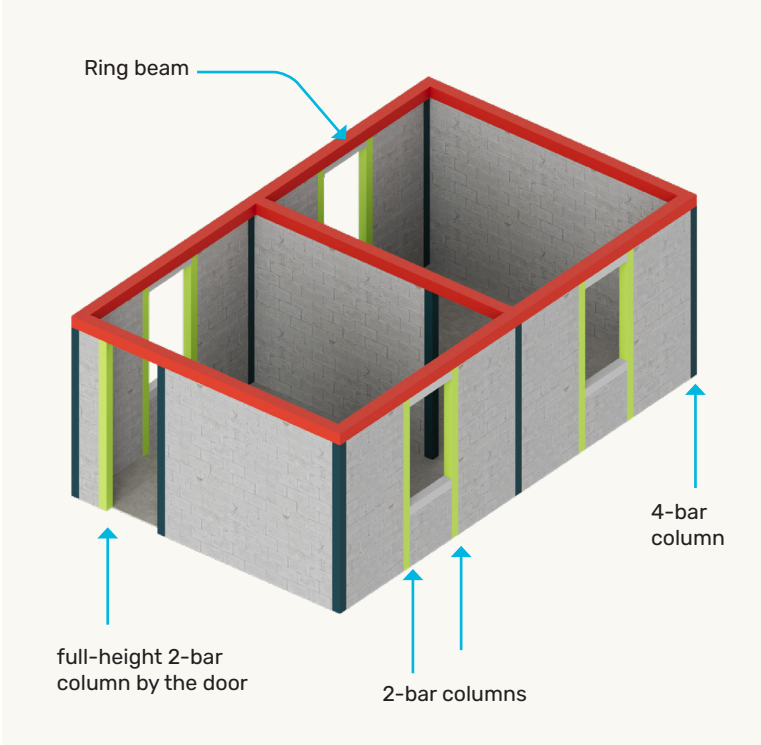
Construct an additional lintel beam at the desired height if planning to continue masonry or install a ventilation panel above door or window up to the ring beam.



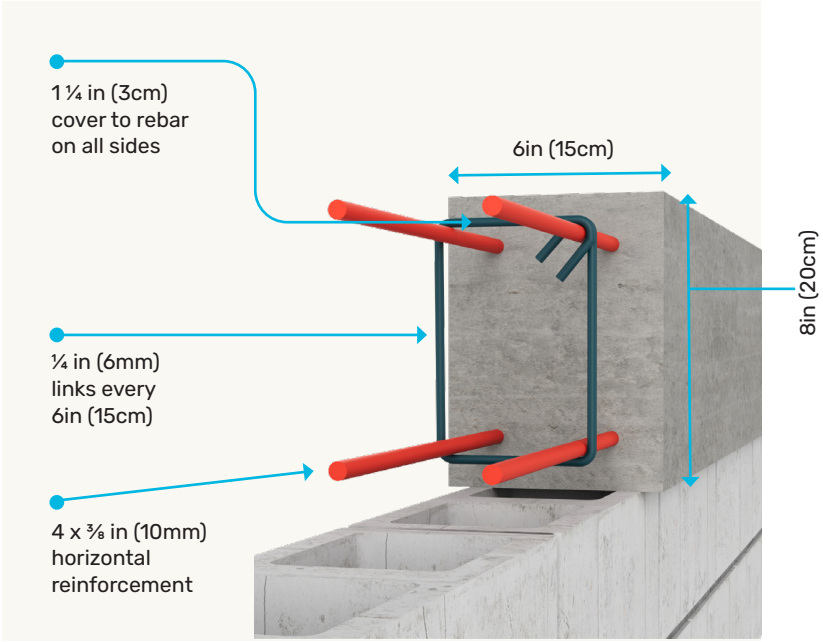
Columns and beams

Location of columns and beams

- Beams: continuous above all walls (exterior and interior)
- Columns: at all wall corners, intersections and free ends. Column reinforcement should be built before the wall construction.



Beam reinforcement



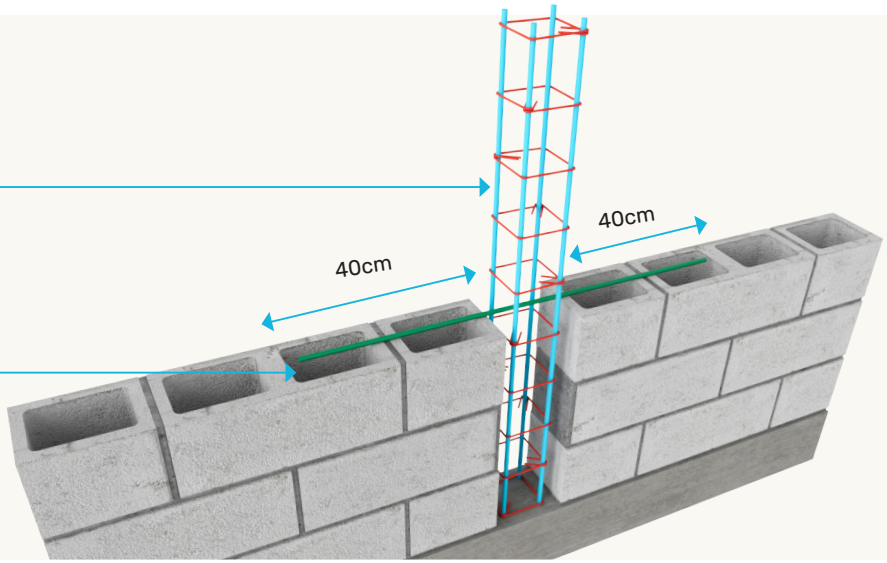
WARNING:

Columns should not be built using only one reinforcement bar as the column will be too weak and links cannot be connected properly. Without links, the column will fail.

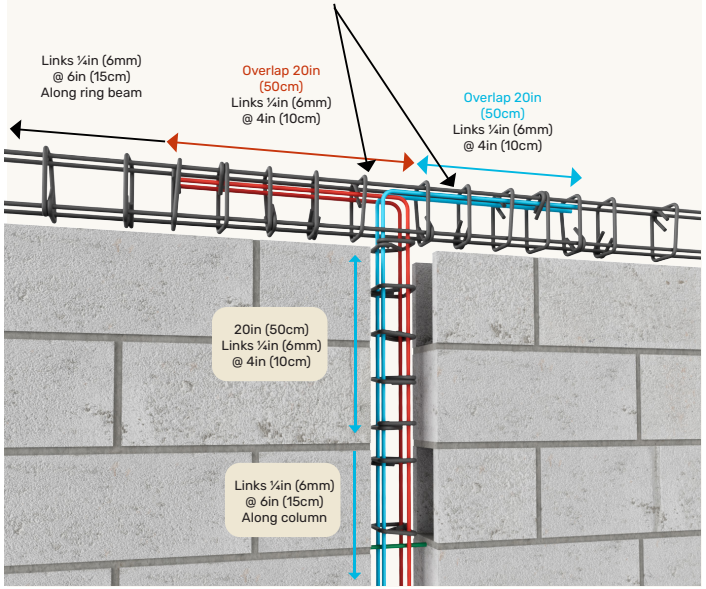
Column reinforcement

4 x ⅜in (10mm) vertical bars in columns

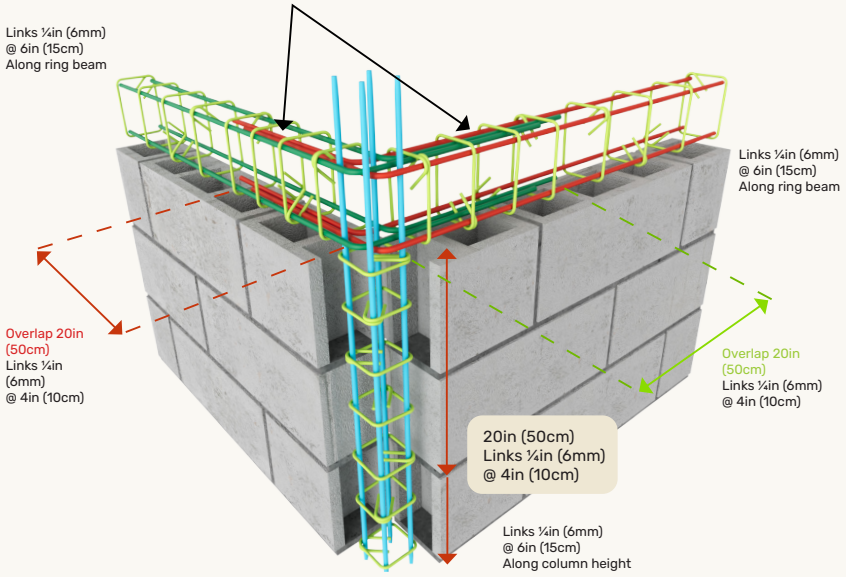
1/4in (6mm) diameter bar to connect walls to column. Position bars in horizontal mortar joints every 3 blocks



Bend column reinforcement inside ring beam longitudinal reinforcement



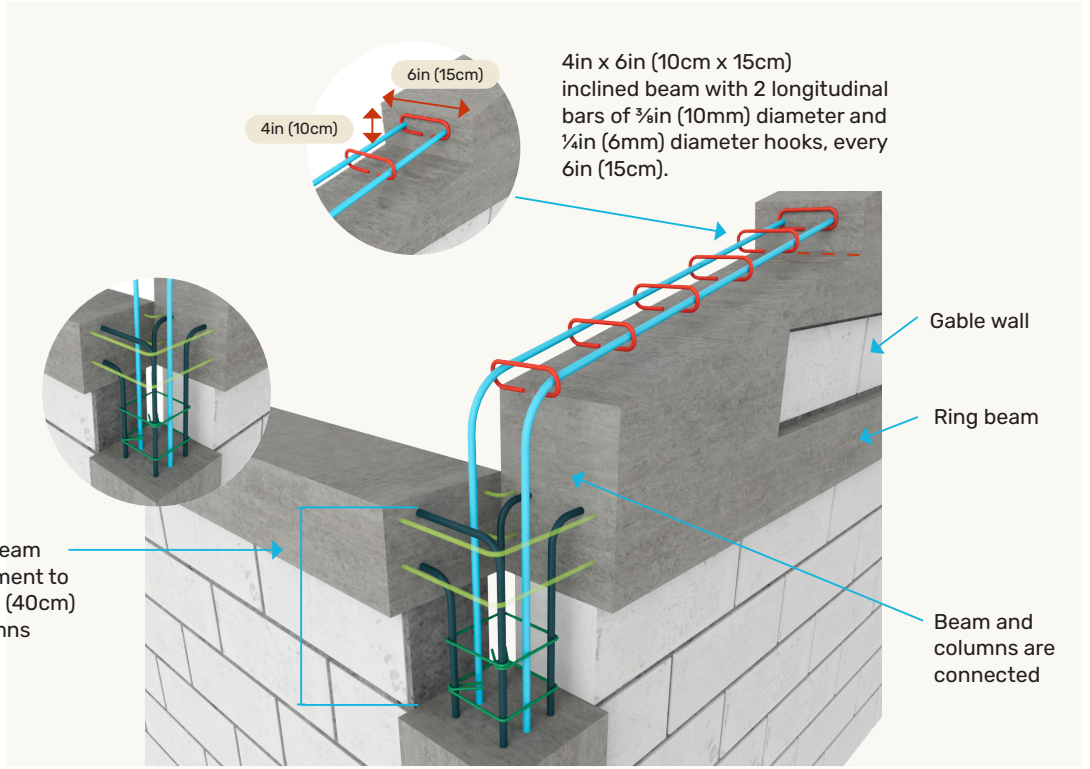
Bend ring beam and column's reinforcements at corner intersections



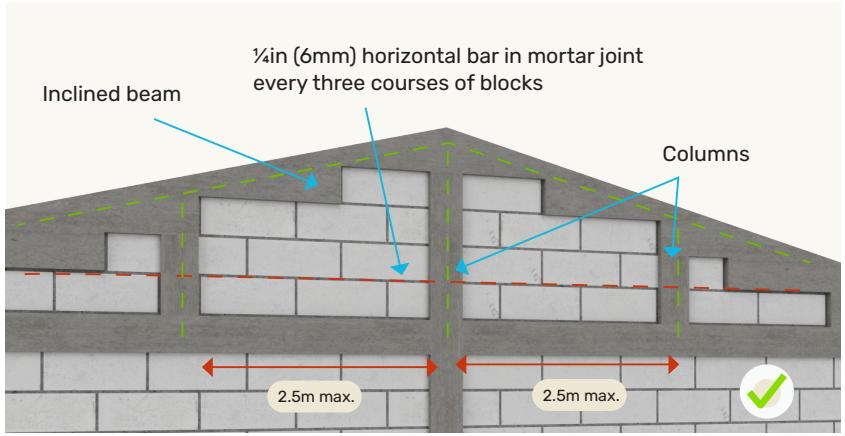
5.4 Connections

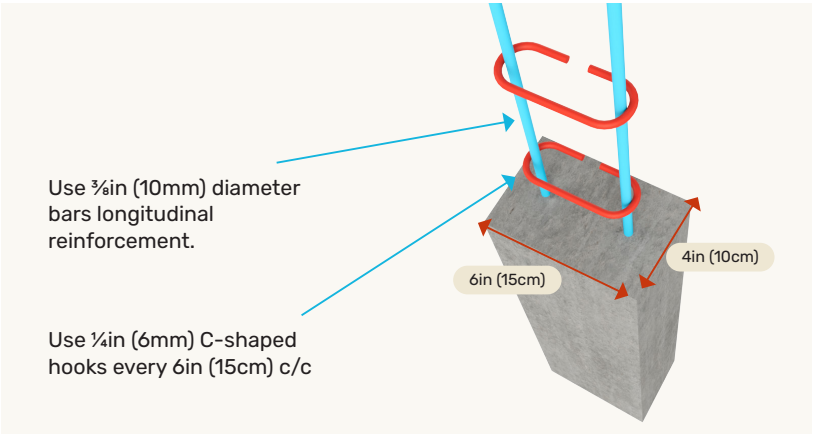
Gable walls

Gable walls are the rectangular or triangle shaped walls above the ring beam and below the roof. It is very important they are well designed and built, because if they collapse it can be very dangerous for people below.



Gable wall reinforcement





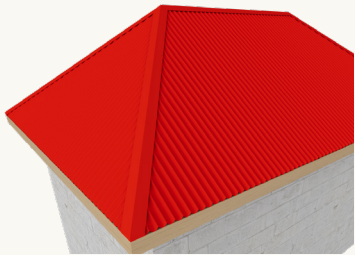
Roof

Shape

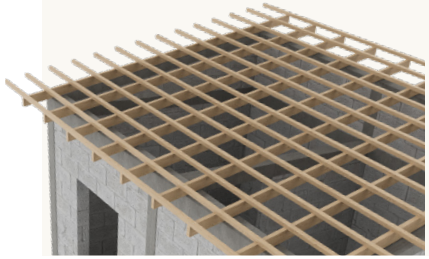
Choose the shape you prefer for your house. Hip roofs are best in strong winds, but they can be more complicated to build.

For all roof shapes, it is very important to use good quality framing elements that are the right size and spacing, and are well connected together. Otherwise, your roof may leak during heavy rain or be damaged in strong winds.

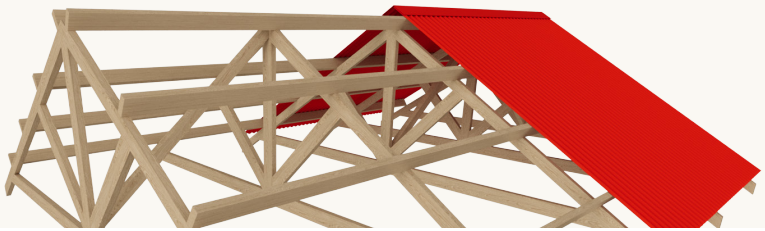
Hip Roof



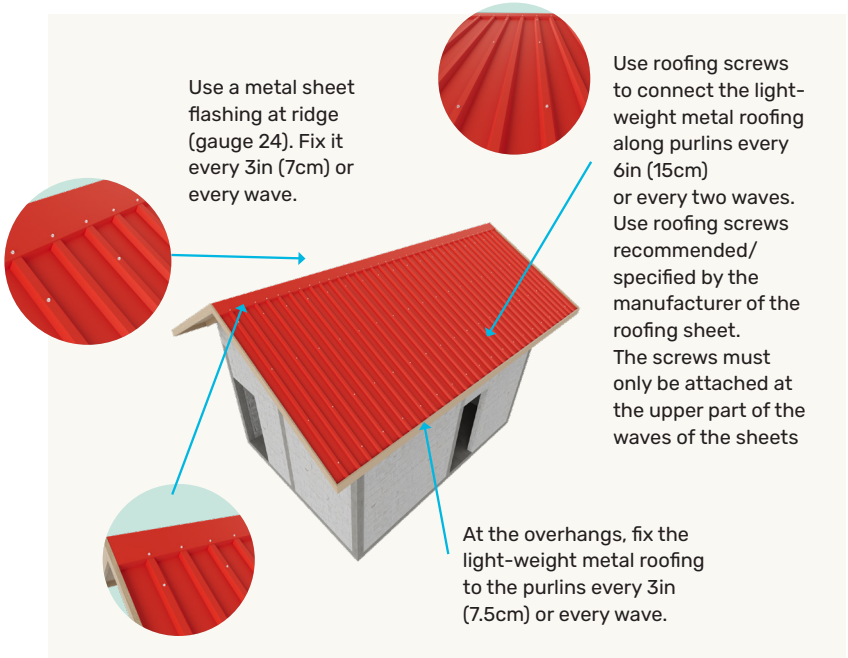
Monopitch Roof



Gable Roof



Connections



If you use light-weight metal roofing sheets to cover the roof:

- Use gauge 24 or less (0.5mm thick or more)
- Place sheets straight and in line; overlap sheets by 6in (15cm) or two waves

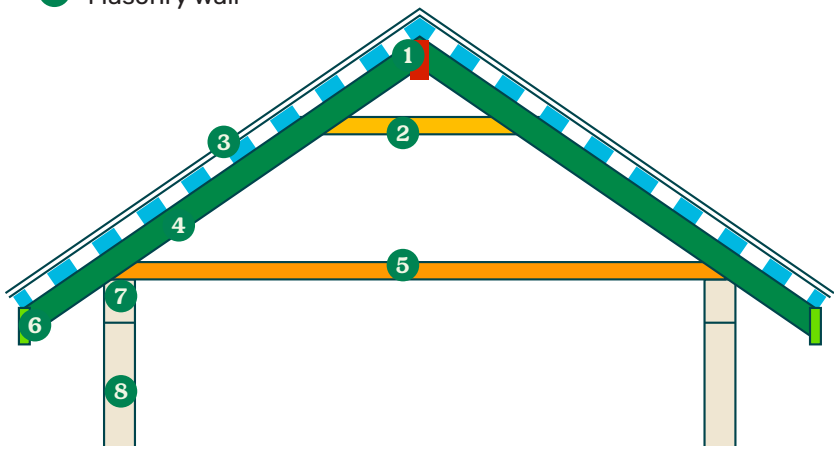
Roof

Connections

For a house to resist storms with strong wind and heavy rainfall, it is very important the roof has:

- Elements that are the right size
- Elements that are not spaced too far apart
- Strong connections between the elements

1. Ridge Board, 2in x 6in (5cm x 15cm)
2. Collar Tie, 2in x 4in (5cm x 10cm)
3. Purlins
4. Rafters
5. Ceiling Joist, 2in x 6in (5cm x 15cm)
6. Fascia board
7. RC ring beam
8. Masonry wall



Span, size and spacing of rafters and purlins

The minimum size of rafters and purlins depends on their span (the distance between supports, for example the span of a rafter is its length from ridge to wall) and their spacing (the distance between consecutive members, for example the distance between each purlin).

Minimum rafters size:

Spacing	Rafter Span					
	10ft (3.0m) or less	11.5ft (3.5m)	13ft (4.0m)	15ft (4.5m)	16.5ft (5.0m)	20ft (6.0m)
2ft (0.6m)	2in x 4in (50cm x 100cm)	2in x 5in (50cm x 125cm)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2x 2in x 6in (50cm x 150cm) sistered
3ft (0.9m)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2x 2in x 7in (50cm x 175cm) sistered
4ft (1.2m)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2in x 7in (50cm x 175cm) sistered	2x 2in x 8in (50cm x 200cm) sistered

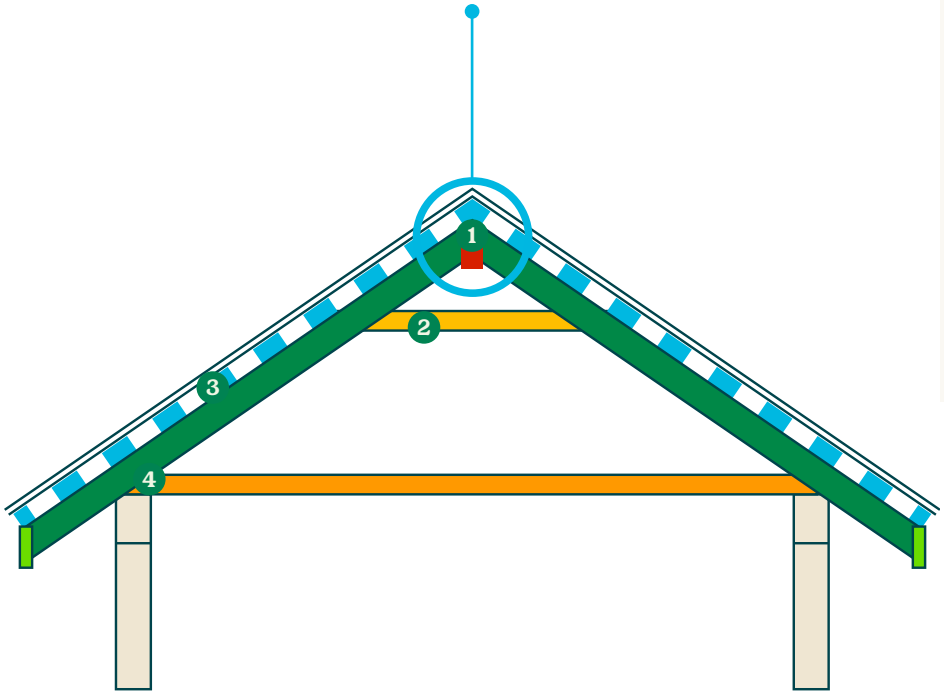
Minimum purlins size:

Spacing	Purlin Span (space between rafters)		
	2ft (0.6m)	3ft (0.9m)	4ft (1.2m)
2ft (0.6m)	1 ⅜ in x 2in (35cm x 50cm)	2in x 2in (50cm x 50cm)	2in x 2in (50cm x 50cm)
3ft (0.9m)	2in x 2in (50cm x 50cm)	2in x 2in (50cm x 50cm)	2in x 4in (50cm x 100cm)

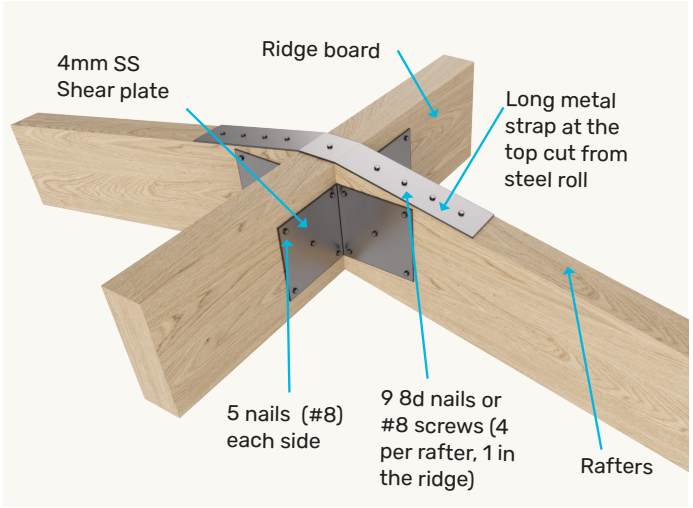
Roof

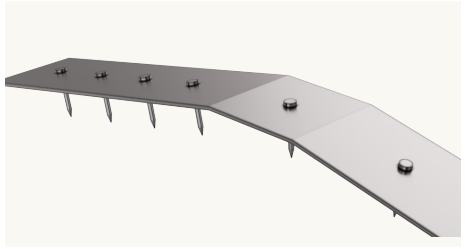
Rafter to rafter connection at ridge

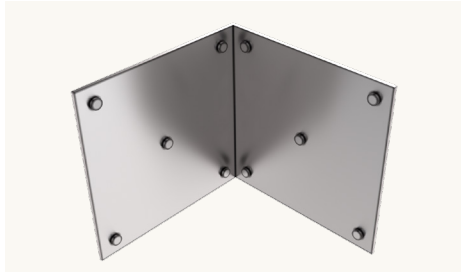
The wind force will try to pull rafters apart at the ridge. Use a long metal strap over the top of the ridge to connect the rafters together (use 4 nails in each rafter). Also, use shear plates to connect rafters to ridge (5 nails per each plate). Nails and screws should be driven at an angle into the timber.



1. Ridge board, 2in x 6in (5cm x 15cm)
2. Collar Tie, 2in x 4in (5cm x 10cm)
3. Purlins
4. Rafters







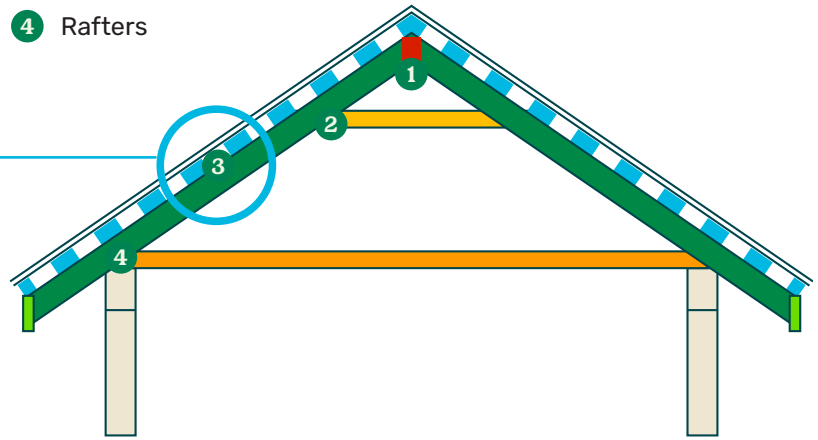
Purlin to rafter connection

Option 1: Use a bent strap (cut from a steel roll) to connect the elements. Make sure there are a total of 4 nails in the purlin and 4 nails in the rafter.

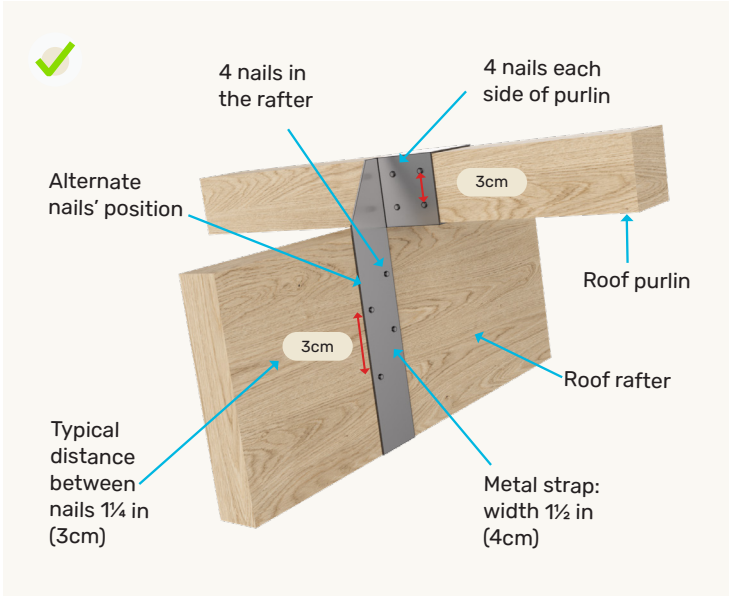
Option 2: Use two 3.5in screws at every connection point. Make sure the screws go 1.5 in (cm) into the rafter.

Do not use fishing wire or string to tie the connection.

1. Ridge board, 2in x 6in (5cm x 15cm)
2. Collar Tie, 2in x 4in (5cm x 10cm)
3. Purlins
4. Rafters

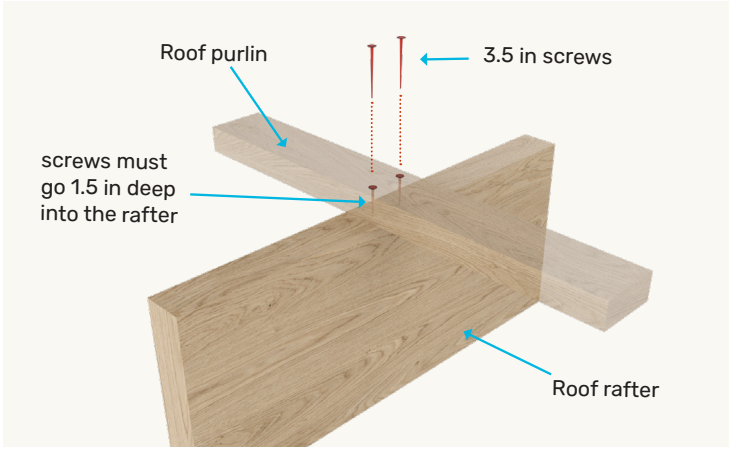


Option 1:



Source: Build Change

Option 2:

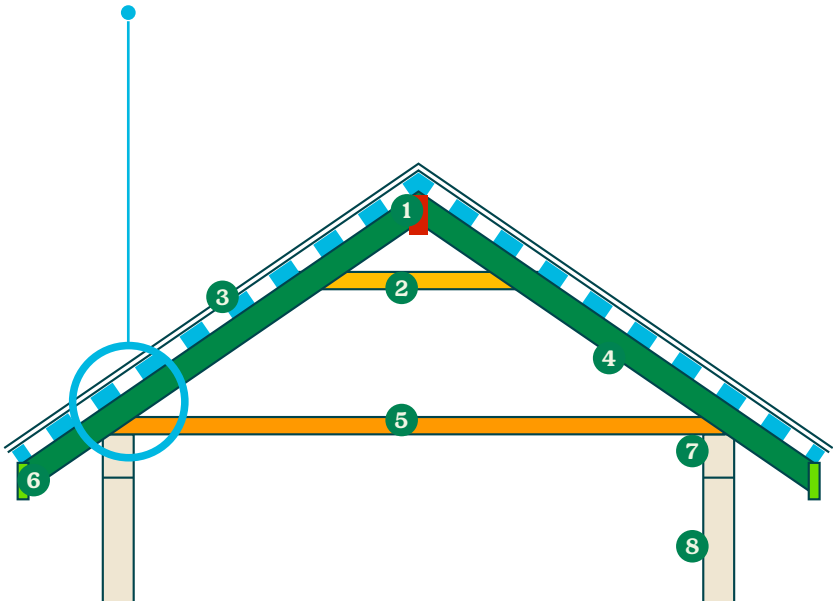


Source: Riyan Private Limited (made for this project).

Rafter to ring beam connection

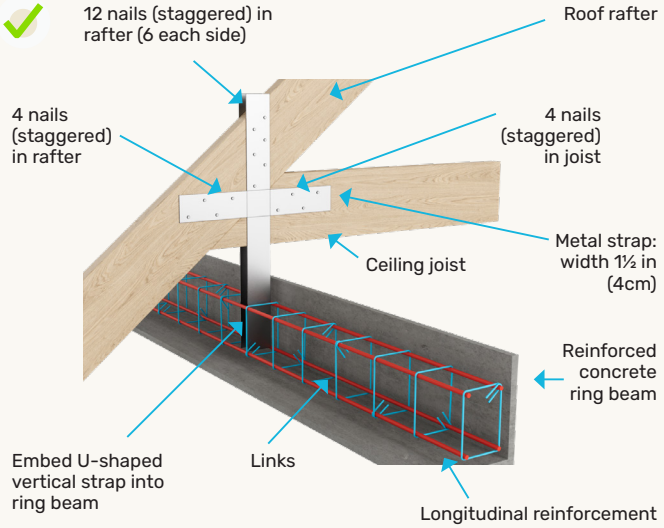
Embed a strap into the reinforced concrete ring beam.

Use a total of 12 nails to connect the strap to the rafter.



1. Ridge board, 2in x 6in (5cm x 15cm)
2. Collar Tie, 2in x 4in (5cm x 10cm)
3. Purlins
4. Rafters
5. Ceiling Joist, 2in x 6in (5cm x 15cm)
6. Fascia board
7. RC ring beam
8. Masonry wall

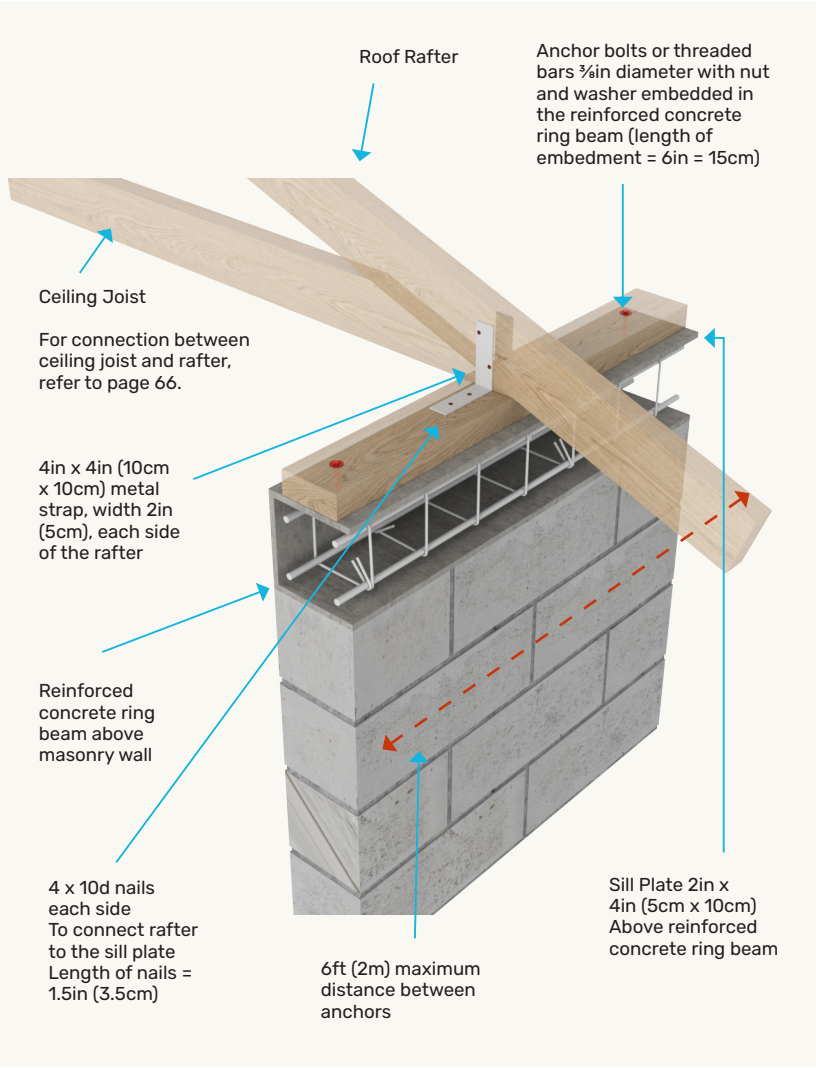
Option 1:



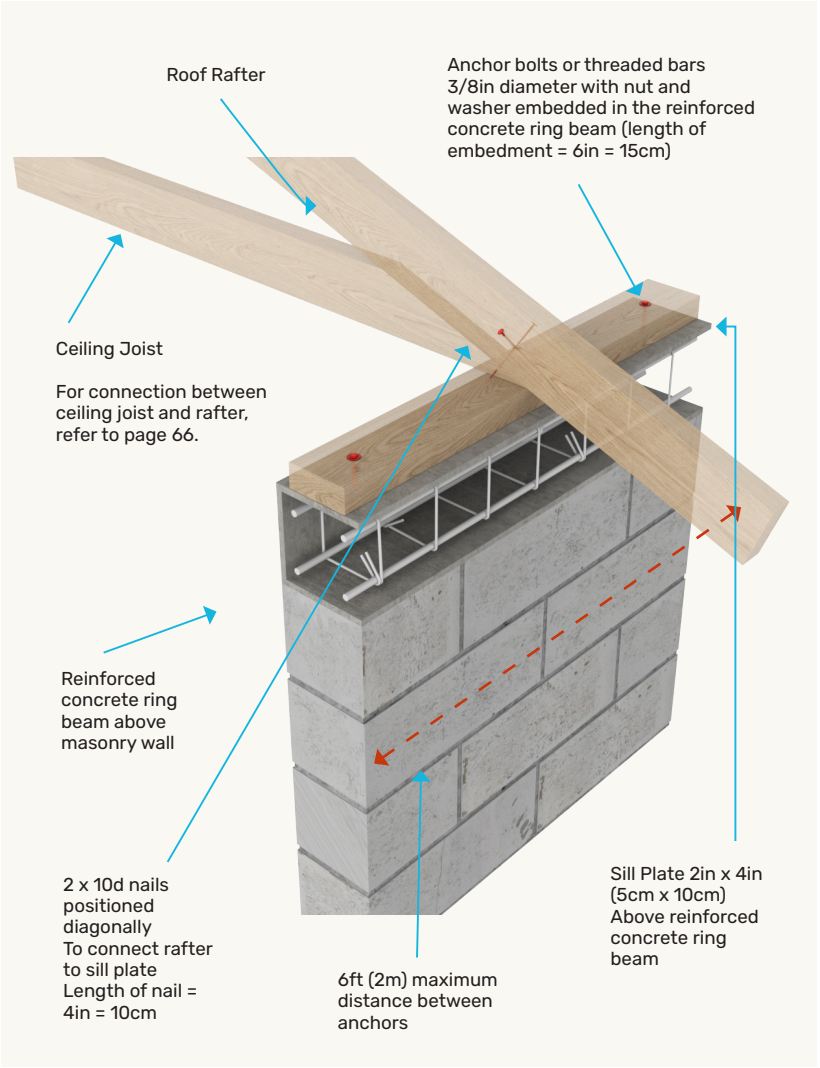
- Do not embed the rafter in masonry without a metal strap.
- Do not use fishing wire to tie the rafter to the wall.

Source: Riyan Private Limited (made for this project).

Option 2:



Option 3:

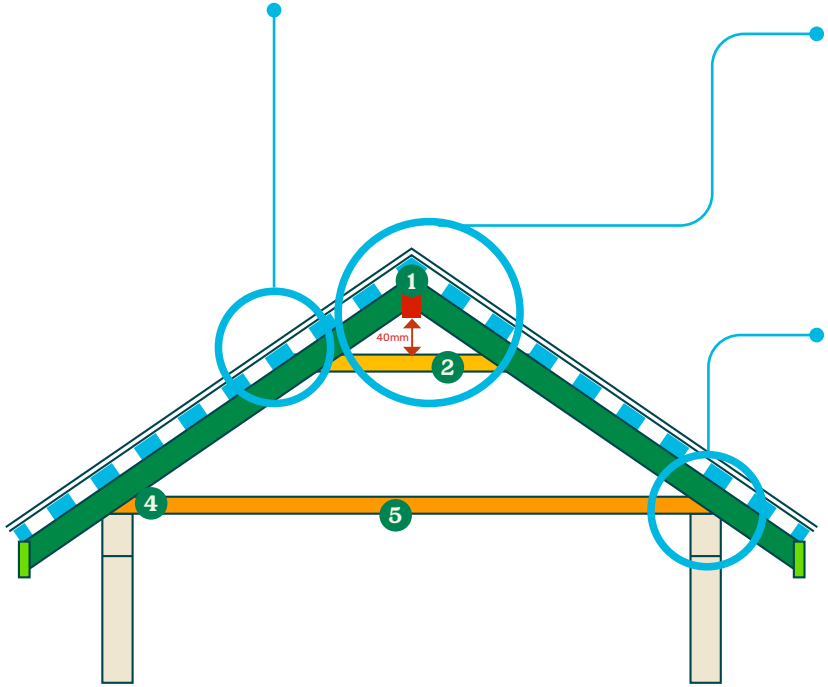


WARNING: It is not recommended to use a single threaded bolt through the narrow side of the rafter to secure it to the ring beam as this will weaken the joint by splitting the rafter.

Collar tie to rafter connection

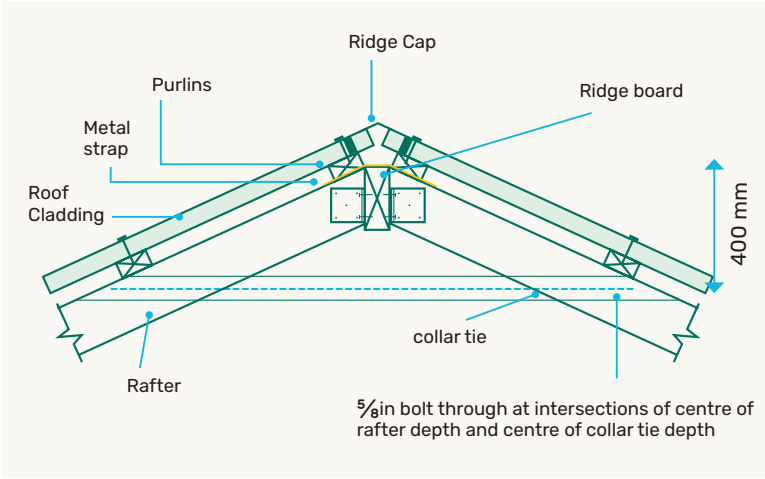
Every 4ft (1.2m) along the ridge beam, connect a 2in x 4in (5cm x 10cm) collar tie to rafters with a through bolt.

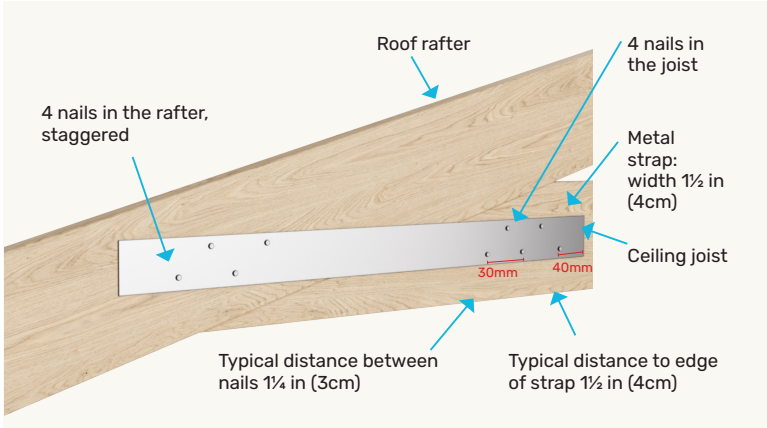
Use a ⅝in bolt if rafters span is >11.5ft (3.5m) or a ¾in bolt for rafter spans <= 11.5ft (3.5m).



1. Ridge board, 2in x 6in (5cm x 15cm)
2. Collar Tie, 2in x 4in (5cm x 10cm)
4. Rafters
5. Ceiling joist

Collar tie to rafter connection





Rafter to ceiling joist connection

Cut the ceiling joist so it can follow the slope of the rafter.

Use a strap on either side to connect the rafter to the joist. Make sure you use at least 4 nails in the tie and 4 nails in the rafter. Nails and screws should be driven at an angle into the timber.

Appendages

Roof overhangs, *undhoalige* and verandahs are very susceptible to damage during strong winds. This is why it is important to build them strong and with resistant connections.

Source: Guide to Dominica's Housing Standards.

Some important construction recommendations for the roofs:

- Build verandah and patio roofs as separate structures rather than extensions of the main building. Then if they do blow off, it will not damage the rest of the house.
- Avoid large overhangs as high wind forces build up under them. Overhangs should not be more than 18in (45cm) at edges or eaves.

In this photo, the carport collapsed due to strong wind. As the carport shared a roof with the main house, when it collapsed it also damaged the main house which otherwise was strong enough to resist the wind.

Some important construction recommendations for the structure of patio roofs:

- Supporting posts should be made of metal posts (3in x 3in - 7.5cm x 7.5cm) or timber posts (4in x 4in - 10cm x 10cm), with maximum spacing of 10ft (3m).
- Connections to the concrete ground slab or to the roof structure should be strong, not corroded and not using fasteners that are too small.
- Timber posts should be raised above ground on a reinforced concrete pillar to avoid contact with water which will cause them to rot.

Anchor plate missing many connections to the slab.

Connection to ground with anchors well spaced and symmetrically positioned.

Timber posts raised above the ground.

Source: Attached structures high wind research, T. Reynhold, R. Reynhold, M. Morrison, Insurance Institute for Business &Home Safety, July 2014.

Source: https://www.secorcomplete.com/perma-columns-pre-cast-post-bases/

- Beams should be made of metal (3in x 3in - 7.5cm x 7.5cm) or timber (4in x 4in - 10cm x 10cm) minimum.
- Timber beams should be fixed to posts with a metal strap, 18 gauge and 2in (5cm) wide, using minimum 10 nails.

6 /

Make your house **Stronger**

Natural hazards such as floods and strong winds cannot be prevented...

...but they do not have to be disasters. You can prepare by improving your existing house to reduce the risk of damage and collapse.

This chapter provides construction solutions to make your existing house stronger. See also Chapter 7 for recommendations on how to make your house comfortable and efficient.

6.1 Identifying problematic cracks due to soil conditions

Look for cracks

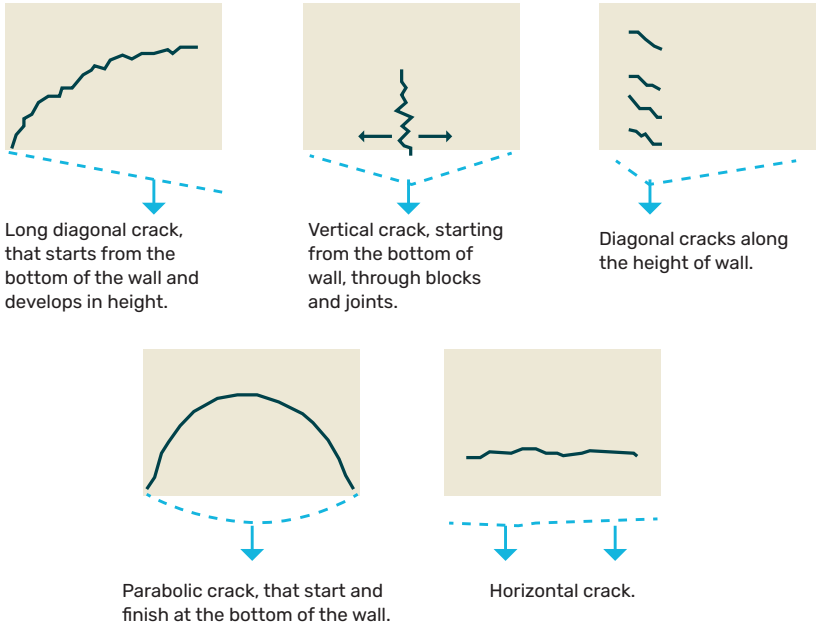
If your existing house has cracks in the walls, it might be a sign that either your soil conditions or your existing foundation are not good enough.

Source: Riyan Private Limited (made for this project)

Other reasons for cracks include heat, and lack of lintels and sills and other structural elements at openings.

How to identify problematic cracks

Not all cracks are a serious problem, but if you notice any of the following patterns of cracking in any of your walls, it might be a sign of foundation and/or soil problems and it is best to consult an engineer before making any changes to your house.



Source: ASI 410 AIS 410: EVALUACIÓN Y REDUCCIÓN DE LA VULNERABILIDAD SÍSMICA EN VIVIENDAS DE MAMPOSTERÍA (Asociaciòn Colombiana de Ingenieria Sismica).

WARNING:

If you notice cracks up to 3ft (1m) long and less than 1/8in (3mm) wide, you can repair them. See 6.2 for details.

If possible, it is best to consult an engineer if you notice any of the following:

- Cracks longer than 3ft (1m) that are over 1/8in (3mm) wide and present on more than one wall.
- Cracks that become wider and/or longer over time.

6.2 Wall Repairs

Cracks can be repaired as follows:

1.

Identify the crack in the wall. If you can see the crack on both sides of the wall, both sides will need to be repaired. Otherwise, only the side where you see the crack needs to be repaired.

2.

If the wall is plastered, chip back the plaster so a 20in (50cm) wide strip is exposed along the crack.

3.

If the crack is less than ¼ in (5mm) wide, fill with cement mortar (1 part cement, 3 parts sand).

4.

If the crack is more than ¼ in (5mm) wide:

- Fill the crack with cement mortar (1 part cement, 3 parts sand).
- Insert 4in (10cm) long hooks into the wall, spaced not more than 1ft (30cm) apart and staggered.
- Lay the mesh over the hooks, making sure there is a gap of ½in (1cm) between the mesh and the wall.
- Once the mesh is installed, cover with cement plaster (1 part cement, 4 parts sand).

WARNING: Cracks reduce the walls strength and can cause water leaks.

6.3 Roof Repairs

Add a ring beam

A ring beam on existing walls can be built as follows:

WARNING:

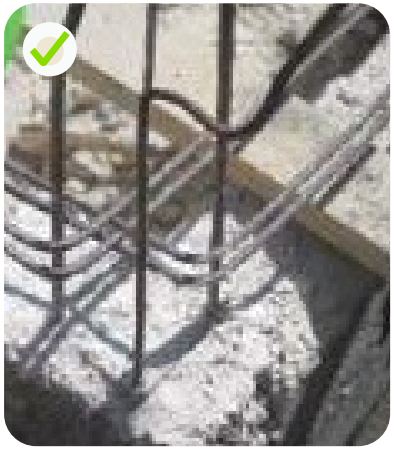
The lack of ring beam above existing walls (made with coral stone or masonry blocks) increases the risk of damage or collapse, especially of the lightweight roof.

1. Remove the existing roof. Check the existing materials and store to be reused.

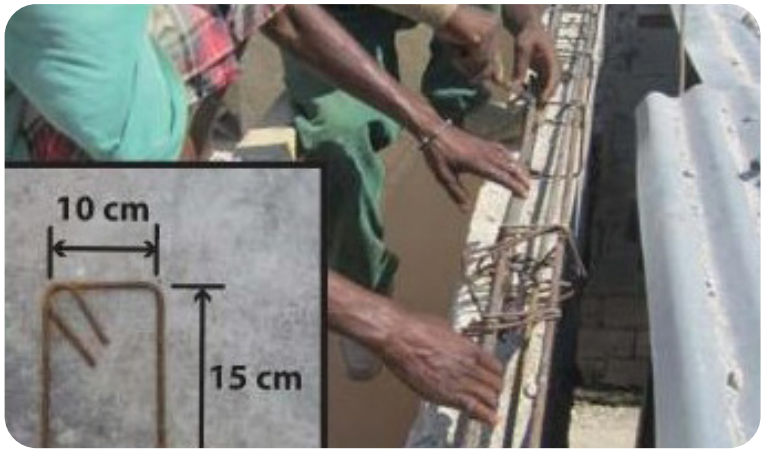
2. Demolish the existing gable walls so that the top of all walls are flat and at the same level.

3. Use a water level to make sure all the walls are at the same level.

4. Cut, bend and place longitudinal bars (4x 3/8in - 10mm bars) for the ring beam.

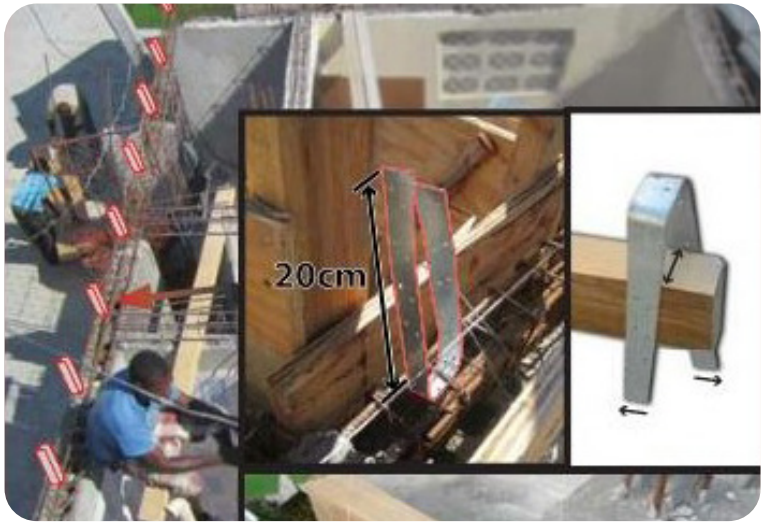


5. Make sure that overlaps are at least 18in (45cm) and bars are well bent at the corners, around the column bars.



6. Bend 1/4in (6mm) bars for links and place them every 6in (15cm). Ensure that the column reinforcement is bent and placed inside the link along with the horizontal reinforcement of the beam.

7. Place the two 3/8in (10mm) starter bars for the inclined gable beam above the new wall.



8. Position the metal straps in the ring beam for the roof rafter connection (see Chapter 5)

9. Place the formwork, reinforcement and 1 1/4in (3cm) spacers (see Chapter 5).

10. Pour the concrete and vibrate it using a hammer. Cure for 3 days before placing blocks.

11. Use string to define the shape of the gable walls and place the blocks (cut blocks as needed).

12. Position the reinforcement for the inclined gable beam and follow concrete steps 9-10 for concrete.

Strengthen existing timber roof elements

Rafters

Existing rafter dimensions and spacing should be as follows:

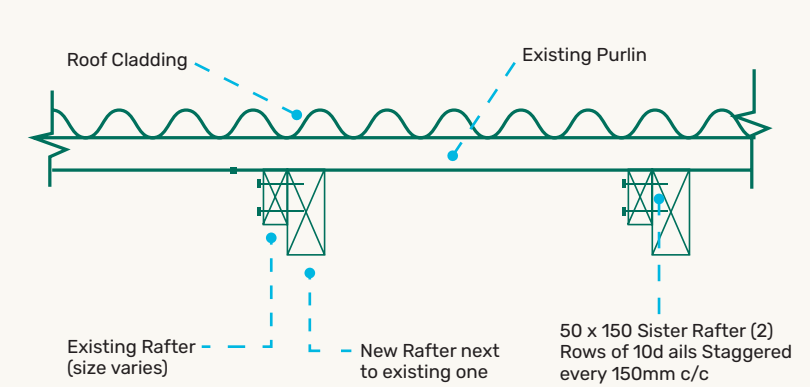
Spacing	Rafter Span					
	10ft (3.0m) or less	11.5ft (3.5m)	13ft (4.0m)	15ft (4.5m)	16.5ft (5.0m)	20ft (6.0m)
2ft (0.6m)	2in x 4in (50cm x 100cm)	2in x 5in (50cm x 125cm)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2x 2in x 6in (50cm x 150cm) sistered
3ft (0.9m)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2x 2in x 7in (50cm x 175cm) sistered
4ft (1.2m)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2in x 7in (50cm x 175cm)	2x 2in x 8in (50cm x 200cm) sistered

WHAT YOU CAN DO

If the existing rafters in your house do not meet these requirements, you can strengthen them by adding additional elements.

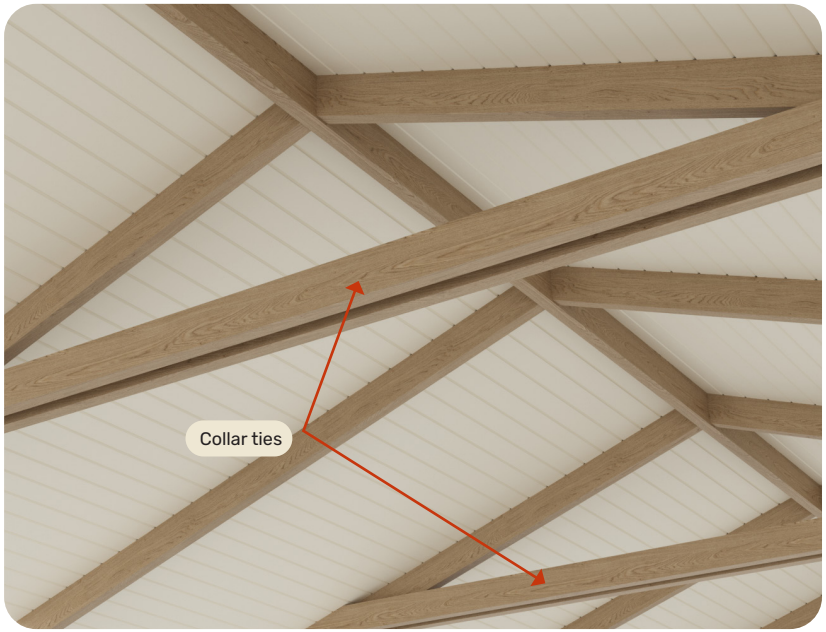
WARNING:

If an existing roof is built with weak elements, it is at high risk of damage or collapse. Furthermore, the habitability of the house can be compromised by the intrusion of debris, drafts and rain if the roof is not fully sealed.



Ridge beam

2in x 4in (5cm x 10cm) collar ties should be introduced every 4ft (1.2m) and connected to rafters, to help strengthen the roof.



Source: Build Change.

Strengthen existing timber roof elements

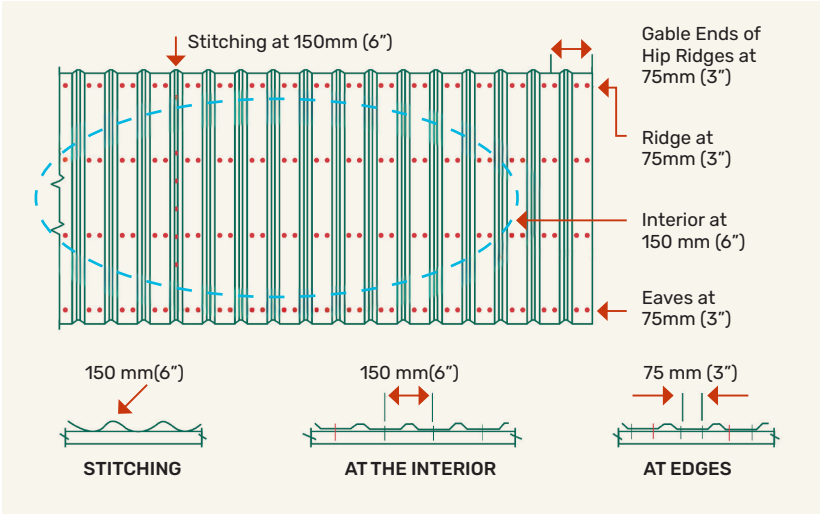
WARNING: Strong connections between roof elements and roof to supporting walls are essential for wind resistance.

Inadequate connections can be strengthened as follows:

Connections between timber elements (light-weight roofing, purlins, rafters, ceiling joists, ridge beam, collar tie)

The connection between roof sheets and purlins can be strengthened by adding screws or nails. 12in (30cm) c/c is recommended if nails are used; 20in (50cm) c/c if screws are used.

Connections between timber elements can be strengthened by using metal clips or straps with nails.



Source: Guide to Dominica's Housing Standards.

Rafters to ring beam connection:

Often rafters are simply supported on walls/ring beam or are connected to them with inadequate materials (e.g. fishing wire).

This connection can be strengthened by introducing a 2in x 6in (5cm x 15cm) ledger along the wall using 3/8in (10mm) bolts through (with nuts and washers) every 6ft (2m). Rafters can be fixed to the ledger with metal clips.

7 /

Build your house **Comfortable and Efficient**

Buildings in hot, humid climates must be designed to minimise heat gain and maximise natural ventilation to create comfortable internal environments.

Maldives is located in the tropical regions close to the equator, with a hot and humid climate throughout the year.

If your home is not properly cooled and ventilated, it may affect you or your family's mental and physical health. This chapter offers recommendations for how you can make improvements in your new or existing home.

7.1 Introduction to Basic Concepts of Comfort and Energy Efficiency

What does COMFORT mean?

- Thermal Comfort – inside your home is a comfortable temperature and humidity level. This can be provided by a mix of cooling systems like AC units, as well as natural cooling strategies like building insulation, shading, and natural air flow for ventilation.
- Indoor Air Quality - ventilation in your home is very important to provide fresh air and remove odors/contaminants from spaces. Without good ventilation, mold can develop which is very dangerous to health.
- Lighting - good lighting distribution and access to daylight improves space comfort within the space.

What does EFFICIENCY mean?

- Minimise the use of energy and water.
- Prioritise using natural resources to reduce energy and water use.
- Use efficient building systems to further reduce energy and water use.

7.2 Comfort

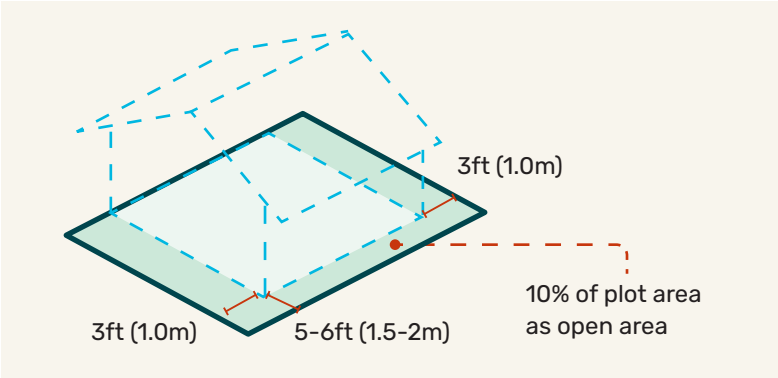
Where and how to build on your plot

House orientation and setbacks

Correct **plot organization** will improve air flow and natural lighting, making living in your house feel more comfortable.

Building without setbacks can result in:

- Heat island effect and hotter temperatures in the area
- Increased risk of fire spreading
- Increased risk of water seepage from between buildings
- Potential damages during demolition and excavation in adjacent plot



Source: Riyan Private Limited (made for this project)

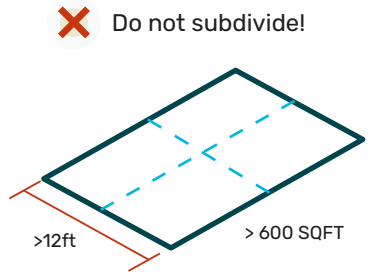
- **Recommended minimum setbacks* from plot boundaries:**
  - 5-6ft (1.5-2.0m) from front;
  - 3ft (1.0m) from other sides;

*Plot sizes might limit the possibility of respecting these setbacks.

- **Minimise exposure of east-west facades through setbacks,** shading and roof overhangs, this will help reducing the solar gain and the temperature in the inside.
- Leave a minimum 10% of plot area as open area .

Plot subdivision

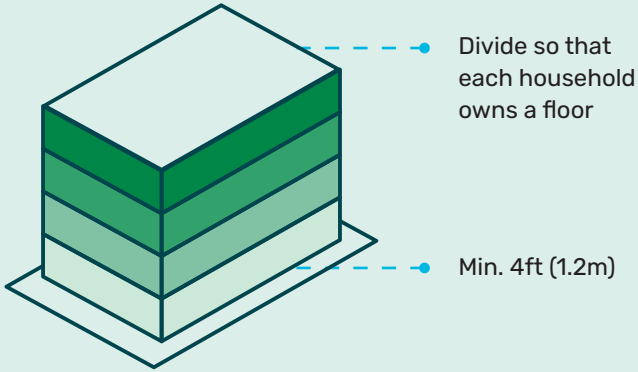
- Avoid plot subdivisions below 600 sqft (56 m2).
- Plot width should not be narrower than 12 ft (3.5m)
- Access paths width should be minimum 4 ft (1.2m). It is recommended that it be 5 ft (1.5m).



WHAT YOU CAN DO: Alternative to small subdivision of plots

You can opt for family-owned condominiums and build multi-storey with each household owning one floor or more. This will ensure each household is provided with sufficient living space with adequate light and ventilation.

Remember: building above 1-storey requires building approval from the Council.

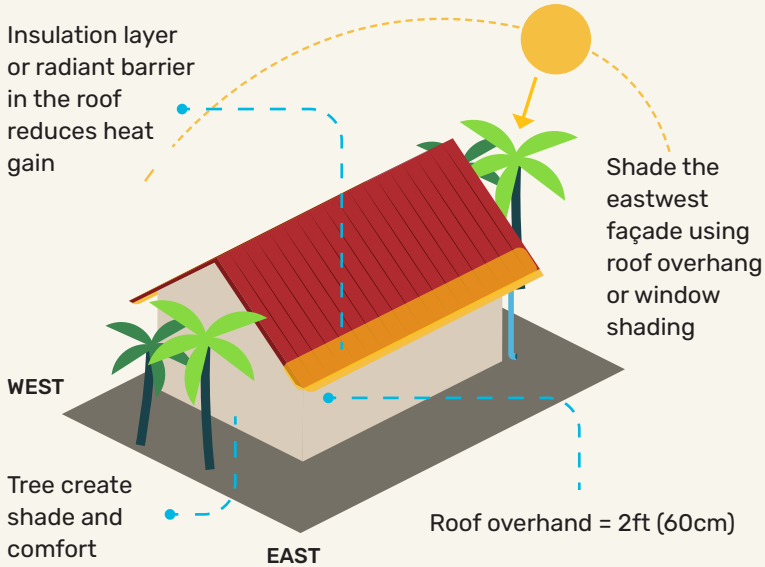


Source: Riyan Private Limited (made for this project)

Thermal

Shading and insulation

- **Shading:** Shading facades and windows—particularly on the East-West facades— can help reduce the temperature inside your house.
- **Roof insulation:** You can insulate your roof with 2in (5cm) thick mineral wool with reflective layers, laid on a wire mesh between the purlins and the roof sheets.
- **Paint colour:** Internal walls and ceiling surfaces should be painted with light colours as these help reflecting and amplifying the light.
- **Internal ceiling:** You can enhance the roof insulation and reduce the need for A/C by adding an internal ceiling.
- **Reflective Glass:** Reflective glass reduces the solar gain so you can reduce the use of energy for AC.
- **Plastering:** You can plaster walls according to chapter 5 to reduce heat gain and help manage humidity



Source: Riyan Private Limited (made for this project).

Natural ventilation and lighting

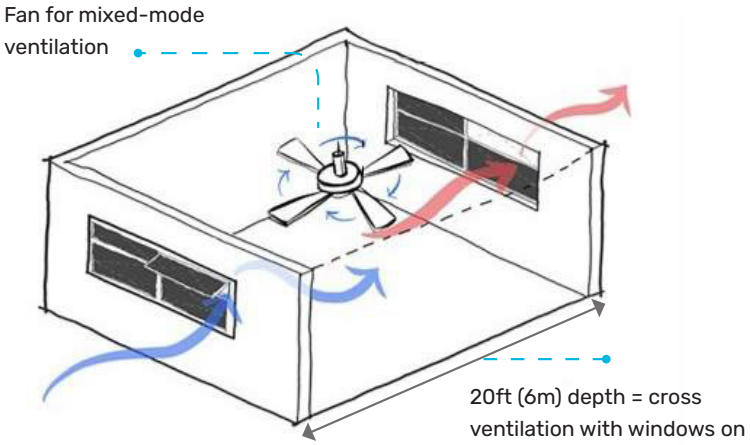
Proper ventilation and natural lighting is required for a healthy home. Poor ventilation can increase the risk of respiratory diseases and problems, and effect the immune system, cognitive ability and sleep quality. Without proper ventilation, mould and moisture problems can develop in your house. Natural light is also essential for our brain function and mental and emotional well being.

WARNING:

You must have provisions for natural ventilation even if the room has an AC.

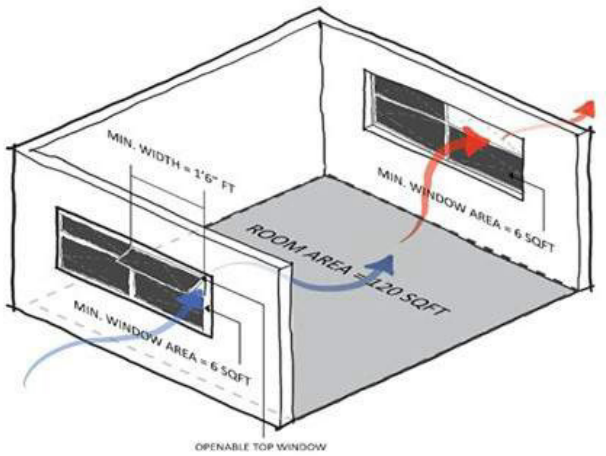
Window types, sizes and shapes

- The total openable window area should be at least equal to 10% of floor area of the room.
  - 5ft x 8ft (1.5m x 2.4m) bathroom: Minimum 2ft x 2ft (60cm x 60cm) window.
  - 9ft x 9ft (2.7m x 2.7m) bedroom: Minimum 2ft x 4ft (60cm x 120cm)window.
  - 12ft x 12ft (3.7m x 3.7m) living room: Minimum 2.5ft x 6ft (80cm x 180cm) window.
- The openable section should not be less than 1.6ft (50cm) wide.
- Windows with a top hung section and a swing section below will encourage flow of air when lower segment is opened on one side and the upper section is opened on the other.



Window positions

- **Single sided ventilation (openings on only one side of a room):** effective for rooms up to 20ft (6m) deep.
- **Cross ventilation (openings on opposite sides of a room):** If the depth of the room is deeper than 20ft (6m)cross ventilation should be provided. Windows do not need to be aligned and can be placed diagonally.
- **Mixed mode ventilation:** Ceiling fans used with open windows improve air flow and thermal comfort.



AC units

When and how to use AC units:

The cheapest and most efficient way to cool your house is by following the recommendations on the previous pages, including:

- Maintaining sufficient building setbacks.
- Minimising east-west façades.
- Placing windows and fans to maximise natural ventilation.
- Providing thermal insulation, with plaster and roof insulation.

At certain times of the day or year you may want to supplement these recommendations with an AC unit.

- Install the outdoor unit away from direct sunlight and as close to the indoor unit as possible to maximise efficiency.
- Consider using multi-zone and/or variable refrigerant flow (VRF) mini- split air conditioning systems if you want to cool multiple rooms. Multi-stage units typically have greater control and increased energy efficiency.
- Where possible, place condensing units for mini-split air conditioning systems in shaded areas to improve energy efficiency. Ensure that there is a minimum of 3ft (1m) clearance on the fan discharge side of the unit.
- Minimise refrigerant piping distance for mini-split systems to reduce cooling energy.

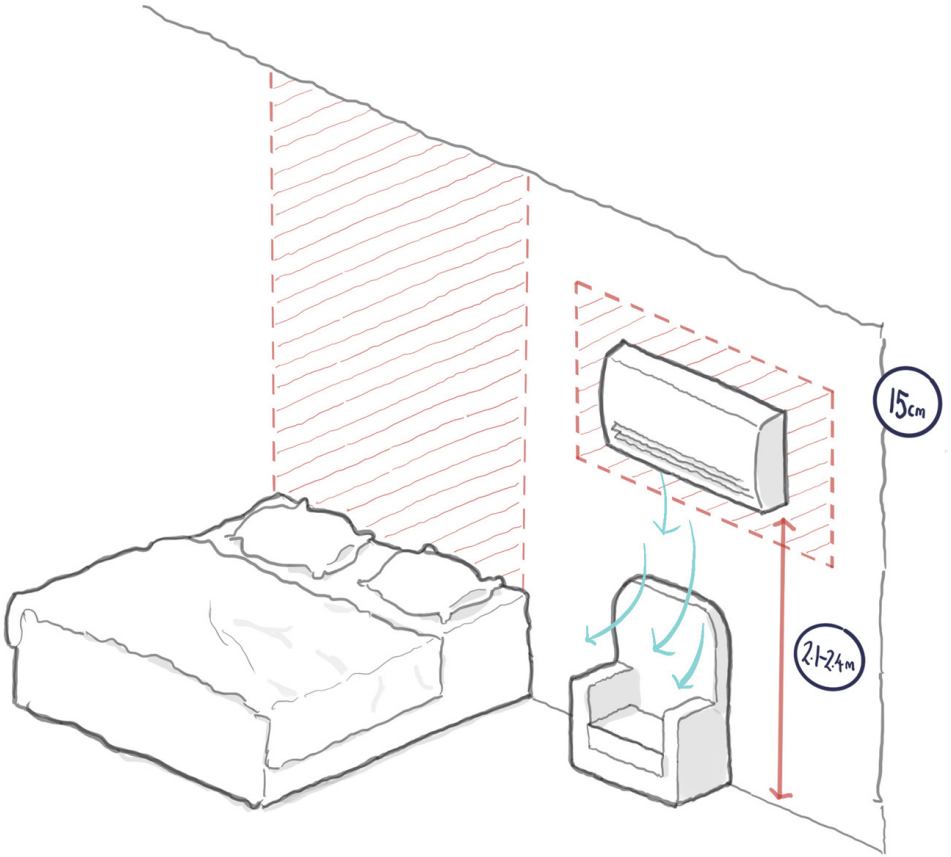
Tips for correct use of AC units:

DO:

- Install the AC unit 7-8ft (2.1-2.4m) above the floor with at least 6in (15cm) clearance around the unit.
- Ensure that there is a minimum of 1ft (30cm) clearance on the fan discharge side of the outdoor unit.
- In bedrooms: Install the indoor unit to the side of the bed or on an adjacent wall to avoid directing cold air onto the bed.
- In living rooms: Install the indoor unit centrally on the longer wall of the living room, or above the sofa.
- Install the outdoor unit away from direct sunlight and as close to the indoor unit as possible to maximise efficiency.

DO NOT:

- Do not install indoor units above a cupboard, door, or TV.
- In bedrooms: do not install indoor units directly above or facing the bed. This will cause dry skin, lips and throat.
- If living room and kitchen are connected, indoor units should not be installed near the kitchen area.
- Do not locate outdoor units in an enclosed space.



7.3 Water Efficiency

Rain water harvesting

Recommended water sources for domestic use

Rain water (collected from roofs and stored in tanks)

- Can be used for irrigation, bathing, flushing and laundry. Rainwater should NOT be used for drinking or cooking unless it has been properly filtered.
- Does not need to be paid for - so can be used to reduce the consumption of supplied water.

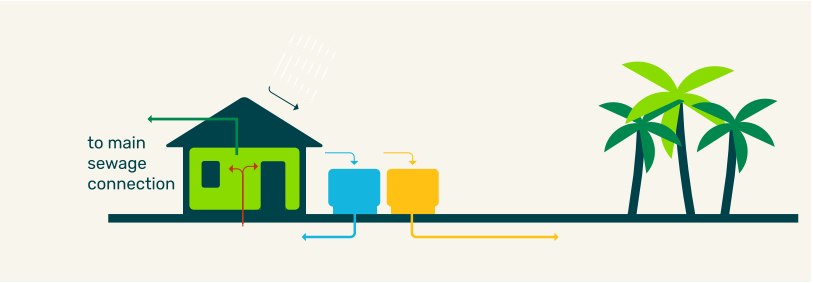
Utility supply (treated seawater, piped to houses)

- Can be used for all purposes, including drinking and cooking.
- It comes with a cost, so its use should be reduced via rainwater.

Ground water (from wells)

- Not recommended for general use as it may be contaminated by seawater and may damage the environment and further increase the risk of seawater intrusion.

Rainwater is a valuable resource as it can reduce your household utility water use, and **lower your water bills.**



Choosing the right roof material

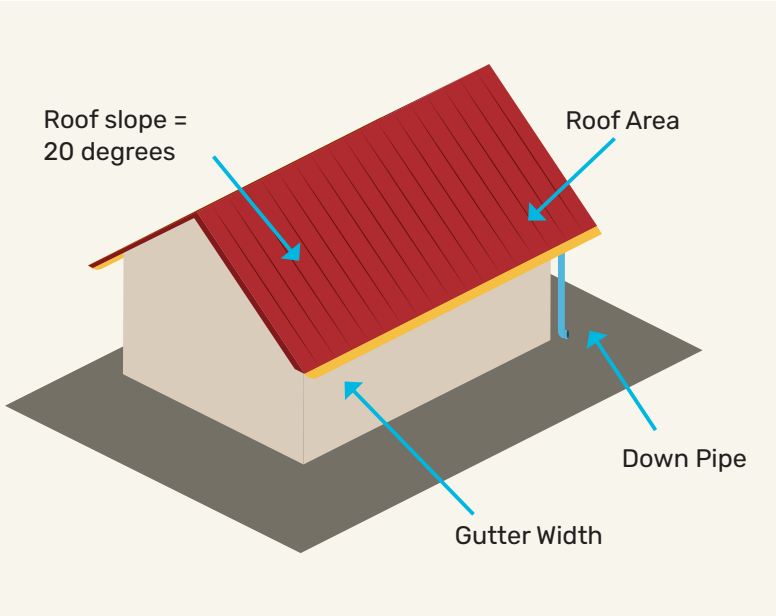
The best roof material for rainwater catchment is either **proprietary coated or galvanised steel sheets.** These are the easiest to use, give the cleanest water, and are available in Maldives.

WARNING:
Rainwater should ONLY be used for drinking or cooking if it has been filtered

Rain water harvesting

Sizing gutters and downpipes

The size of the gutter and downpipes depends on your roof area:

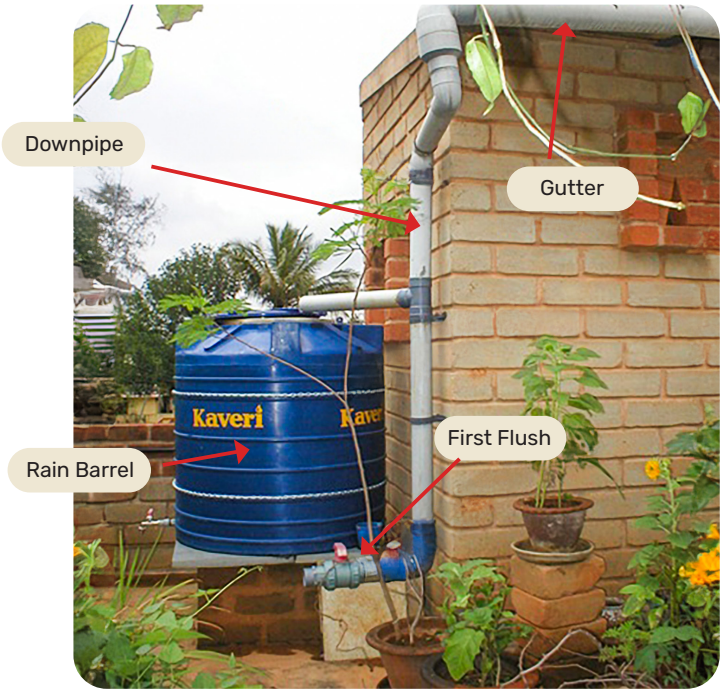


Source: Riyan Private Limited (made for this project).

Roof Area	Gutter Width	Down Pipe
270-370sqft (25-34m²)	3 in (8cm)	2in (5cm)
500-700sqft (46-66m²)	4in (10cm)	2.5in (6cm)
1400sqft (130m²)	5in (12cm)	3in (7.5cm) recommended
2300sqft (210m²)	6in (15cm) recommended	3.5in (9cm)

Choosing a storage tank

- **HDPE and PVC storage tanks are recommended** as they have resistance to high temperatures, rust, and are lightweight.
- A tank with capacity of 1,200 Liters can provide water for 4 people for 15 days. A tank with capacity of 2,400 Liters can provide water for 4 people for a month.
- **PVC pipes 3/4 - 1in (2-2.5cm) diameter** distribute the water from the tank to the house.



https://www.ntotank.com/blog/first-rain-separator

- Consider installing an additional pipe and valve to divert tank overflow into the groundwater well. Additionally, during heavy rainfall in low lying areas, overflow may need to be diverted into the island storm water management system.

Plumbing

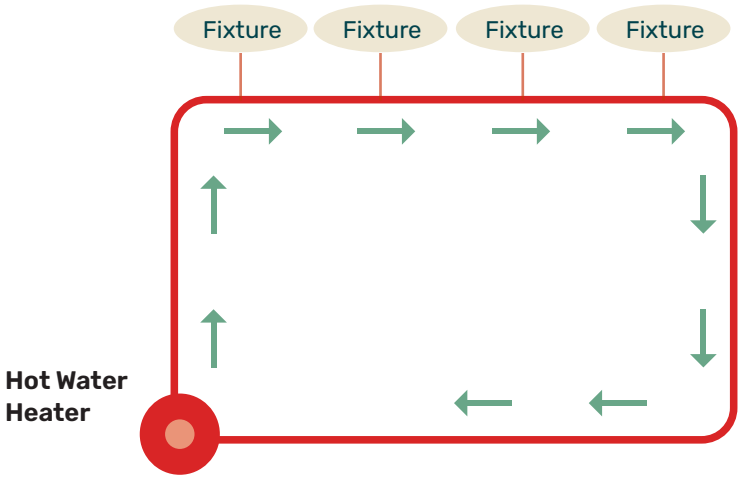
Hot water systems

Hot water can be provided in your house with either a:

- Water heater.
- Solar water heater.

Designing the hot water piping system to include a **circulation loop with branch takeoffs to fixtures** not exceeding 10ft (3.0m) will:

- Minimise water usage.
- Minimise heating.
- Enable more flexibility in the system for future expansion (for example if you add another bathroom).

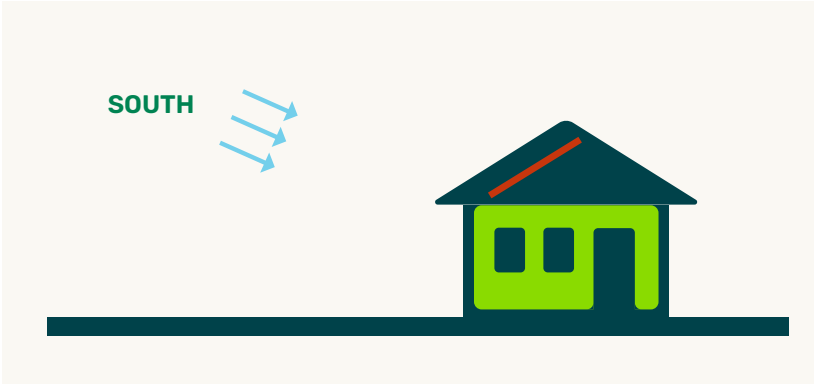


7.4 Energy Efficiency

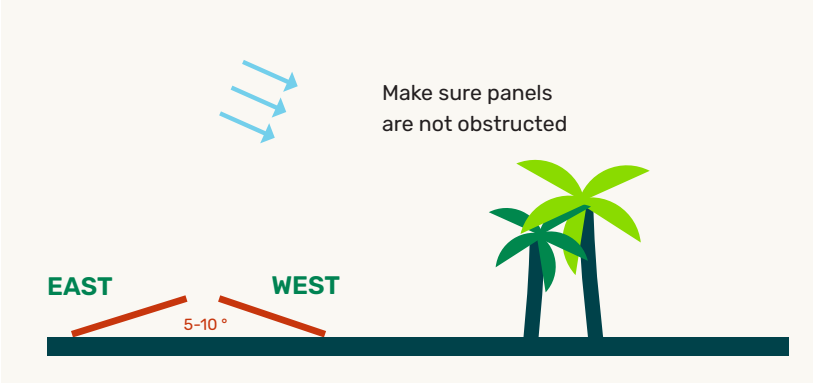
Solar power

Solar power is an excellent opportunity to reduce the amount of utility provided energy, which will reduce your household costs and have a positive impact on the environment.

Panels can be installed on the roof:



Or panels can be installed on the ground:



WHAT YOU CAN DO: Solar power

- Discuss with solar panel providers such as STELCO to plan the most suitable setup for the house (solar capacity, connection to grid, battery storage, etc).
- Talk to your utility provider (STELCO, FENAKA) to see whether they will buy back excess power your panels produce, and at what rate.
- Consider allocating space on your plot for future battery storage, so you can store energy to use at night or when the main energy supply is cut. Batteries should be kept in a dry and ventilated space.

Tips to optimize electrical systems

- Design the primary electrical system to enable inclusion of future photovoltaic panels.
- Consider the potential future electrical loads when sizing the main electrical utility service to enable electric vehicle charging.
- To save energy and cost of electricity, it is recommended to use LED lighting. They also stay cool and don't heat up a room.
- All electrical wiring & installations must be carried out by a licensed electrical engineer, registered with the Ministry.

7.5 The benefits and the costs of making your home comfortable and efficient

Savings Strategies:	What will the strategy improve?			How much will the strategy save and cost?		
	Thermal Comfort	Interior Air Quality	Resilience	**Operational Cost Saving** (how much you will save over time, compared to not implementing the strategy)	**Added First Cost** (the extra you will pay at the time of building or improving your home)	**Overall Benefits** (to prioritize strategies)
Orientation, minimise openings and maximise shading to East-West facades	✓		✓	Lowest	$	High
Insulation, in the roof or by plastering walls	✓	✓	✓	Low	$	Highest
Shading, with trees and large overhangs	✓		✓	Lowest	$	High
Natural ventilation, by spacing buildings on the plot, and using windows	✓	✓	✓	High	$	Highest
Ceiling fans, to support natural ventilation	✓	✓		Moderate	$	High
Mechanincal ventilation for bathrooms with no windows.		✓		Low	$	High
Multi-zone or dual-stage mini split AC, compared to single split system	✓			Moderate	$$	Moderate
VRF (variable refrigerant flow) AC, compared to single split systems	✓			High	$$	Moderate
LED lighting, LED bulbs are more efficient and longer lasting than traditional bulbs		✓	✓	Lowest	$	Moderate
Lighting controls, to use your lights efficiently			✓	Lowest	$	Low
Solar panels, on your roof or plot			✓	Highest	$$$$	Low
Solar thermal, using solar energy to heat your hot water			✓	Lowest	$$$	Low
Efficient water fixtures, for example low-flow shower heads or dual flush toilets			✓	Low	$	Low
Efficient water distribution layout, to minimise pipe leaks, use rainwater harvesting		✓	✓	Lowest	$	Moderate

8 /

Build your house For the Future

There are many reasons you might want to expand your home: a growing family, for increased resilience against changing weather, or to create space for your business.

This chapter gives recommendations on how you can safely expand your home horizontally:

Horizontal expansion Increases the footprint area by adding new rooms horizontally, or to the side of the existing house.

Guidance is not provided for vertical expansion, as this requires a building permit (even if it is just a half storey or mezzanine)

Vertical expansion
Increases the number of storeys by adding new rooms vertically, or above the existing house.

8.1 Basic Steps for Expansion

Process for horizontal expansion

1

Evaluate the safety of the plot and the existing house

Follow the minimum recommendations in Chapters 2 and 3, or hire an engineer/ architect to help you.

2

Design the expansion

Follow the recommendations included in Chapters 5, 6 , 7 and 8, or, hire an engineer/ architect to help you.

3

Build the expansion

Once you have the necessary funds and permits (if applicable), hire a builder (or do the work yourself), following the recommendations in Chapters 4, 5, 6, 7, 8 and 9.

4

Enjoy living safely and comfortably in your expanded home

Maintain your home to enjoy living safely and comfortably.

Process for vertical expansion

If you decide to vertically expand your home:

1. Hire a registered engineer or an architect. They will evaluate the safety of the existing house, and draft the plans you need to obtain a building permit.
2. Submit the new design, engineering calculations and other relevant documents (specified in the Regulations under the Construction Act) to the local and city council. Your appointed architect or engineer can help you with this documentation.
3. Once the plans are approved you will receive a building permit. Only once you have received the building permit can you begin work on your house.

Always consult with the island council and refer to your island's Planning Regulations, and the Construction Administrative Regulation, as there may be other permits and considerations required for your building. Your appointed architect or engineer can help with additional permitting processes.

WARNING:

A building permit may be required for some horizontal expansion

If you plan to expand your house horizontally to open a small business or to increase the size of your house to more than 1200sqft, you will also need to obtain a building permit before starting the work. You can follow the same steps as for vertical expansion.

8.2 Evaluate the safety of the plot and the existing house for expansion

Is your plot safe?

Refer to the checks in Chapter 3. In case of doubt or any issues regarding the safety of your assigned plot, please raise such issues with the island or city council.

Is your existing house safe to expand?

Refer to the table to see which types of houses can be expanded horizontally or vertically.

For safe vertical expansion, your existing house should have:

- No damage to walls related to foundation settlements or soft soil (other damage should be repaired before expanding).
- Masonry walls with concrete blocks plastered or unplastered.
- It is strongly advised not to vertically expand upon coral stone masonry houses
- Continuous foundations under all walls.

Description of the existing house		Vertical Expansion	Horizontal Expansion
Wall material	# Storeys		
Masonry - Concrete Blocks 	1	✓*	✓
	2	✗	✓
Masonry - Coral Stone 	1	✗	✓
Masonry - Coral stone & Concrete Blocks) 	1	✗	✓

*always requires a building permit

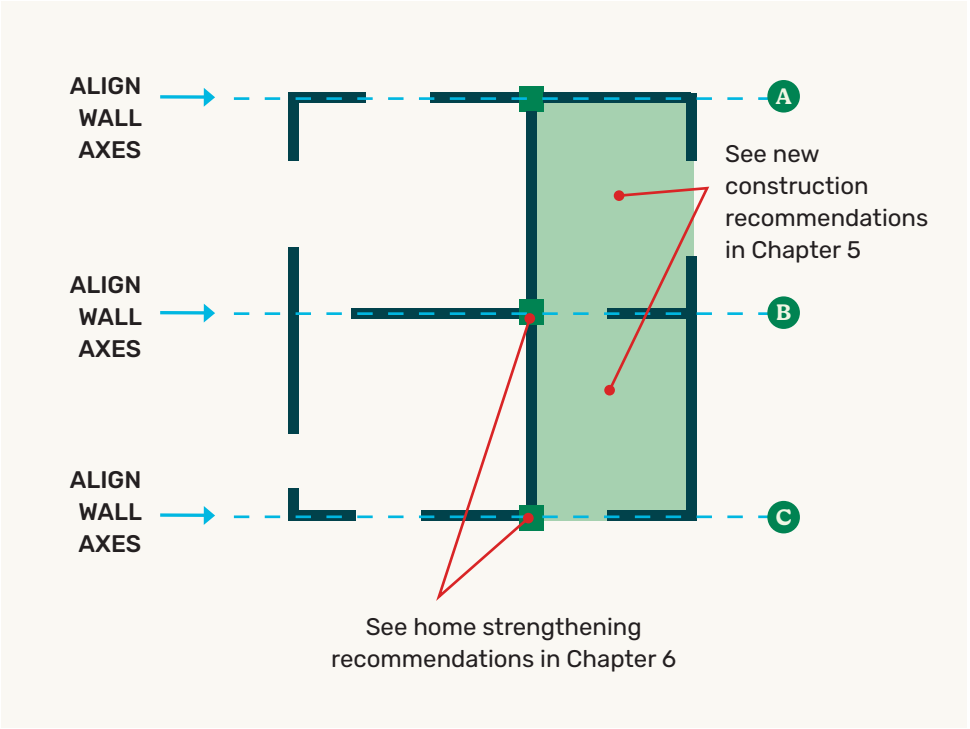
8.3 Design the expansion

Evaluate the available space on your plot

- Respect distances: from the perimeter, adjacent buildings, roads, and underground tanks or pits (where present). Site geometry is specified on the site registry.

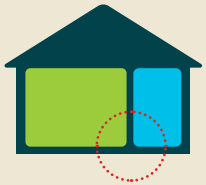
See Section 7.2 for recommendations on how to best use the available space on your plot.

- Define the geometry
- **Rectangular shapes are better than L or T shapes,** but the length of the complete structure (the existing with the addition of the expansion) should not exceed four times the structure width.
- **Identify the grid of existing walls:** try to make the expansion follow the same grid-lines and perimeter walls as the existing house.
- **Coordinate strengthening and expansion works:** it is often cheaper and more convenient to complete home strengthening (see Chapter 6) and expansion at the same time. For example, if your existing house does not have a ring beam and you want to add one to strengthen it, this is a good time to also build a horizontal expansion.



8.4 Build the expansion

Connecting the foundations



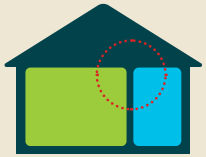
Step 1:
Excavate and expose existing foundation.

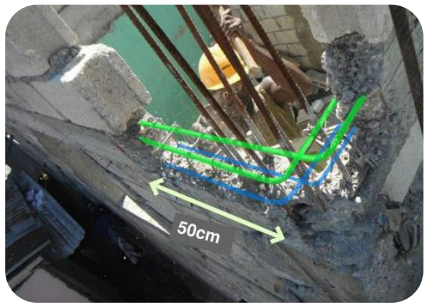
Step 2:
Mark straight lines where new foundations will be built.

Step 3:
Excavate and build the new foundation in line with existing one.

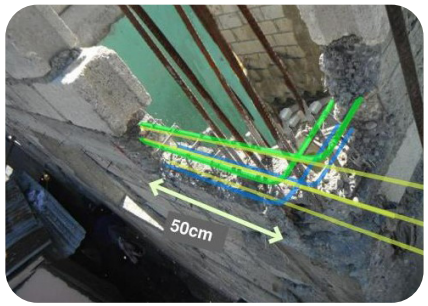
Step 4:
Place reinforcement for the new plinth beam. Use four ⅜in (10mm) horizontal bars, ¼in (6mm) links.

Connecting the ring beams

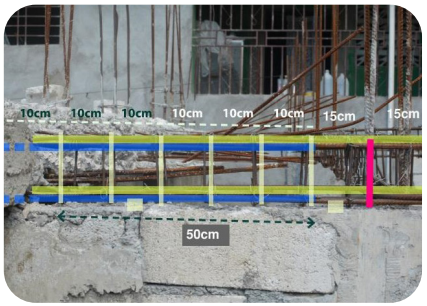




Step 1:
Chip out concrete of existing ring beam 20in (50cm) and expose the bars. Be careful not to damage existing reinforcement and the wall.

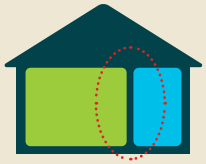


Step 2:
Insert four new bars and overlap with existing bars. Use four ⅜in (10mm) bars. Remember to use 1¼in (3cm) spacers! (See Chapter 5).



Step 3:
Place ¼ in (6mm) links at: 4in (10cm) spacing , where horizontal bars overlap; 6in (15cm) spacing elsewhere.

Connecting the walls



Step 1:

Mark the new wall on the existing wall. Roughen the surface of the existing wall to create better bond.

Step 2:

Create "C" ties with ⅜in (10mm).

Step 3:

Knock out a hole in the existing wall in the places where you will put the C-tie (repeat every 2 courses of blocks).

Step 4:

Clear debris from the hole in the places where you will put the C-tie.

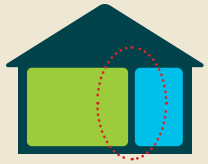
Step 2:

Water the roughened surface of wall, the inside of the hole, and the blocks.

Step 6:

Knock open the top cell of new blocks, cut a small notch in the block as shown.

Connecting the walls



Step 7:
Lay the new blocks next to the existing wall.

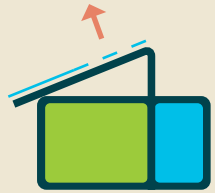
Step 8:
Fill the hole in the existing wall and the cell of the new block with mortar.

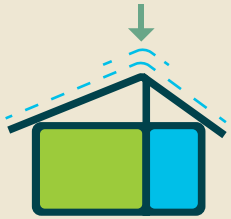
Step 9:
Place the C-tie in place to connect the existing to the new wall. Make sure that the C-tie is centred in the void.

Step 10:
Cover the C-tie with mortar. Make sure that the mortar is surrounding all sides of tie.

Step 11:
Repeat every two courses of blocks using the tie on a full-size block (skip the partial blocks).

Connecting the roof





Step 1:
Remove the last row of roof sheets, closest to the high eave.

Step 2:
Frame the roof over the expansion, following the guidance in chapter 5.

Step 3:
Replace the roof sheets over the existing portion of the house and install new sheets over the expansion

Step 4:
Add a new ridge cap, flashing along the gable end walls, and gutters and downspouts along the eaves.

Note: Refer to Chapter 5 for roof connection details.

9 /

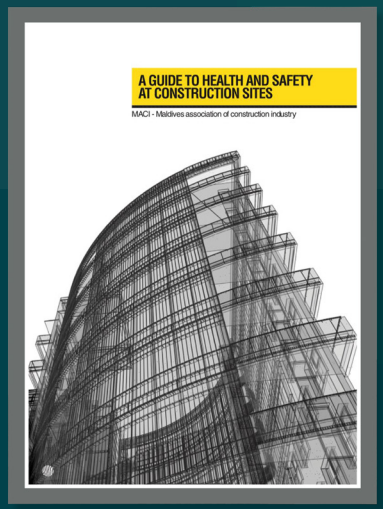
Build your house Safely

Construction can be dangerous. Site safety procedures help to reduce the risk of injury or harm to construction workers, residents, and the general public.

The lead builder is responsible for safe site management, but everyone working on or visiting the site has a responsibility to make sure that they are keeping themselves and those around them safe.

This chapter includes key recommendations on how to keep yourself and others safe during the construction of your house.

For more information, refer to the Maldives National Association of Construction Industry (MNACI) **Guide to Health and Safety at Construction Sites and to the Regulations for Health & Safety (2019 / R-156)** issued under the Construction Act.



9.1 Personal protection equipment

Minimum personal protective equipment on site

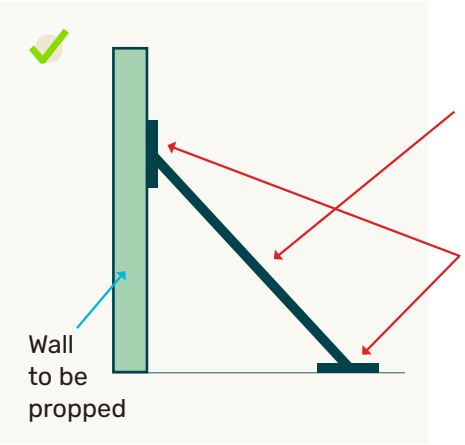
Helmet | Closed Cap Shoes | Gloves

Safety depends on everybody that works or visit a construction site (including homeowners)

Source (for all pictures in this page): Riyan Private Limited (made for this project)

Props and shoring

Props and shoring are very important, as they ensure the stability of elements during construction.



Propping of walls consists of diagonal timber or steel elements (about 2m long) every 3m along the wall that has to be stabilised.

The force from the wall is transferred to horizontal timber planks along the wall, through the diagonal prop, and then into the timber along the ground.

9.2 General recommendations for a cleaner, safer site

An organised site is a safer place for everyone

- Keep common paths of travel, access to aisles, exits, ladders, stairways, scaffolding and emergency equipment free from obstructions.

- Remove or neatly store scrap and unessential materials as work progresses. Remove nails from scrap wood for recycling.
- Remove trash and other debris at regular intervals.

- Store tools, equipment, materials and supplies in an orderly manner.
- Quickly clear all spills: oil and grease shall be cleaned from walking and working surfaces.

Clear stagnant water regularly to prevent mosquito breeding. Check areas such as containers, material storage, canvas sheets, equipment and machinery, puddles on the ground or on the concrete floors, water storage drums, water tanks, trenches.

Source (for all pictures in this page): Riyan Private Limited (made for this project)

9.3 Staying safe when working at height

What is working at height?

- Any work where a person could potentially fall and injure themselves due to a change in elevation.
- A ladder, a roof's edge, an opening on the floor, can be considered working at height.
- Caution should be taken when working next to any elevation change, and protection must be provided for work at any height change equal to 4ft (1.2m) or more.

Source: Riyan Private Limited (made for this project)

How to increase safety when working at height

Use personal protection: Wear a rope or an all-body harness to reduce the injury during a fall.

Anchor to a safe point while working: e.g. Beams, columns, steel profiles.

Check ladders:

- Extend 3ft (1m) past the level of climbing
- Have a 4:1 ratio of rise and run: for every four feet high the ladder rises, its base should be placed one foot away from the structure. When using a ladder, always make sure the climber has **three points of contact with the ladder at all times:** two feet, one hand; or two hands, one foot.

Railings: Should be provided at each edge or border that defines a change in height (higher than 1.2m).

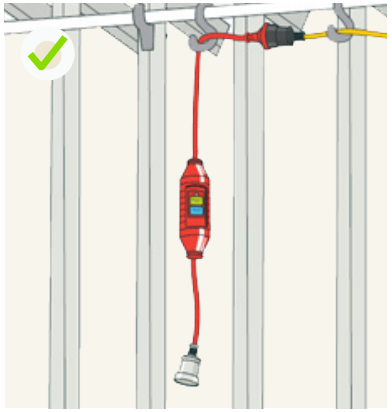
9.4 Power tools and how to use them safely

- **Conditions:** Tools should be kept in good condition: sharp, clean, well maintained, and regularly serviced. Worn tools are dangerous.

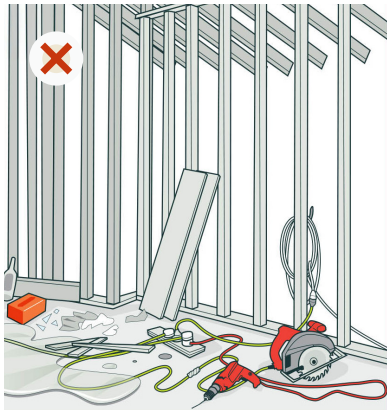
- **Capacity:** Always use the right tool for the job, following the instructions of the manufacturer or supplier. Tools should not be forced beyond their capacity.

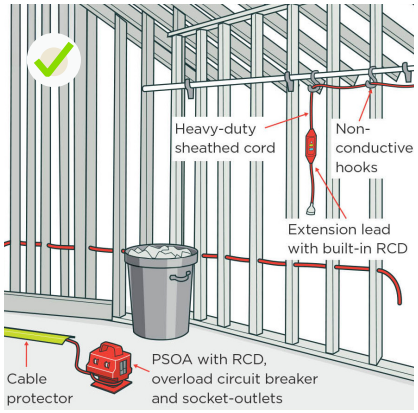
- **Electrical Hazard:**
  - Power tools should not be used in wet conditions or in the rain.
  - Wiring should be elevated and not laying on the ground.
  - If there are power cords immersed in water, do not enter the pond.

- **Fire Hazard:** Carefully monitor for fires. A fire extinguisher or large barrel of water should be kept on site to extinguish fires. Fires should never be left unattended.



Source: https://www.highspeedtraining.co.uk/hub/welding-hazards-in-the-workplace/





Source: https://www.worksafe.govt.nz/topic-and-industry/electricity/electrical-safety-on-construction-sites/

10 /

Maintain your House

Regular maintenance will help to extend the life of the structure and systems in your house, saving money on early replacement or repair costs.

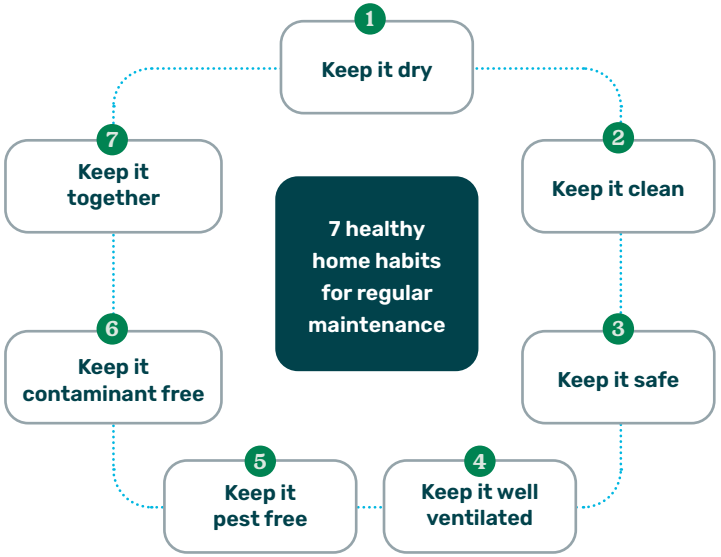
Regular maintenance will:

- → Save you money
- → Keep your home looking good
- → Increase your home's value
- → Increase your home's climate and disaster resilience

10.1 The importance of maintenance

Why is maintenance important?

- It prolongs the service life of the house
- It ensures the safety of the people living in it



Who is responsible for maintenance of the house?

- The maintenance needs of a house begin after the construction is completed.
- Who is responsible depends on the timing after construction and whether you hired a builder/contractor. If you did hire a builder, the stages of responsibility can be divided into three main streams:

DEFECTS LIABILITY PERIOD	REGULAR MAINTENANCE	MINOR & MEDIUM REPAIR
(12 Months)	(Annual)	(1-5 years)
Responsibility of the **contractor**	Responsibility of the **owner**	Responsibility of the **owner**

This guide is not intended to be used as a substitute for handling all of your home maintenance and repair needs; your larger home maintenance repairs; or manufacture requirements and guidelines. This reference guide provides easy-to-use tips for keeping your home healthy, safe and well maintained on a regular basis.

10.2 What should be checked during the liability period?

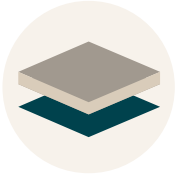
What is a liability period?

- It is a period that includes the construction time and 12 months after the construction has been completed.
- For the liability period to be effective, it has to be included in a written contract agreed upon by the homeowner and contractor.
- It is possible that during this period, you start to see a problem or malfunction with a part of the house.
- Defects that appear during the liability period might be caused by poor quality construction.
- You can contact your builder to perform necessary repairs, as the constructor is responsible for maintenance and repairs during this period.

Defects checklist during the liability period

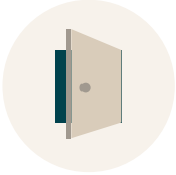
Walls and ceilings

- Stains, scratches, hairline cracks or marks
- Uneven surfaces
- Water seepage
- Mold or cracks



Flooring

- Scratches or discolouration
- Gaps, misalignment in tiles
- Uneven, jagged or rough surfaces



Doors and Windows

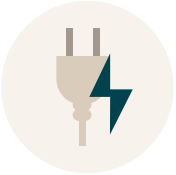
- Difficulties in fully opening, closing, locking or unlocking
- Scratches, cracks, rusting, leaks
- Improper installation or integration

Concrete

- Visible cracks
- Voids
- Exposed reinforcement

Plumbing

- Leaks, faulty taps or shower heads, low water pressure
- Faulty flushing system
- Blocked drainage



Electrical

- Power points not working properly
- Lights, fans or air-conditioning not functioning

Built-in Carpentry

- Difficulties in fully opening, closing, locking or unlocking
- Proper finishing (no scratches or blemishes)

Bathroom Fixtures

- Cracks, scratches or water seepages
- Uneven surfaces or misalignment

10.3 What should be inspected to ensure regular maintenance and repairs in a house?

Housing elements that require maintenance and repair

Timber elements

Inspect timber elements, such as roof framing, for:

- Termite damage
- Water damage and rot
- Cracks and weathering

Roof and Gutters

Regularly inspect roofs and gutters,looking for:

- Leaks in roof sheeting and flashing
- Rusting or corrosion of nails
- Cleaning / blocking of gutters
- Weak joints and detached pipes
- Holes or other damages

Doors and Windows

Doors and windows should be regularly cleaned. Periodically inspect, looking for:

- Damage
- Water and air tightness (caulking) – are there any signs of leaks?
- Functionality (hinges) – do they open and close as they should?
- Safety (locking) – do the locks work?

Paints and Plasters

Exterior repainting is recommended every 2 years. In addition, periodically:

- Inspect and repaint any cracks / peeling
- Clean any signs of mold or water leaks

10.3 What should be inspected to ensure regular maintenance and repairs in a house?

Housing elements that require maintenance and repair

Rainwater harvesting

Inspect and clean the:

- Tank (where possible, it should be installed in a shaded area to reduce algae growth)
- Roof surface
- Gutters and filters

Photovoltaic panels

- Clean the front glass to ensure efficient energy production (use a microfiber cloth and ethanol)
- Call a qualified technician to check the electrical connections to make sure they are well adjusted, with no signs of oxidation.

Electrical system

Regularly inspect the electrical system, looking for:

- Sparks in outlets, flicks in lights, burnt bulbs
- Buzzing of the electric panel
- Distribute devices plugs into different outlets around the home
- Unplug and store unused devices
- Check ground-fault circuit interrupters to ensure they are functioning well (these are special outlets with a button to be pushed seen in kitchens and bathrooms).

AC units

Regularly clean the indoor and outdoor units. See Section 10.4 for details.

Plumbing

Regularly inspect for:

- Leaks in pipes (check water bills: if they are unusually high, there might be a leak)
- Leaks in the water heater
- Problems in angle stops behind toilets and sinks

10.4 Maintenance of ac units

- It is important to regularly clean both indoor and outdoor units to ensure efficient cooling, increase equipment lifespan and prevent high electricity consumption.
- **CAUTION!** Turn off and unplug all AC power switches before doing any maintenance.
- Contact an AC maintenance contractor for most optimal and safe maintenance. In any case, it is recommended to have a full service by a specialist annually.

Outdoor unit cleaning process

The following process should be performed **every 3 months:**

- Remove the covers on the top & side of the condenser unit by removing the screws or bolts
- Clean any debris stuck on the condenser or fan using gloves and a small brush
- Deep clean the grills using a vacuum to remove any dust or dirt

Indoor unit cleaning process

The following process should be performed **every month:**

- Remove the front cover by pulling from a side
- Remove the two filters removal, sliding carefully
- Clean the dust from the filters using a vacuum, a gentle brush or low- pressure water
- Dry the filters and re-insert them back into the unit

11 /

Minimum Construction Standards

This chapter is intended to be used by city and island councils, and building professionals.

The recommended minimum construction standards were developed using engineering calculations based on the reference standards outlined in Chapter 1.

11.1 New House Construction

11.1.1 Site requirements

- Site should be located at least 66ft (20m) and an access road away from bodies of water.
- Ground floor should be raised at least 1ft (30cm) above road level. If your plot is in an area that is prone to frequent flooding, you should raise your house further. In this case, dig a trial pit of 1ft x 1ft x 1ft to determine the water table level. If you hit the water table at 1ft, it is recommended to raise your house by at least 4 ft from the water level to prevent flooding.
- Site should preferably not be located in an area at risk for storm surge or tsunami. If located in such an area, residents should be aware of the risk and ready to evacuate in the event of a cyclone or tsunami.

DEMOLITION

- **Timing:**
  - Install shoring prior to the start of corresponding demolition works.
  - Where applicable, demolition shall occur at only one level at a time, and shall not progress to the next level until the stability of the structure at the current level is restored. Demolition shall be done as to ensure the structure retains adequate vertical and lateral stability throughout construction.
- **Roof Removal:**
  - Brace walls before removing roofs.
  - Place vertical planks every 3 meters along affected walls for stability.
  - Secure planks at the top with inclined props and at the bottom with metal stakes in the ground.
- **Wall Demolition:**
  - Protect walls from collapse when demolishing
  - Place vertical planks every 3 meters along affected walls and at each end of wall piers if needed.
  - Secure planks at the top with inclined props and at the bottom with metal stakes in the ground.
- **Suspended Slab Demolition:**
  - Protect the area below from falling debris.
  - Place wood planks or ¾" plywood under the opening and support with metal props or 4"x4" posts every 2 meters.
  - Support slabs with steel trusses or 2x4 wood beams on each side of the area to be demolished.
  - Use metal props to support truss beams every 1 meter and at each end.
  - For upper stories, align vertical supports with ground floor supports. Secure vertical supports at the top with inclined props and at the bottom with metal stakes in the ground.
- **Safety:**
  - Minimum safety recommendations included in Chapter 9 should be followed during demolition.

11.1.2 Building placement requirements

- Plot subdivisions less than 600 square feet and narrower than 12 feet should be avoided.
- Minimum width of access path: 4 feet (1.2m). Recommended width: 5 feet minimum (1.5m).
- It is recommended that minimum 10% of plot area should be designated open area.
- Setback recommended: 5-7ft (1.5-2.0m) from the front; 3ft (1.0m) from sides and back.
- Tree planting on front setback will create shade and comfort.

11.1.3 Masonry Requirements

FOUNDATIONS

- Excavation: minimum 20in (50cm) deep by 2ft (60cm) wide for soft soils.
- Column anchorage reinforcement should be placed at every corner, wall intersection, and on either side of door openings. Column anchorage reinforcement should be placed at the same depth as the strip footing.
- Foundations are made of reinforced concrete strip footing with masonry knee wall:
  - 2in (5cm) minimum concrete cover over steel in the reinforced concrete strip.
  - Concrete strip footing 8in (20cm) minimum height, 2ft (60cm) minimum width, with three of longitudinal ½in (12mm) bars and ⅜in (10mm) transverse bars every 1.3ft (40cm).
  - Knee wall made of 6in (15cm) solid or fully grouted hollow blocks.
- Use a plinth beam on top of the foundation at the base of walls.
- Top of plinth beam is level with the top of the floor slab.

WALLS

- Confined masonry construction is used. Build walls before columns are poured, and cast the ring beam directly on top of the completed wall.

- **Confining Elements:**
  - 6in x 8in (15cm x 20cm) (deep) plinth beam at the base of all walls.
  - 6in x 6in (15cm x 15cm) columns at all corners, wall intersections, and on either side of door openings.
  - 6in x 8in (15cm x 20cm) (deep) ring beam on top of all walls.

- **Reinforcing Steel:**
  - Four ⅜in (10mm) ribbed bars used as longitudinal steel in columns and beams.
  - ¼in (6mm) links with 2in (5cm) hooks, rotated 135 degrees.
  - Reinforcement is new (not recycled) and is not rusty.
  - Links spaced at 4in (10cm) within 20in (50cm) of beam-column joints, and 8in (20cm) elsewhere.
  - Lap splices are 1.3ft (40cm) for ⅜in (10mm) steel and 20in (50cm) for ½in (12mm) steel.

- **Concrete:**
  - Concrete mix is 1 part cement : 2 parts sand : 3 parts gravel.
  - Cement is Portland.
  - Sand should be clean river sand.
  - Gravel is crushed and angular, 1in (2cm) diameter (max).
  - Slump is 8cm to 10cm.
  - Concrete is well compacted such that there are no voids, exposed steel, or honeycombing.

- **Blocks:**
  - Select good quality concrete masonry blocks at least 5in (13cm) wide that do not break when dropped. If 5in blocks are used, walls must be plastered both inside and outside.
  - Blocks may be made from local sand; imported river sand is recommended for best quality.
  - AAC blocks, 5in (13cm) minimum thickness.

- **Block Laying:**
  - Mortar is 1 part sand : 5 parts cement.
  - Sand is clean river sand.
  - Mortar joints around ½in (between 1cm and 1.5cm thick).
  - A line and storey pole are used to build the wall plumb and level.
  - First half of columns are cast after 5ft (1.5m) of wall height.
- Reinforcement: ¼in (6mm) L-shape rebar dowels, 1.3 + 1.3ft (40+40cm) long, horizontally cast every 3 courses at wall-column connection.
- Plaster is 1 part cement and 4 parts sand.

- Plaster may be made from local sand; imported river sand is recommended for best quality.
- Minimum thicknesses recommended as follows:
  - ⅜in (1cm) on internal walls ;
  - ¾in (2cm) on external walls ;
  - On exterior walls, waterproofing admixtures can be considered to improve the waterproofing performance.

11.1.4 Wood Roof Requirements

- Use pine, Red Meranti, Balau for all structural members.
- Corrugated steel roof sheets minimum gauge 24.
- 18 gauge (1.2mm) minimum thickness metal for straps, 2in (5cm) wide.
- Use preservative on all wooden members placed on concrete or exposed to the elements.
- Build roof with a system of rafters, ties and purlins:
  - Maximum rafter span between supports is 20ft (6.0m) and their size depends on their span;
  - Rafters are spaced at 2ft, 3ft, 4ft (60cm, 90cm or 120cm) maximum;
  - Purlins are spaced at 2ft, 3ft, 4ft (60cm, 90cm or 120cm);
  - 2inx4in (5cm x 10cm) horizontal collar tie is used to connect rafters every 4ft (1.2m), maximum;
  - 2in x 4in (5cm x 10cm) ceiling joists fastened at each end to the rafter base with a notched joint, and straps each side with a total of 4 nails in the rafter and 4 in the tie;
  - 2in x 6in (5cm x 15cm) ridge beam to support rafters connected with shear plates each face (5 nails each plate).
- Roof should be insulated with 2in (5cm) thick mineral wool with reflective layers. These can be laid on a wire mesh positioned over purlins to support the insulation.

11.1.5 Windows and Door Requirements

- Window and door openings should have a reinforced (with at least 2 bars) lintel above them.
- Window and door openings should have 6x6 in (15cm x 15cm) confining column, or 2-bar column on either sides.
- Materials for doors should be:
  - Solid Wood (external door)
  - Laminate wood (internal doors)
- Height of doors: 7ft (2.10m);
- Width of doors:
  - Main door - 2.7-2.8ft (0.85 m- 0.95m);
  - Internal door - 2.6-2.7ft (0.80m - 0.85m);
  - Bath door - 2ft (0.60m);
- Minimum openable window area 10% of the floor area.
- It is recommended that the width of openable section of windows not be less than 20in (50cm) .
- Windows having both a top hung section a swing section below will also encourage flow of air when lower segment is opened at one side and the upper section is opened at the other.
- Height of window parapet for ground floor ONLY: minimum 18 in (45 cm)
- If a window has a parapet of 18 in (45cm), the confining columns should go down to foundation. On the upper part, a reinforced concrete lintel or the extension up to the ring beam is still necessary.
- Height of window parapet on upper floors: 3 ft (1.0 m). If the depth of the room is deeper than 20ft (6.0m) cross ventilation must be provided, with windows on opposite walls.
- A mixed- mode ventilation solution should be taken into consideration whenever possible, where ceiling fans enhance the air circulation from exterior openings and improve thermal comfort, reducing the need for mechanical cooling.

11.1.6 Minimum Habitable Space Requirements

→ It is recommended that these dimensions are met for interior spaces:

- Bedroom: minimum 8 ft x 8 ft.
- Recommended sizes: 9 ft x 9 ft, 10 ft x 10ft , 10 ft x 12 ft, 11ft x 11 ft, 12ft x 12 ft
- Bathroom: minimum 7ft x 4ft. Recommended size: 8 ft x 5 ft
- Living room: minimum 10 ft x 10 ft . Recommended size: 12 ft x 12 ft
- Minimum living plus dining : 9.5 ft x 17.5 ft
- Kitchen: 8 ft x 10 ft.

11.2 Existing House Reinforcement

11.2.1 Walls Repairs

→ Cracked walls can be repaired:

- Cracks below 1/5in (0.5cm) can be repaired with cement plaster (1:5 cement-sand proportion);
- Cracks between 1/5in - ⅜in (0.5cm - 1cm), can be repaired with a mesh fixed to the wall and plaster (1:5 cement-sand proportion);
- Walls with cracks beyond ⅜in (1cm) should be demolished and rebuilt as their stability is severely compromised.

11.2.2 Roof Repairs and Strengthening

ROOF ELEMENTS

Existing roof timber elements should respect the following minimum dimensions:

→ Rafters can be sistered to new elements to reach the minimum dimensions required. Use 2 nails 10d every 6in (15cm) maximum, staggered along the rafter span.

→ New purlins can be introduced in order to respect the maximum distances and size limits (This would require the removal and reinstallation of light-weight metal roofing sheets).

→ For ridge beams ≤ 2in x 6in (5cm x 15 cm), collar ties should be connected to rafters:

- Collar tie dimensions: 2in x 4in (5cm x 10cm);
- One collar tie every 4ft (1.2m) maximum;
- Tie should be connected to rafters with one bolt through each end;
- Bolts diameter should be ⅝in (16mm) for rafters span > 11.5ft (3.5m);
- Bolts diameter should be ¾in (20mm) for rafters span ≤ 11.5ft (3.5m);

	Rafter Span					
Spacing	**10ft (3.0m) or less**	**11.5ft (3.5m)**	**13ft (4.0m)**	**15ft (4.5m)**	**16.5ft (5.0m)**	**20ft (6.0m)**
2ft (0.6m)	2in x 4in (50cm x 100cm)	2in x 5in (50cm x 125cm)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2x 2in x 6in (50cm x 150cm) sistered
3ft (0.9m)	2in x 5in (50cm x 125cm)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2x 2in x 7in (50cm x 175cm) sistered
4ft (1.2m)	2in x 6in (50cm x 150cm)	2in x 6in (50cm x 150cm)	2in x 7in (50cm x 175cm)	2in x 8in (50cm x 200cm)	2in x 7in (50cm x 175cm) sistered	2x 2in x 8in (50cm x 200cm) sistered

	Purlin Span (space between rafters)		
Spacing	**2ft (0.6m)**	**3ft (0.9m)**	**4ft (1.2m)**
2ft (0.6m)	1 ⅜ in x 2in (35cm x 50cm)	2in x 2in (50cm x 50cm)	2in x 2in (50cm x 50cm)
3ft (0.9m)	2in x 2in (50cm x 50cm)	2in x 2in (50cm x 50cm)	2in x 4in (50cm x 100cm)

ROOF CONNECTIONS STRENGTHENING

- The roof should be connected to a reinforced concrete ring beam. The width of the ring beam should be the same as the thickness of the walls underneath (6in (15cm) minimum) and its height should be:
  - 8in (20cm), for beam lengths up to 13ft (4.0)m;
  - 10in (25cm), for beam lengths between 13ft and 15ft (4.0m and 4.6m);
- Rafters connection to walls can be strengthened by introducing a timber ledger:
  - Ledger dimension: 2in x 6in (5cm x 15cm) (minimum);
  - Ledger connected to walls every 6ft (2.0m) with a ⅜in (10mm) bolt / threaded bar through;
  - Each rafter connected to ledger with a metal clip (5 nails each side of clip);
- All purlins (new or existing) should be connected to rafters with a minimum numbers of connectors as the options specified below:
  - 2 #8 screws; or
  - 3 nails – for purlins spaced at 2ft (60cm) maximum;
  - 4 nails – for purlins spaced at 3ft (90cm) maximum;
- Roofing connection to purlins should be strengthened by adding connectors to respect the following limits:
  - 1ft (30cm) – for smooth shank nails (8d);
  - 1.65ft (50cm) – for screws (#8);

11.3 Building Services

11.3.1 AC System Requirements

- As a general rule, the cooling capacity can be calculated as follows:

  Area of Room (Sqft) × 80 = Required AC Capacity (BTU/hr)

- Multi-zone and/or variable refrigerant flow (VRF) mini-split systems should be considered whenever possible in homes with multiple cooling zones. Multi-stage units typically offer greater control and increased energy efficiency.
- AC Units Positioning:
  - Height of installation: 7-8ft (2.1 - 2.4m) above ground;
  - A minimum of 6in (15cm) clear should be assured around the units
  - In bedrooms, installation should be placed high above the bedhead or on a wall adjacent to the bed, to avoid direct cold air onto the bed and help preventing dry skin, lips and throats
  - In living rooms, the AC unit should be installed centrally on the longer wall or above the sofa.
  - The outdoor unit should be installed away from direct sunlight and as close to the indoor unit as possible to maximise efficiency.
  - The outdoor unit should not be located in an enclosed space where there is no fresh air flowing through.
  - The units should not be installed above a cupboard, door, or TV.
  - Should not be installed directly above the bedhead or on the opposite wall facing the bed.
  - If living room and the kitchen are connected, the unit should not be installed near the kitchen area.

11.3.2 Electrical System Requirements

- Electrical Demand: the total LED wattage needed for a room can be measured as follows:

  Area of Room (Sqft) × Required Lux ÷ 968.4 = Total Watts

Assuming the following lux requirements:

Room Type	Required Lux
Bedroom	200
Kitchen	500
Dinning/Living Room	300
Bathroom	150

  - The calculated Total Watts can be divided to the appropriate number of fixtures for layering to get effective light distribution.
- LED lights should be used to save energy and cost of electricity and to reduce the heating of the room where they are installed.
- The electrical system should be sized considering the potential future electrical loads, including electric vehicle charging.
- The design of the primary electrical system should enable the inclusion of future energy source inputs such as solar photovoltaic panels.
- Cabling and general safety watch outs:
  - All electrical wiring & installations must be carried out by a licensed electrical engineer;
  - A maximum of 10 LED lamps and 2 fans can be installed in a circuit within a room (not more than 800 ft² - 74m² provided the circuit

does not exceed 1000W. Such a circuit shall be made of 2.5 mm² size wire and max rated MCB with Trip Curve C of 10A;

- A maximum of four 13A sockets can be installed in a circuit within a room (not more than 800 ft²) provided high load equipment are not connected to this circuit. This circuit shall be made of 2.5 mm² wire and max rated MCB with Trip Curve C of 16A;
- High load equipment such as AC, fridge, heaters, and kettles shall have a separate circuit;
- The design load of any circuit must not exceed 80% of the breaker's rated current;
- Wiring must be run within flexible conduits or trunking while junction boxes shall be used for diversions. This ensures the cabling is kept tidy and safe;
- Distribution Boards (DB) must be protected by a cover of at least IP30 and IP65 for indoors and outdoors respectively;
- The highest point of DB should not be more than 6ft (1.8m) from floor level but at least 4.6ft (1.4m) above the ground floor;
- In Single Phase wiring, the phase wire must be brown, neutral must be blue, and the earth must be green with yellow stripes;

11.3.3 Solar Power and PV Units

→ An area of 100 ft² - 9.3m² should be dedicated on the roof or on the ground for a typical PV system of 4 panels (rated 430W);

→ The area dedicated to PV panels installations should be unobstructed, free from obstacles or projected shades;

→ The roof should have a minimum capacity of 180kg of weight.

→ The panels are most effective if tilted at an angle of 5-10o. Panels should be orientated towards the East or West. For Northern Atolls, the panels could also be orientated South, or for Southern Atolls the panels could face North.

→ Two types of systems can be installed:

- Off-grid system: accommodate light and power circuits without high load equipment. Batteries enable the system to power the home during night and cloudy periods, while also ensuring consistency. This system enables the home to be powered even during utility disruptions;
- On-grid systems: allow the generated electricity to be exported to the utility grid and the home is billed by the difference of the energy fed and consumed. (Utility providers such as STELCO offers PV system packages based on a household's demand, ensuring savings and ease of installation);

→ PV systems should include an inverter to convert the generated DC electricity to 230V AC electricity;

→ Minimum maintenance should be performed on the panels, to keep them clean and well functioning;

→ As an average estimation, it can be assumed that 11 square feet (1m²) of solar panel in the Maldives generates 252 kWh of electricity per year;

11.3.4 Rain Water Harvesting

→ Ground water obtained via wells and pumps is not suitable for general use and might have an adverse impact on the environment, as it might be contaminated by the intrusion of seawater.

→ Rain water should be harvested to reduce the consumption of supplied water. It can be used for irrigation, bathing, flushing and laundry but NOT for drinking or cooking as it might be contaminated (unless it is properly filtered).

→ Roofs for rainwater harvesting should be built with galvanised steel sheets as they are the easiest to use, give the cleanest water, and are readily available in Maldives.

→ Gutters for rainwater collection should be installed on the edges of the roof to collect and transport rainwater from the roof to the storage tank via a downpipe.

- Gutters can be shaped semi-circular, rectangular, or V-shaped;
- They can be made by plain galvanised iron sheets or PVC;
- The gutter should be installed ¼in (6mm) below the line of the roof and sloped one-sixteenth inch per foot to ensure a smooth flow,

while gutter hangers should be placed every 3ft (1.0m).

- The sizes of the gutter and down-pipes are dependent on the roof area and can be determined as in the table.

Roof Area	Gutter Width	Down Pipe
270-370sqft (25-34m²)	3 in (8cm)	2in (5cm)
500-700sqft (46-66m²)	4in (10cm)	2.5in (6cm)
1400sqft (130m²)	5in (12cm)	3in (7.5cm) recommended
2300sqft (210m²)	6in (15cm) recommended	3.5in (9cm)

- Leaf screens made of ¼in (6mm) wire mesh is installed along the length of the gutter with a wire screen or basket at the head of the downspout as filters to trap debris.
- A first flush device is used to clear the harvesting setup from contaminants laying on roof and gutters. The device has a separate vertical pipe is fixed to the down pipe with a valve provided below the "T" junction. After the first rain is washed out, the valve is closed to allow the water to reach the storage tank.
- A perforated filter container made of Ferro cement, aluminum or plastic is filled with filter media (such as coarse sand, charcoal, coconut fiber, pebbles and gravels) is placed above the tank.

Tanks:

- HDPE or PVC storage tanks are recommended as they have resistance to high temperatures, rust and comparatively lightweight.
- The tank sizes are dependent on the rainfall data, roof area, water demand, cost, and available space. The water demand can be calculated as follows assuming 20L per day per person: as the requirement.
- Monthly Water Demand = 20 × number of persons × 30 days
- As a general rule, tanks could be dimensioned based on the longest period of dry months, which in The Maldives is about 4 months.
- Water from the tank can either be pumped or drawn via a ¾in to 1in (2-2.5cm) diameter PVC or GI pipe through gravity. Similar size pipes can also be used for overflow and drain pipes;
- A collection pit should be built beneath the outlet of the tank (generally made of brick masonry) to ensure water containers are held in place. The pit should also have a small drain hole to prevent stagnation of any spilled water;

11.4 House Expansion

11.4.1 Vertical Expansion

- Should be performed only on existing single-storey masonry houses, built with concrete blocks;
- Should not be performed on two-storey houses or single-storey houses built with coral stone or a mix of walls between coral stone and concrete blocks;
- The feasibility of the intervention should be confirmed by an engineer/ and architect;
- A building permit should be obtained from the local council prior to construction;
- Internal mezzanines should be considered as additional storeys and their construction as vertical expansion. For this reason, their execution should involve an engineer/architect to confirm the feasibility and design the intervention prior to obtaining a building permit.

11.4.2 Horizontal Expansion

- Can be performed on single storey houses built with concrete blocks, coral stone or a mix of both;
- Horizontal expansion of two-storey houses on both storeys can be considered but it must involve an engineer/architect to

confirm its feasibility, design the intervention and obtention of a building permit;

- The available space in the plot should be evaluated to plan the expansion, in order to respect setbacks, distance from adjacent buildings and roads, distances from underground tanks or pits (where present). See 11.1.2 for details.
- Wherever possible, the expansion should generate a regular geometry of the final volume (squared, rectangular with a maximum ratio between short and long side of 1:3. L or T shapes should be avoided).
- The wall distribution in the expanded area should keep the existing wall edges and perimeter walls should be aligned.

  The retrofit of the existing house should be performed in conjunction with the housing expansion, following the standards specified in 11.2.
- The foundations of the expanded area must connect with the existing ones. Steel rebars should be anchored into the existing strip footing for a minimum of 1.5ft (45) cm to assure continuity. Insert minimum 3 bars, ⅜in (10mm) diameter, in the new strip footing.
- New walls should be connected to the existing ones using steel C-ties, ⅜in (10 mm) diameter, every two courses of blocks.

  New walls should be built following the requirements of 11.1.
- Ring Beam: Existing and new walls should be confined with a top ring beam:

  - Dimensions: 6in x 8in (15cm x 20cm) (deep), on new walls. On existing walls, the width of the ring beam should be as the wall thickness, with a minimum of 6in x 8in (15cm x 20 cm) (deep).
  - Reinforcing Steel:
    - » Four ⅜in (10mm) ribbed bars as longitudinal steel;
    - » ¼ in (6mm) links with 2in (5cm) hooks, rotated 135 degrees;
    - » Reinforcement is new (not recycled) and is not rusty;
    - » Links spaced at 4in (10cm) within 20in (50cm) of beam-column joints, and 8in (20cm) elsewhere.
    - » Lap splices are 1.5ft (45cm) for ⅜in (10mm) steel and 20in (50cm) for ½in (12mm) steel.
  - If a ring beam already exists on the existing housing, its concrete should be locally chipped out at the meeting points with the new ring beam, to expose existing rebars and overlap the new ones for a minimum of 1.3ft (40cm).
- Roof:
  - The configuration of the new roof should coordinate with the existing one, to avoid gaps, changes of levels especially at ridge;
  - If the slope of the lightweight roof expansion is the opposite direction than the existing lightweight roof, it is necessary to add a ridge to make the connection .
  - New roof construction should follow requirements specified in 11.1.4.
  - Where the new roof meets the existing roof, appropriate connections are required to ensure structural safety:
    - » Remove the existing metal sheets from the roof adjacent to the expansion;
    - » The new rafter should be placed adjacent to the old rafters and linked together with metal straps;
    - » Install the new roofing over the expansion and the removed sheet from the existing house following requirements from 11.1.4;
    - » Both parts of the roof should be fixed at the ridge with a metal flashing.

11.5 Site Safety

11.5.1 Use of Personal Protection Equipment

- Wear hard hat, thick-soled closed cap shoes, long pants.
- Use eye protection, especially when welding.
- Use gloves when handling construction material and working tools.
- Use ear protection when drilling or using other tools that generate heavy noise.

11.5.2 Excavation

- Underground utilities and services should be identified before starting excavation.
- Excavation should be performed to the required depth

  Average size of excavation for foundation: 2.3ft (70cm) wide x 3ft (1m) deep

  Average size of excavation for trial pits: 2.6ft (80cm) x 2.6ft (80cm) x 3ft (1m) deep
- If excavation is deeper than 5ft (1.5m) deep, it should be protected with sloping, benching, shoring, shielding, or other protective systems.
- Trenches less than 5ft (1.5m) deep can be protected by sloping the trench wall cut at an angle inclined away from the excavation as needed to maintain slope stability.
- Trenches deeper than 4ft (1.2m) deep shall be provided with a ladder, stairway, or ramp for egress.
- Regardless of the depth, excavation area must be protected from any water flowing in.
- Temporary barricades should be erected around the excavations
- Keep excavated soil and other materials at least 2 feet (0.6m) from trench edges.
- Do not work/excavate under existing wall foundations.
- Enter any excavation wearing boots or protective shoes.
- Earth backfill should be hard dry material from excavations.
- Excavation should not be made next to or under an adjacent existing building. If set backs cannot be respected, a professional engineer should supervise the construction and adequate protection should be provided to protect the existing foundations.

11.5.3 General and Housekeeping

- Do not smoke on site, do not drink alcohol or use drugs, or other distractions and impairments.
- Homeowners and house occupants should relocate during construction in the house.
- Common paths of travel should be established and kept free from accumulation of materials. Keep access to exits, ladders, stairways, scaffolding and emergency equipment free from obstructions.
- Store tools, equipment, materials and supplies in an orderly way.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area. Remove nails from scrap wood for recycling.
- Trash and other debris shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.
- Carefully monitor for fires and keep an extinguisher or large barrel of water on site to extinguish fires. Never leave a fire unattended.

11.5.4 Electrical Hazard

- Electrical equipment should be grounded.
- Electrical wiring is elevated and not lying on the ground.

- Electrical panels should be covered.
- Be aware of electrical hazards in wet environments.
- Do not enter an area of standing water if there are power cords immersed in water.
- Do not use power tools in the rain or when standing in water.
- If a tool falls into water, do not reach for the tool. First, unplug the power-cord, then remove the tool from the water. Do not use tool until it is completely dry.

11.5.5 Fire Prevention

- Carefully monitor any rubbish fires and keep a fire extinguisher or large barrel of water on site to extinguish fires. Never leave a fire unattended.
- Combustible materials used during the construction should be stored outside and at least 10 feet from any building.
- Be aware of sulfuric odors (like rotten eggs): flammable compressed gas is often scented with an odor to warn of a leak.

11.5.6 Lifting

- Manual Lifting:
  - Proper lifting techniques must be used when lifting any object: bend knees to reach load, do not bend at the waist and grasp load and straighten knees to lift;
  - Plan storage and staging to minimise lifting or carrying distances.
  - Split heavy loads into multiple smaller loads.
- Heavy Equipment:
  - Stand clear of overhead loads. Under no circumstances should loads be lifted over the heads of personnel.

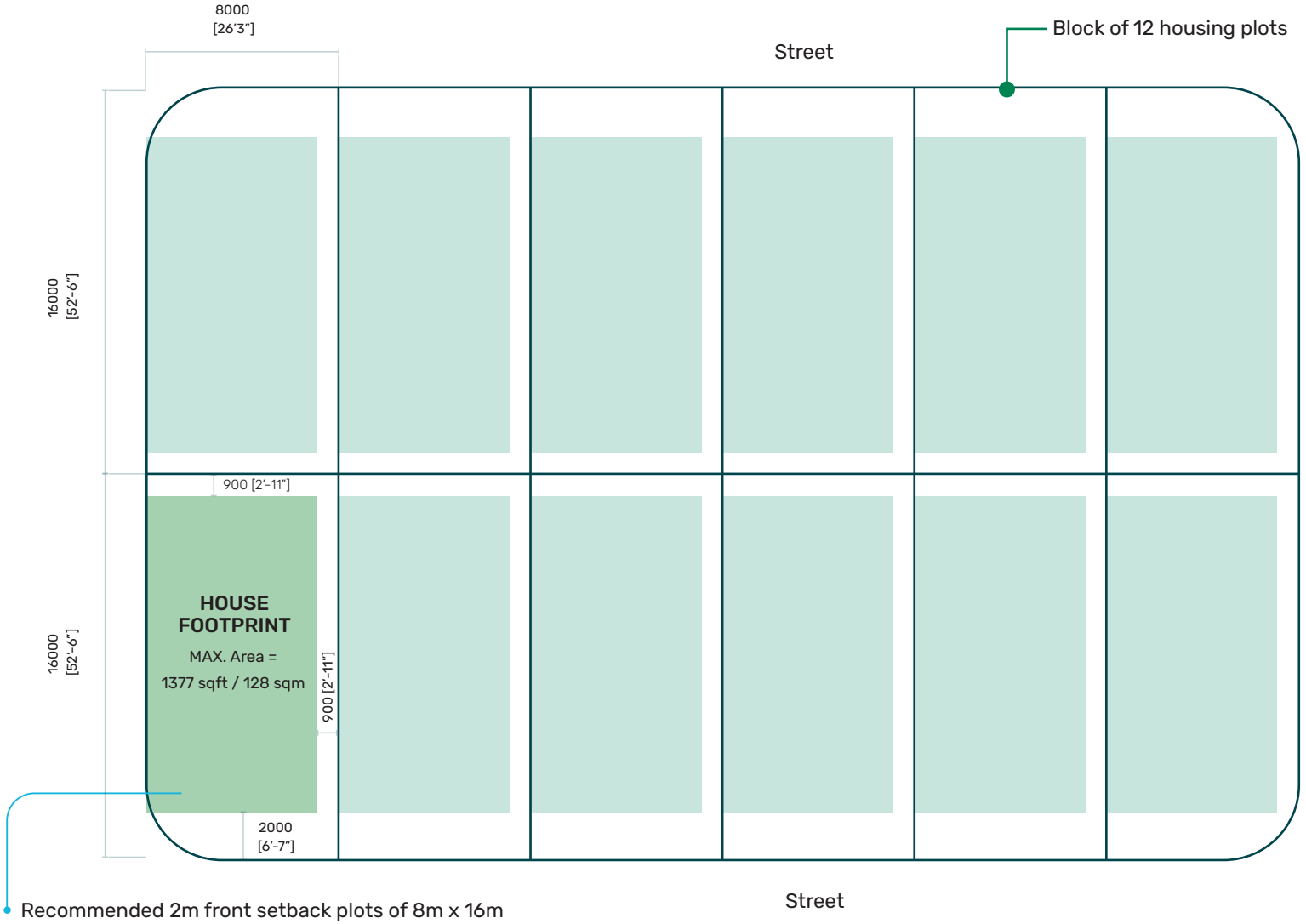
1.5.7 Shoring

- Shoring should be used for the construction of new structural elements or during demolition of existing ones;
- Shoring of new suspended beams:
  - Use timber 2in x 2in (5cm x 5cm) minimum or metal posts at 3ft (1.0m) maximum spacing;
  - Vertical supports shall be held in place at the top by opposing pairs of inclined props, alternating direction and at the bottom by a metal or timber stake securely anchored in the ground;
  - Shims at the post bases shall be provided as required for stability;
  - Shoring shall be left in place for 14 days after casting.
- Shoring of new confining beams or columns:
  - Use inclined props/braces as required to maintain all formwork firmly in the correct position;
  - Leave shoring in place for 24 hours minimum;
- Propping of walls: should be used any time that demolition works have to be performed or during the construction of new walls, while the top ring beam is still unbuilt.
- Prop configuration:
  - diagonal timber elements about 6ft (2m) long every 10ft (3.0m) along the wall;
  - a horizontal plank on the surface of the wall, held in place by the horizontal elements;
  - a horizontal plank on the floor, on which diagonal elements will be supported;

Annex A:

Recommended Strategies for Plot Subdivision

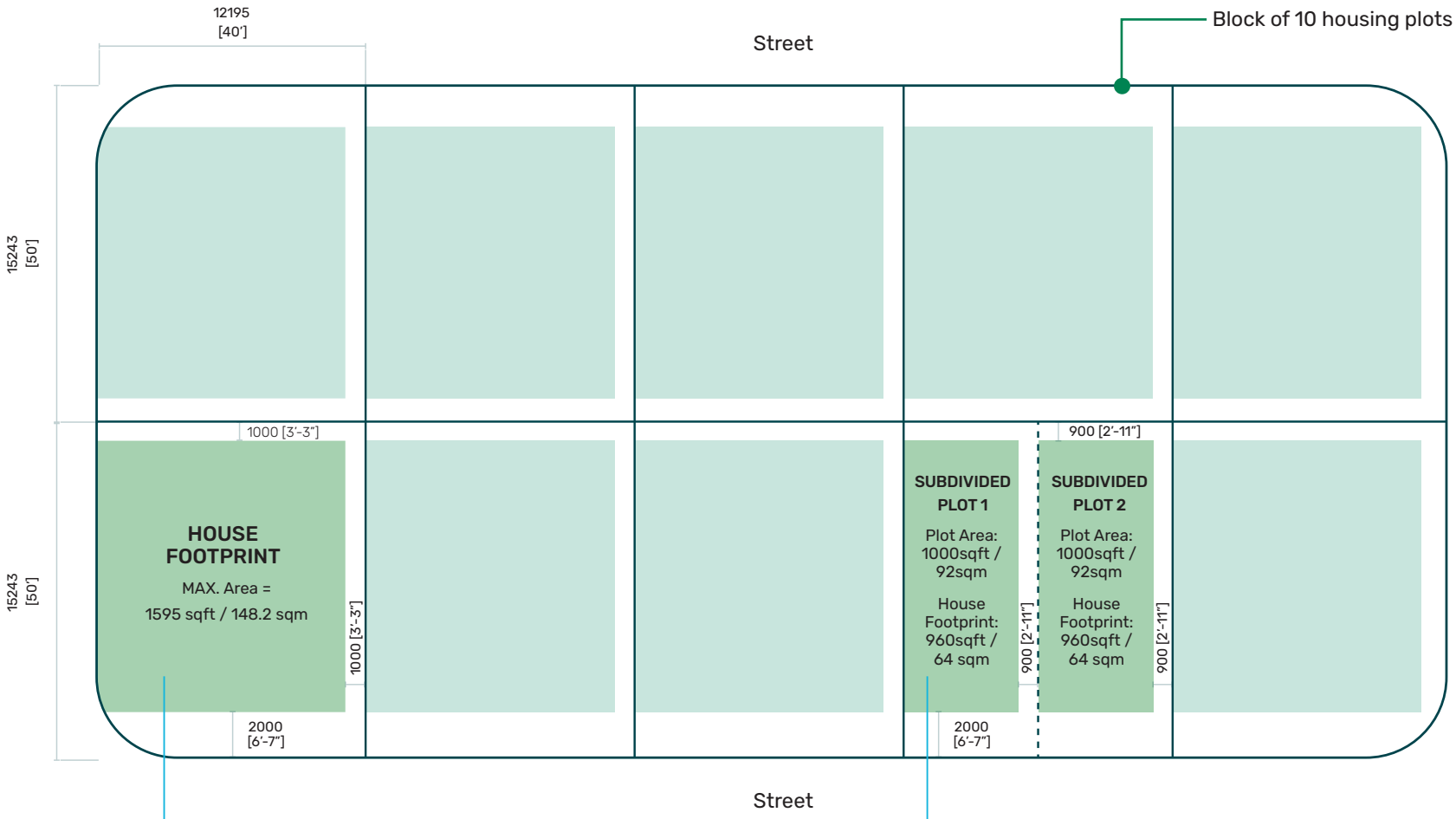
Typical Housing Block with 1377 sqft / 128 sqm plots



- Recommended 2m front setback plots of 8m x 16m to ensure adequate light, ventilation, space for plants and prevent potential water damage.
- Minimum front setback 1m

Recommended building set-backs on typical new housing
Plot type A (1377 sqft / 128 sqm)

Typical Housing Block with 2000 sqft / 185.8 sqm plots

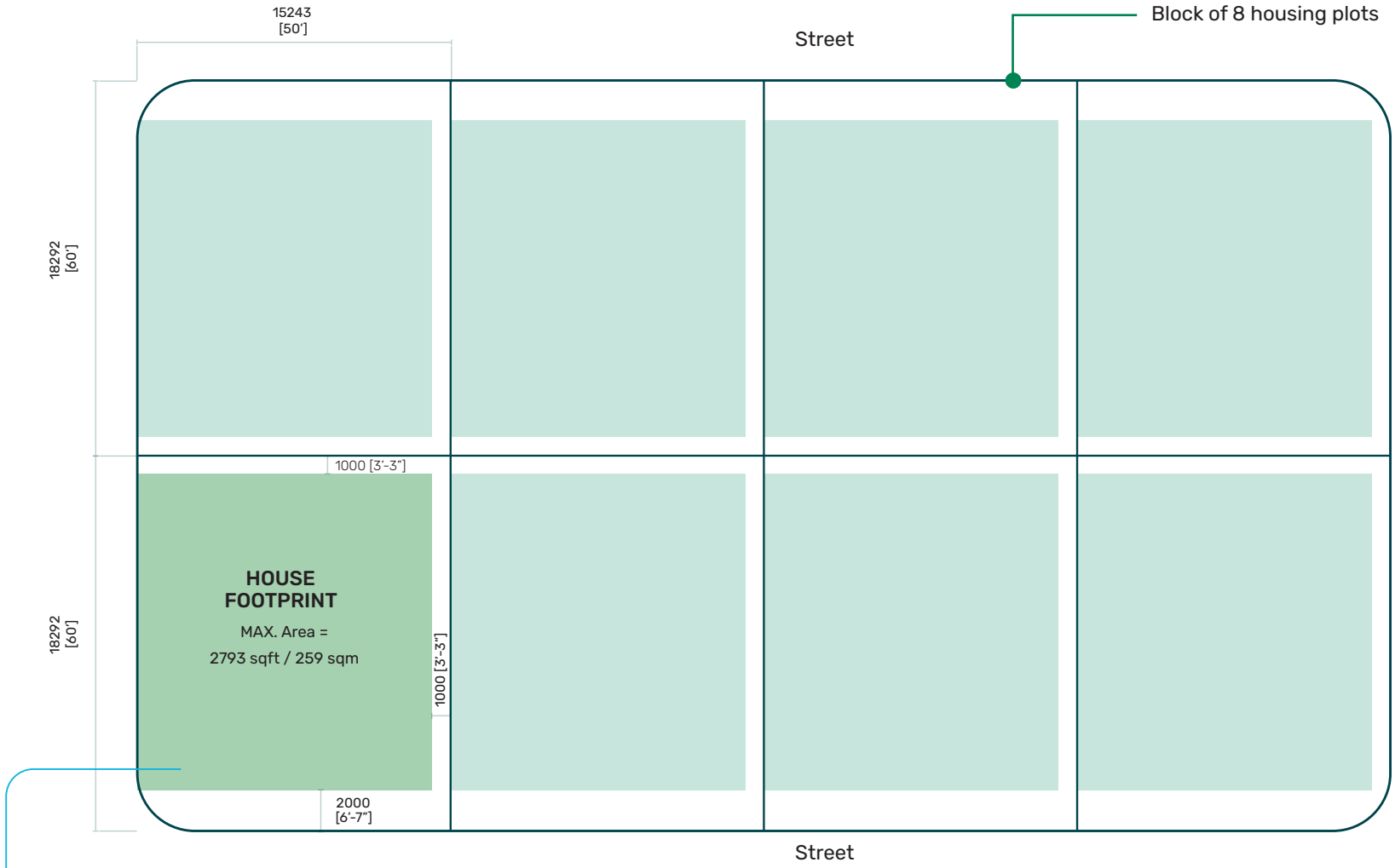


- Recommended 2m front setback plots of 15.2m x 12.2m to ensure adequate light, ventilation, space for plants and prevent potential water damage.
- Minimum front setback 1m

- If such a plot needs to be sub-divided, this is a recommended division into 2 plots, to still ensure set-backs, access paths, healthy ventilation and minimal damage

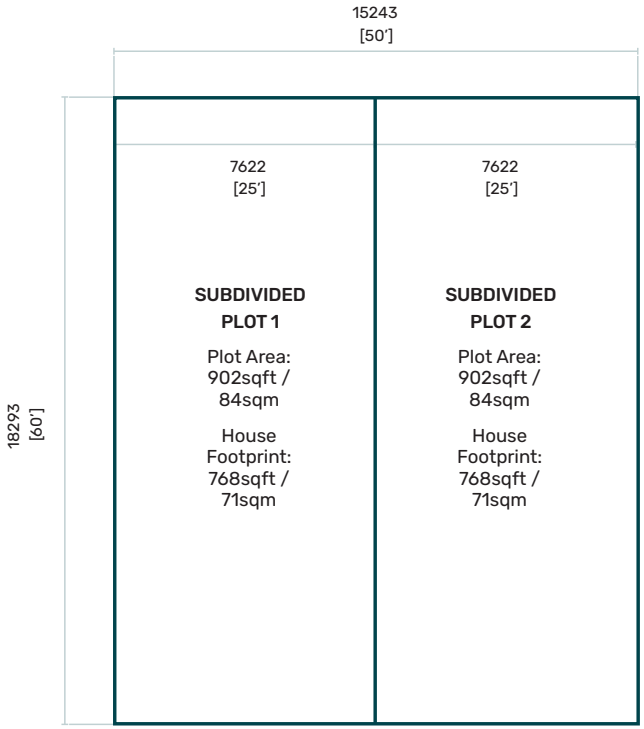
Recommended building set-backs & plot sub-divisions on typical new housing plot type B (2000sqft / 185.8 sqm)

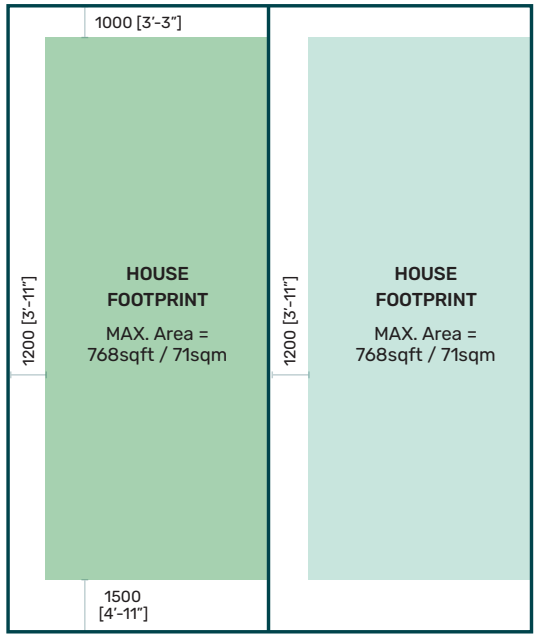
Typical Housing Block with 3000 sqft / 278 sqm plots



- Recommended 2m front setback plots of 15.2m x 18.2m to ensure adequate light, ventilation, space for plants and prevent potential water damage.
- Minimum front setback 1m

Recommended building set-backs on typical new housing
Plot type C (3000 sqft / 278 sqm)



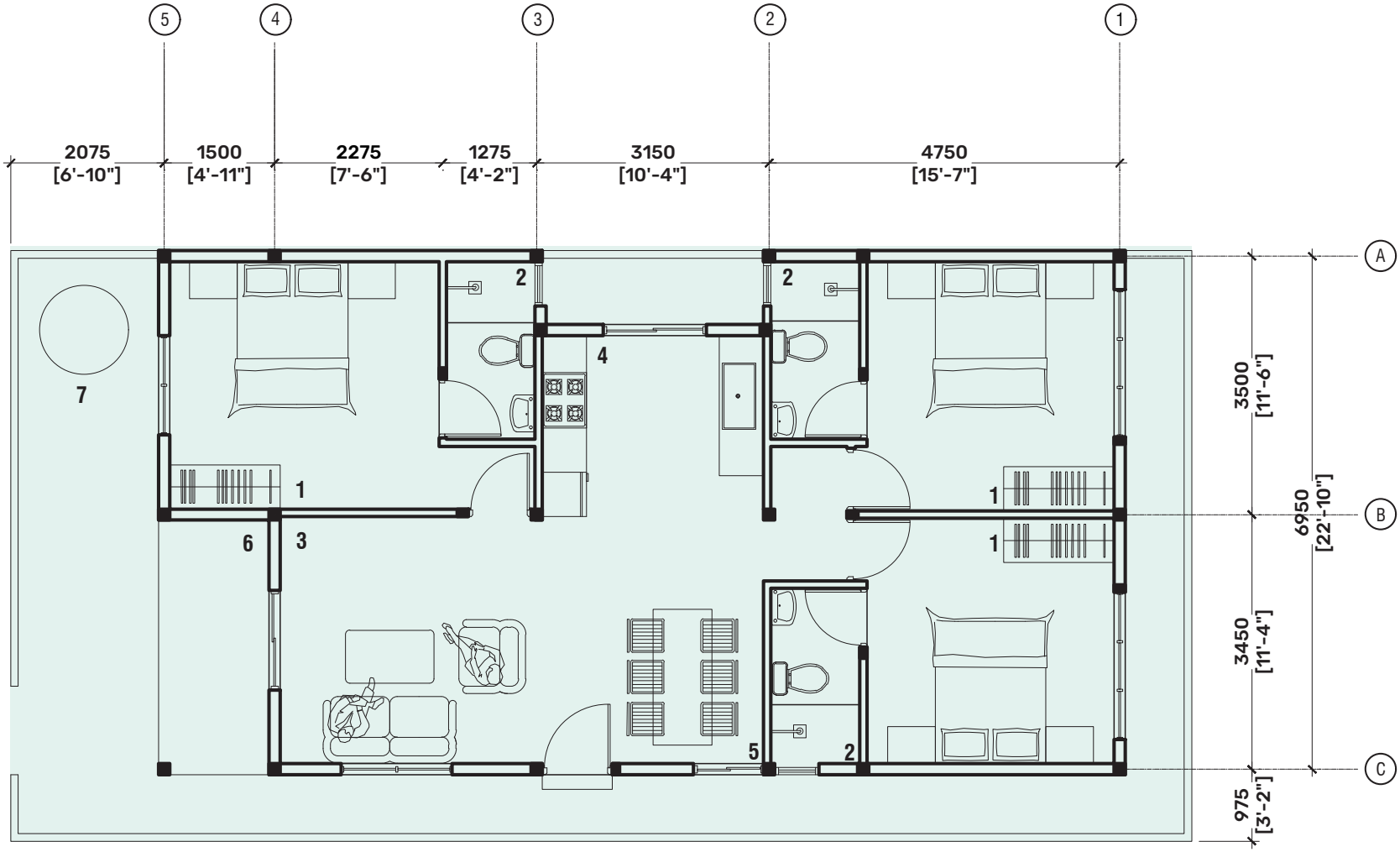


Recommended plot sub-divisions on typical new housing plot type C(3000 sqft / 278 sqm

Annex B:

3 Bedroom model sample house layout

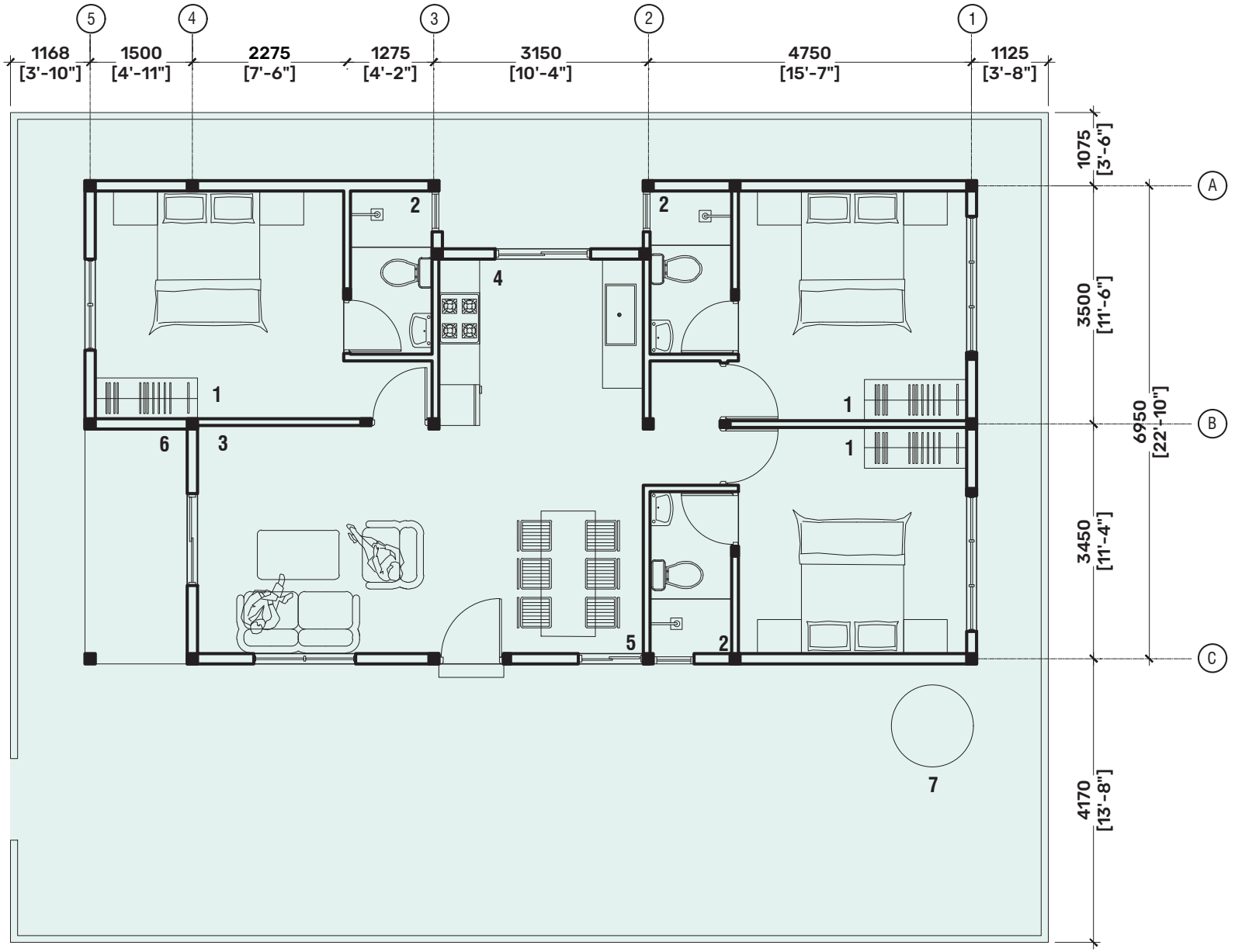
NOTE: These drawings are intended to be a guide for homeowners wishing to build a single storey, resilient home and should be used with conjunction with the recommendations in the handbook. These drawings are not full construction documents and may need additional engineering or architectural inputs to be adjusted to suit particular site conditions. These drawings must not be used for commercial gain.



Sample House - Plot Type A

PLOT AREA: 1377 SQFT (128 SQM)
BUILT-UP AREA: 969 SQFT (90 SQM)

1. Bedroom
2. Bathroom
3. Sitting Room
4. Kitchen
5. Dining Area
6. Verandah
7. Rainwater Tank

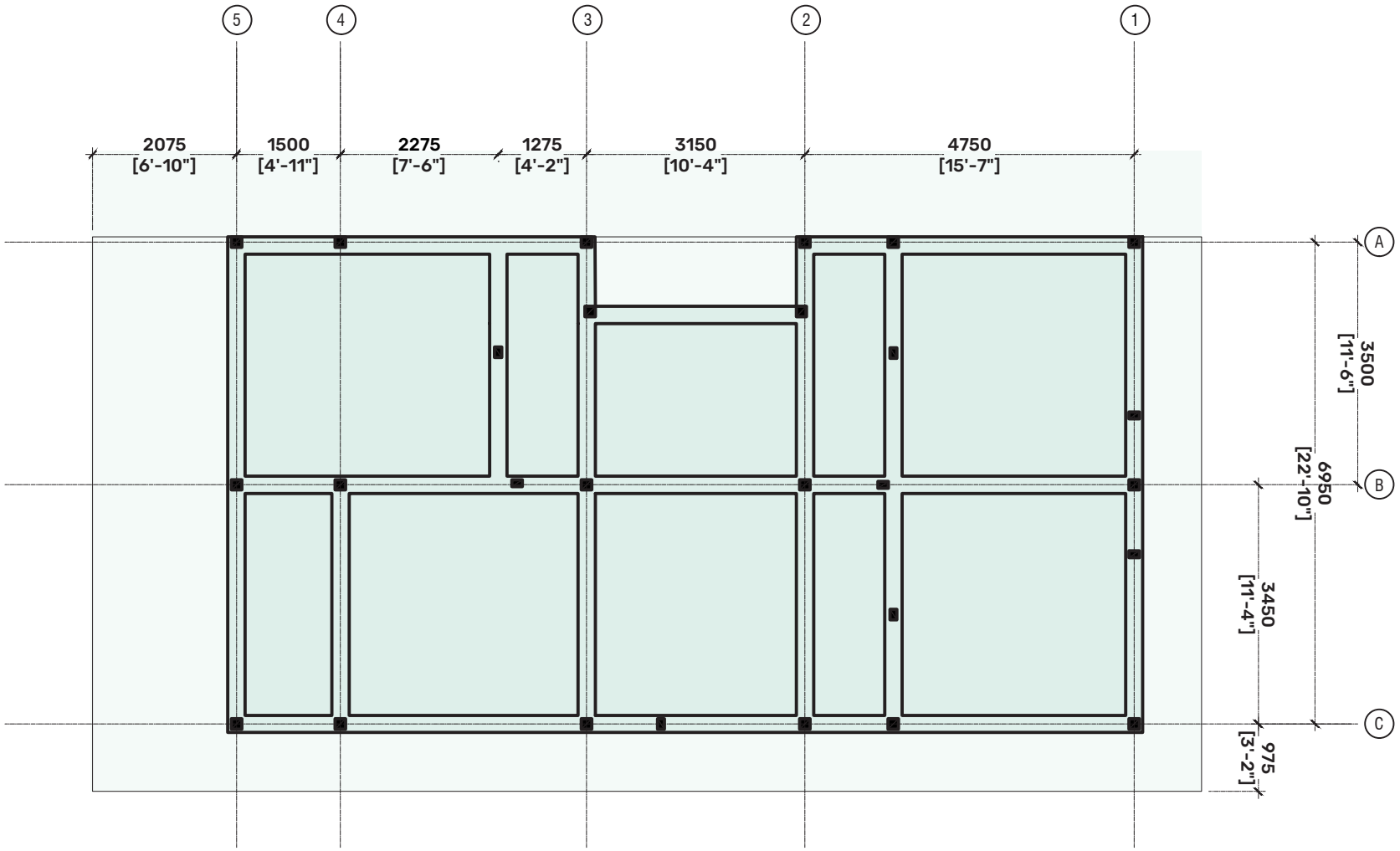


Sample House - Plot Type B

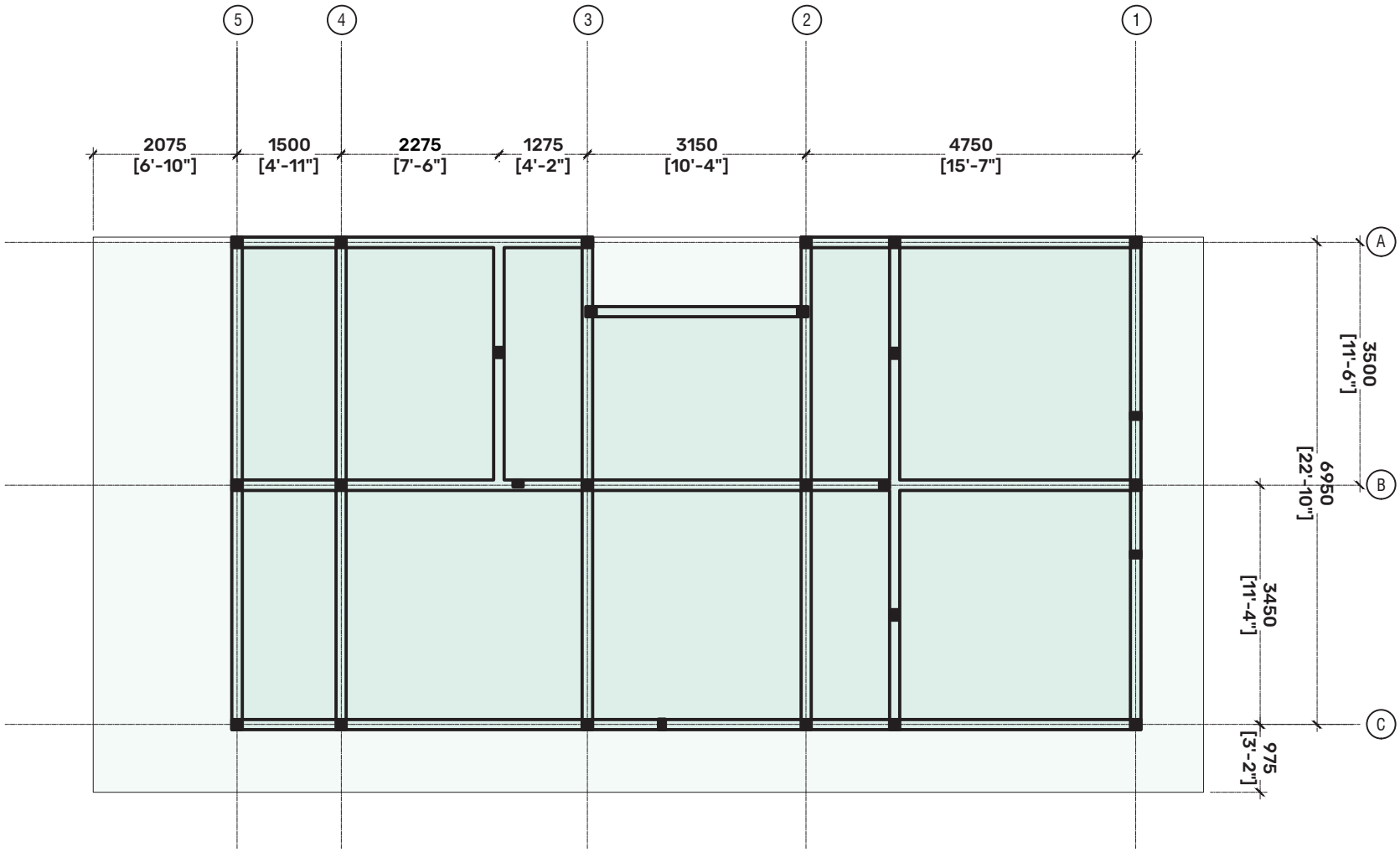
PLOT AREA: 2000 SQFT (185 SQM)
BUILT-UP AREA: 969 SQFT (90 SQM)

1. Bedroom
2. Bathroom
3. Sitting Room
4. Kitchen
5. Dining Area
6. Verandah
7. Rainwater Tank

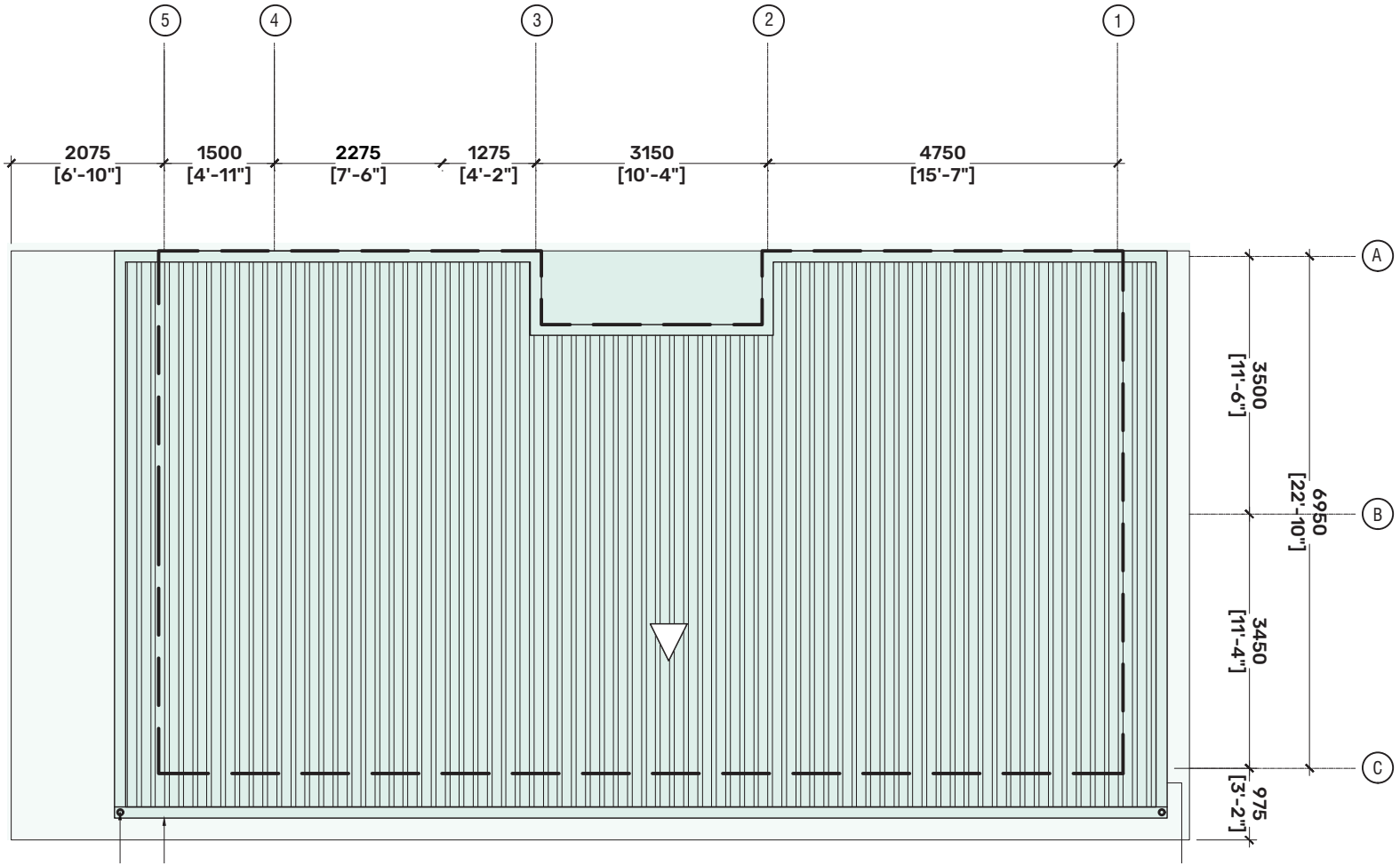
Foundation Beam Plan



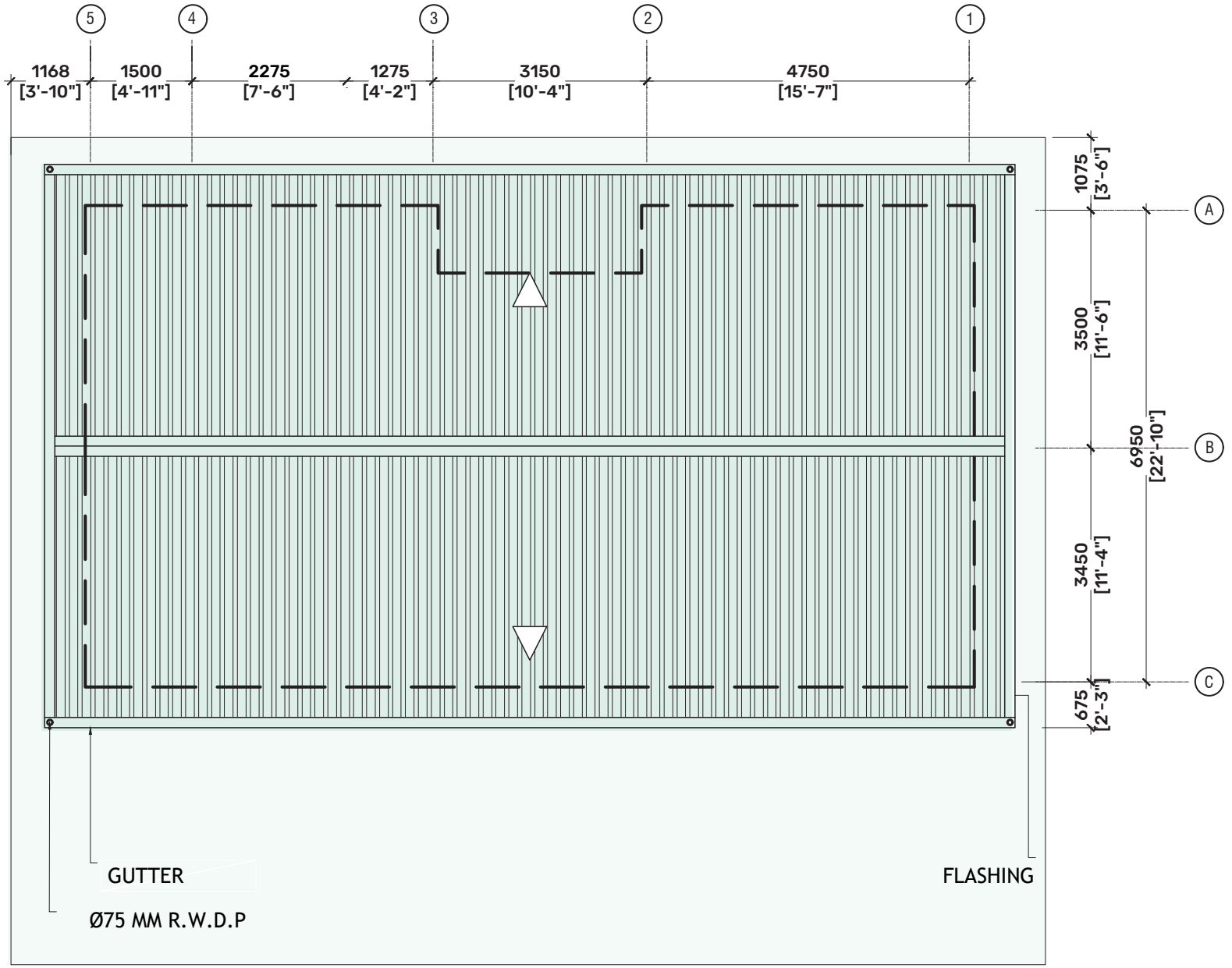
Roof Beam Plan



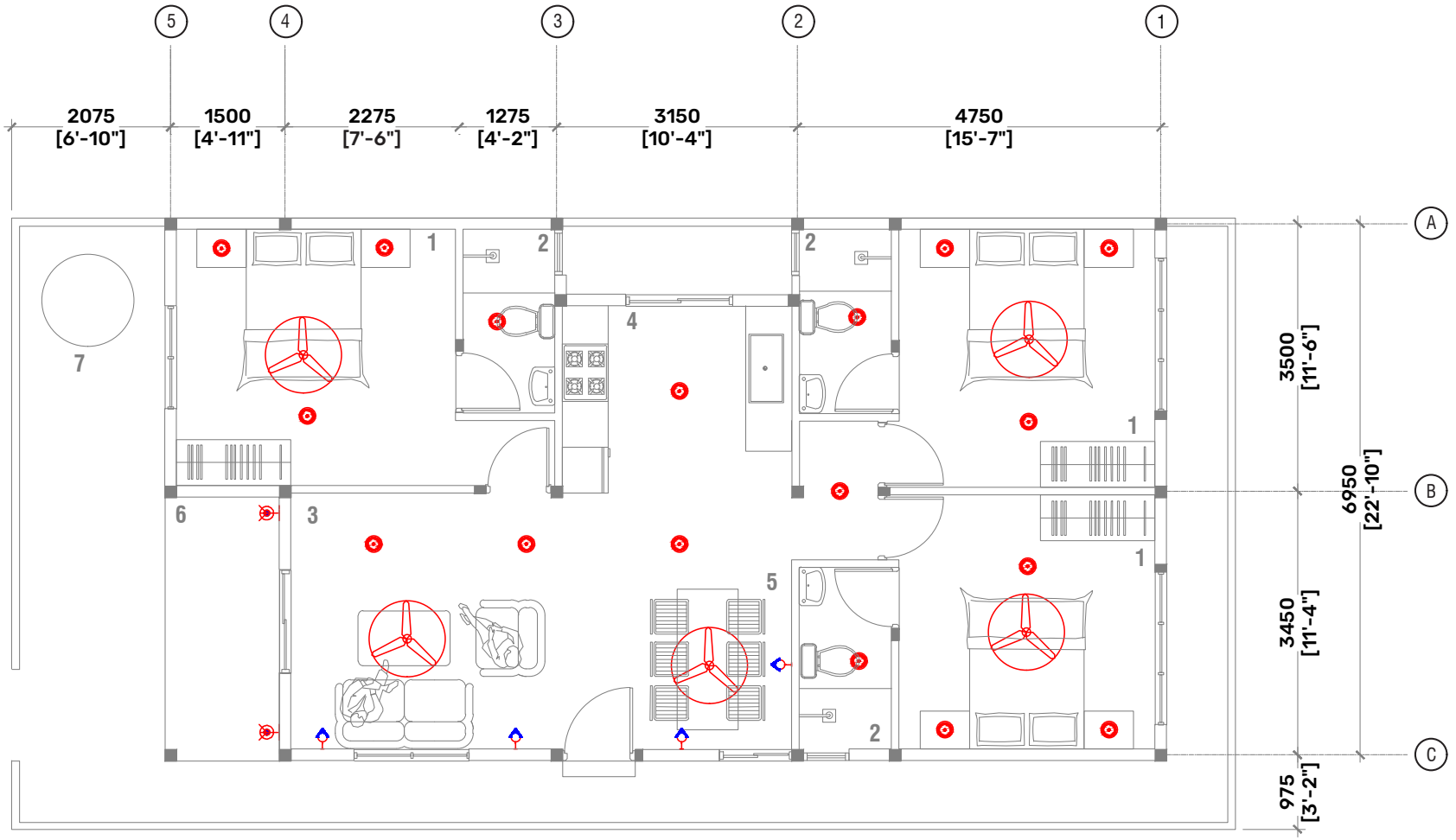
Roof Plan - Option A (Single-side Sloping)



Roof Plan - Option B (Two-side Sloping)



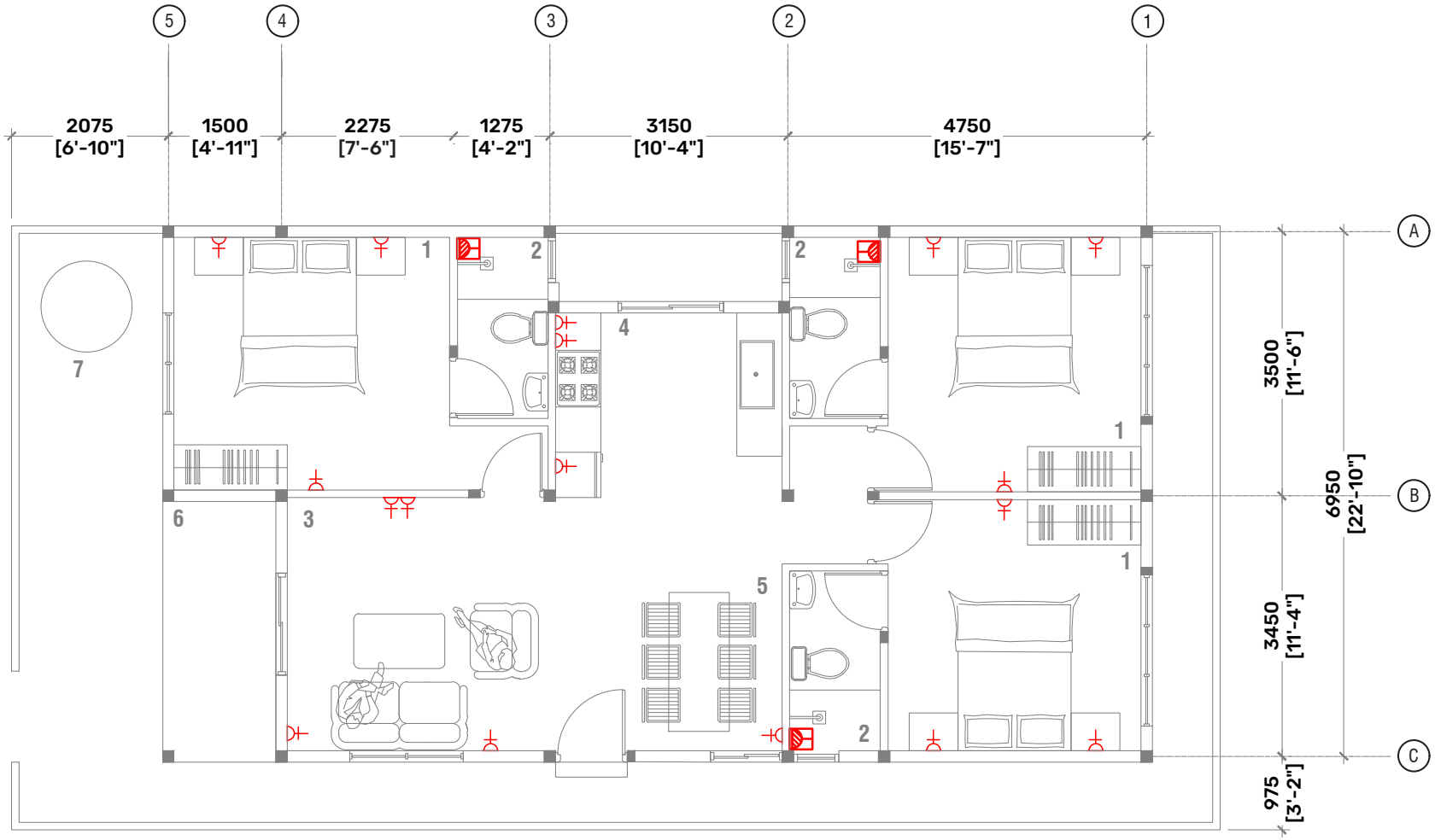
Lighting / Electrical Layout



SYMBOL	DESCRIPTION
●	LED RECESSED LIGHT (13W)
⊣◆	LED INDOOR WALL LIGHT UP/DOWN (20W)
⊢◆	LED OUTDOOR WALL LIGHT UP/DOWN (20W)
✳	CEILING FAN (52"-54")

1. Bedroom
2. Bathroom
3. Sitting Room
4. Kitchen
5. Dining Area
6. Verandah
7. Rainwater Tank

Power Layout



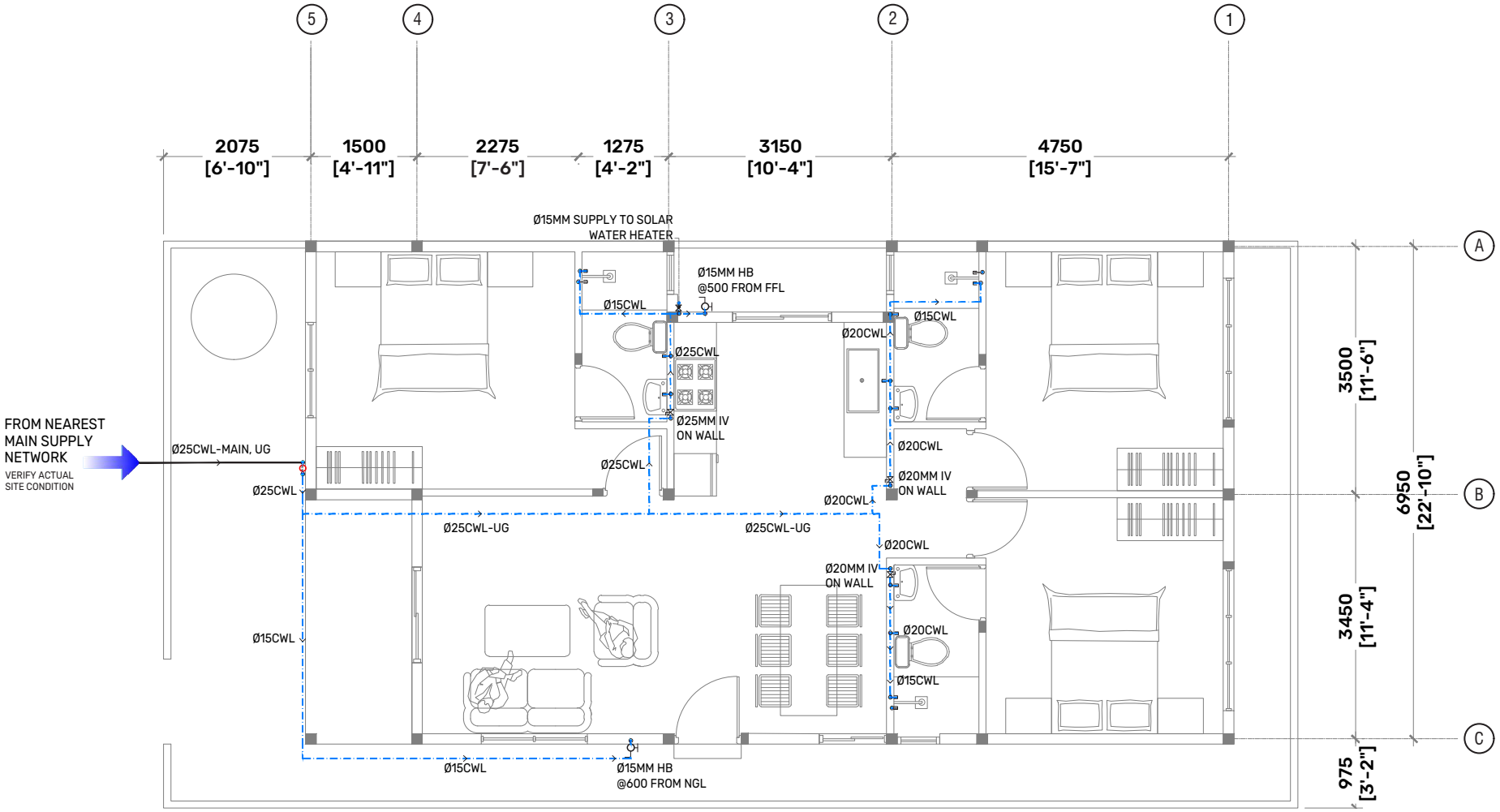
SYMBOL	DESCRIPTION
	13A POWER OUTLET
	13A SWITCHED SOCKET OUTLET@H.L

1. Bedroom
2. Bathroom
3. Sitting Room
4. Kitchen
5. Dining Area
6. Verandah
7. Rainwater Tank

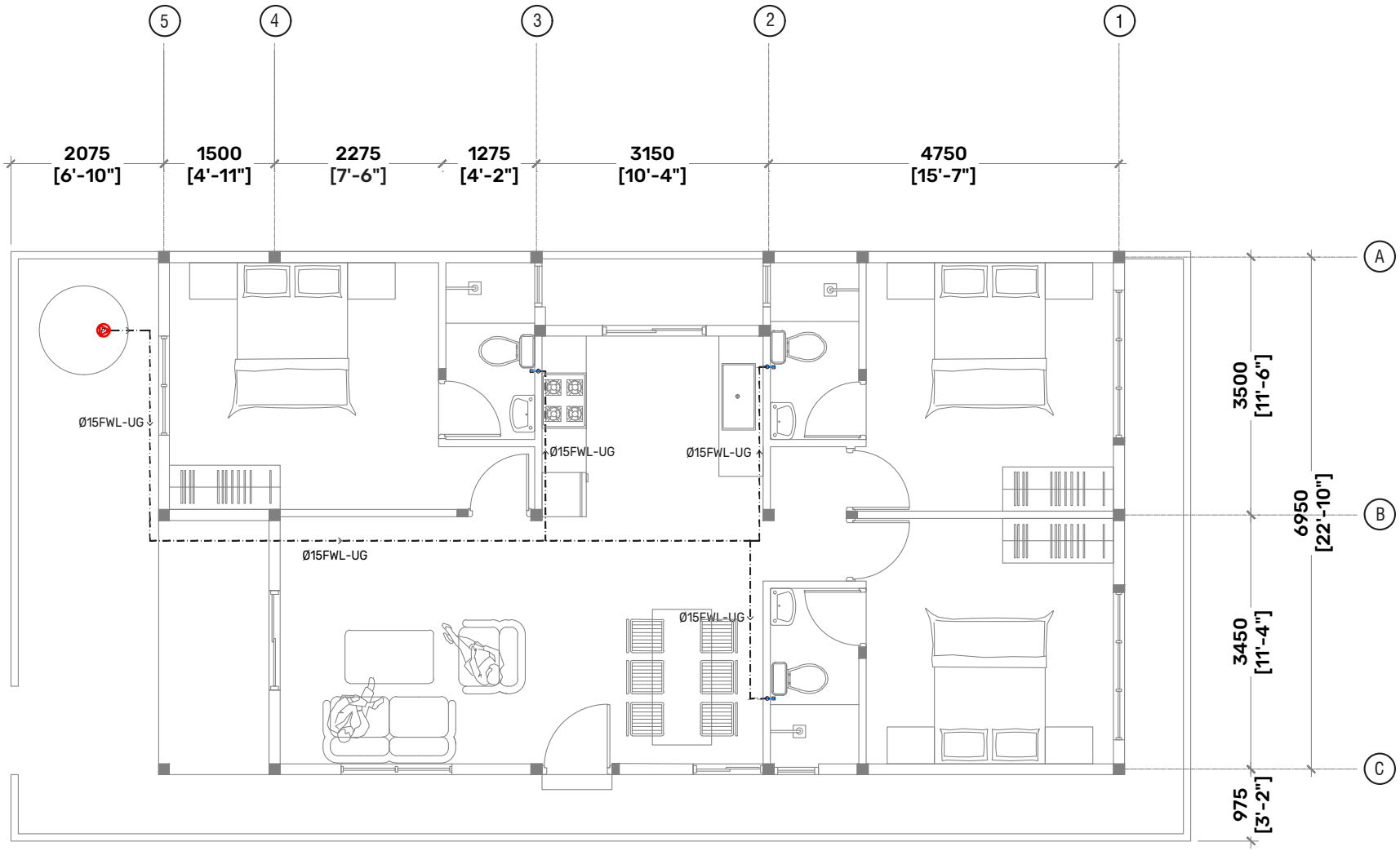
Hot and cold water supply legend:

Symbol	Description	Symbol	Description
	WATER SUPPLY		
	Cold water supply line	NPT	National pipe thread
	Hot water supply line	IV	Isolation valve
	Valve	GV	Gate valve
	3-way valve	CV	Check valve
	Globe valve	FLV	Float valve
	Check valve	HB	Hose bib
	Float valve	CWL	Cold waterline
	End cap or end plug	HWL	Hot waterline
	Taps	FWL	Flushing waterline
	Pipe down	RWL	Recovered waterline
	Pipe up	HWL-RL	HWL - Return line
WM	Water meter	CWL-AC	CWL - Above feiling
	Pump	CWL-UG	CWL - Underground
WH	Wall mounted elect. water heater		
	Riser or downfeed		

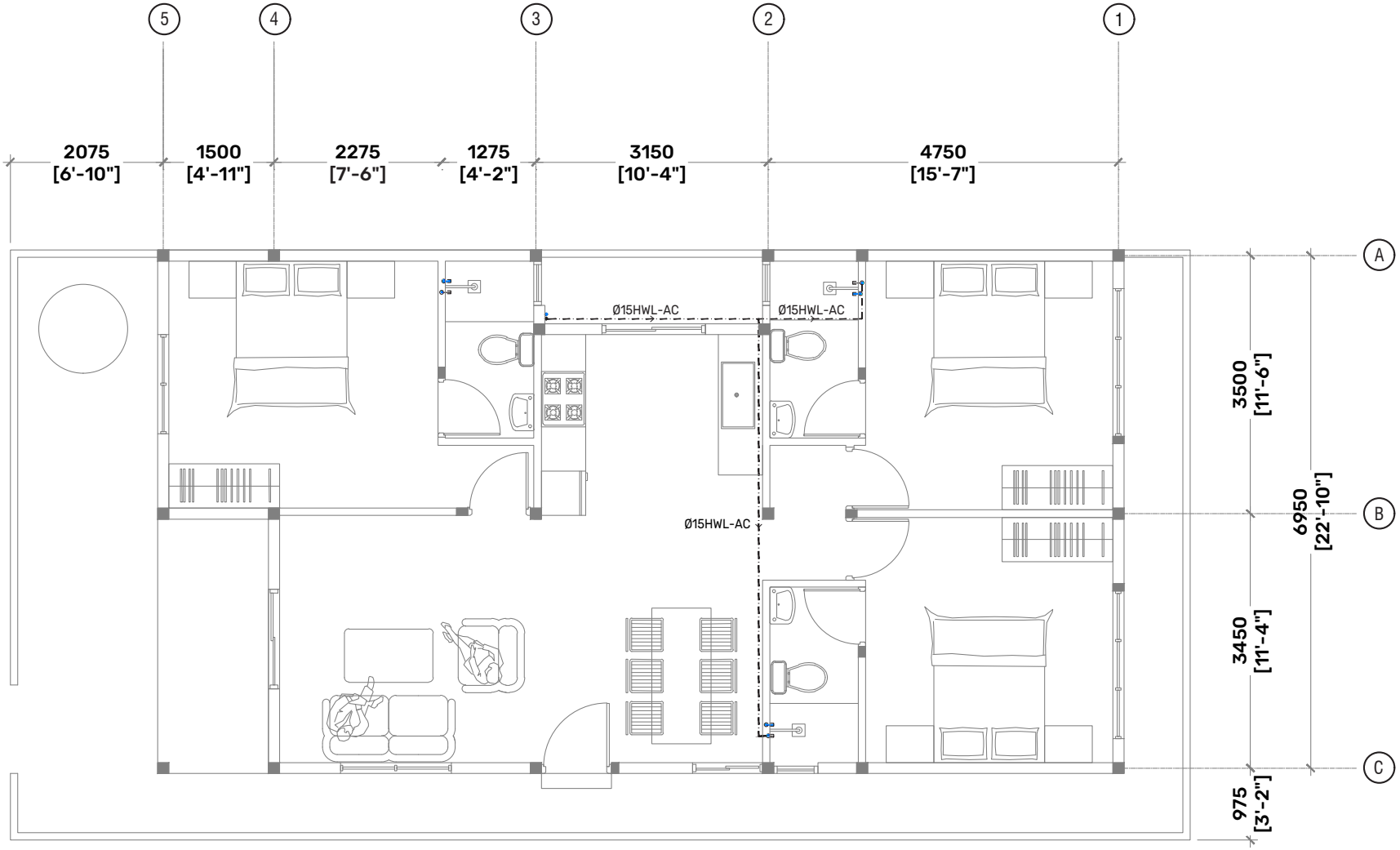
Domestic Water Supply line



Flushing Water Supply Line

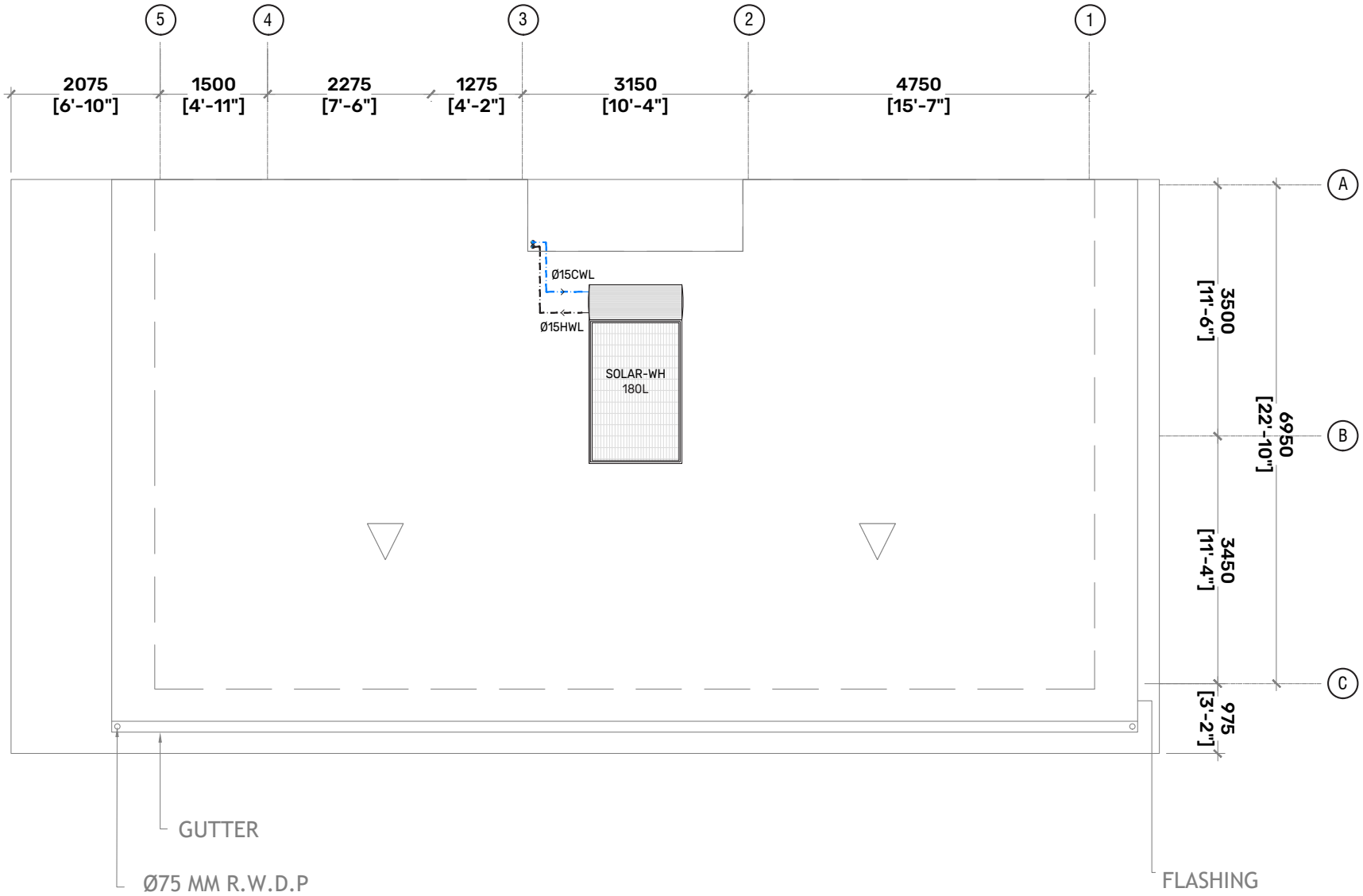


Hot Water Supply Line



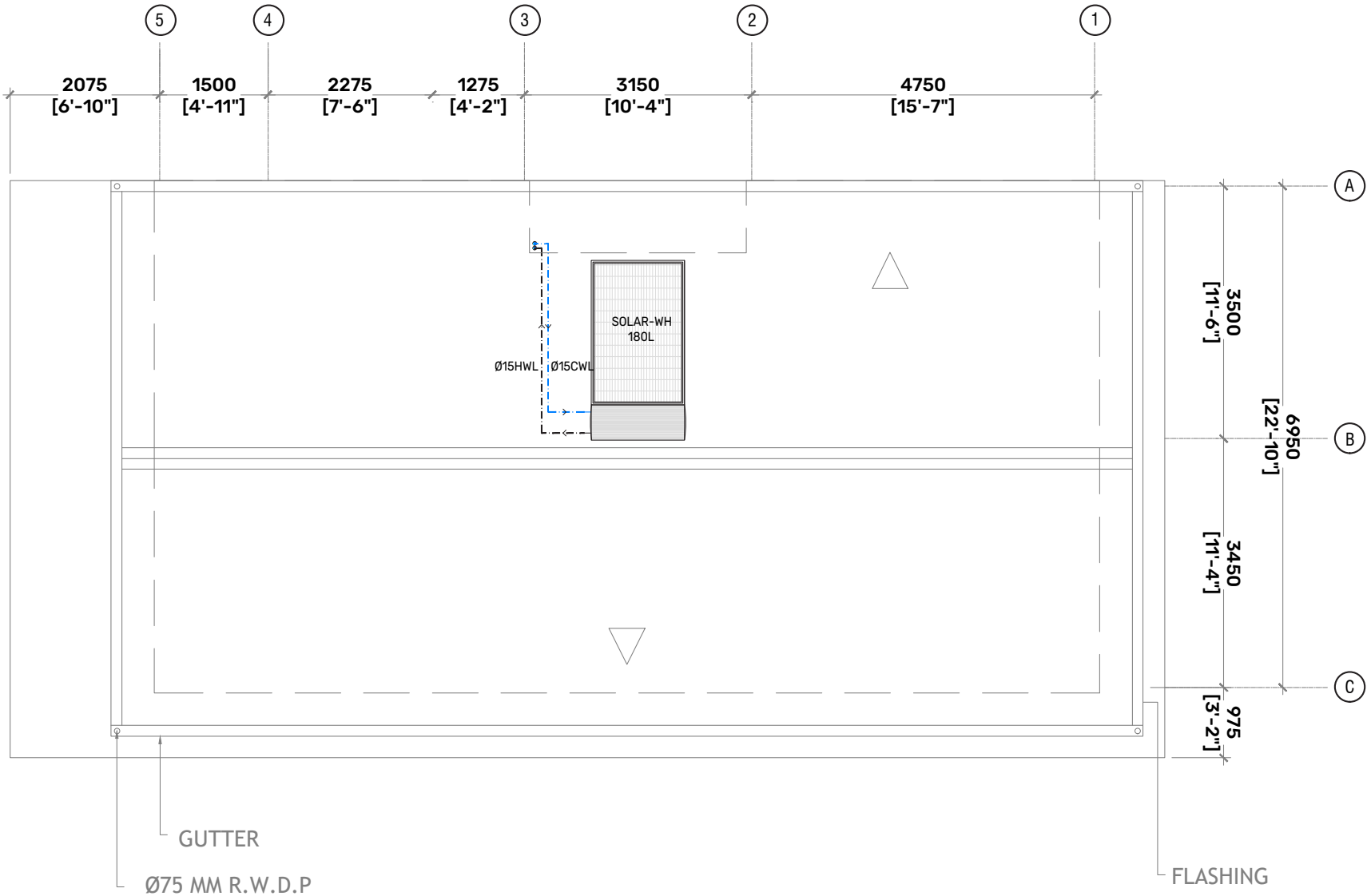
Solar Water Heater Layout - For Roof Option A

NOTE: The Solar Water Heater shall be installed based on the recommendations of the supplier such as the orientation, water demand and geographical location to maximize efficiency. The layout illustrates a typical installation in a resilient housing unit.



Solar Water Heater Layout - For Roof Option B

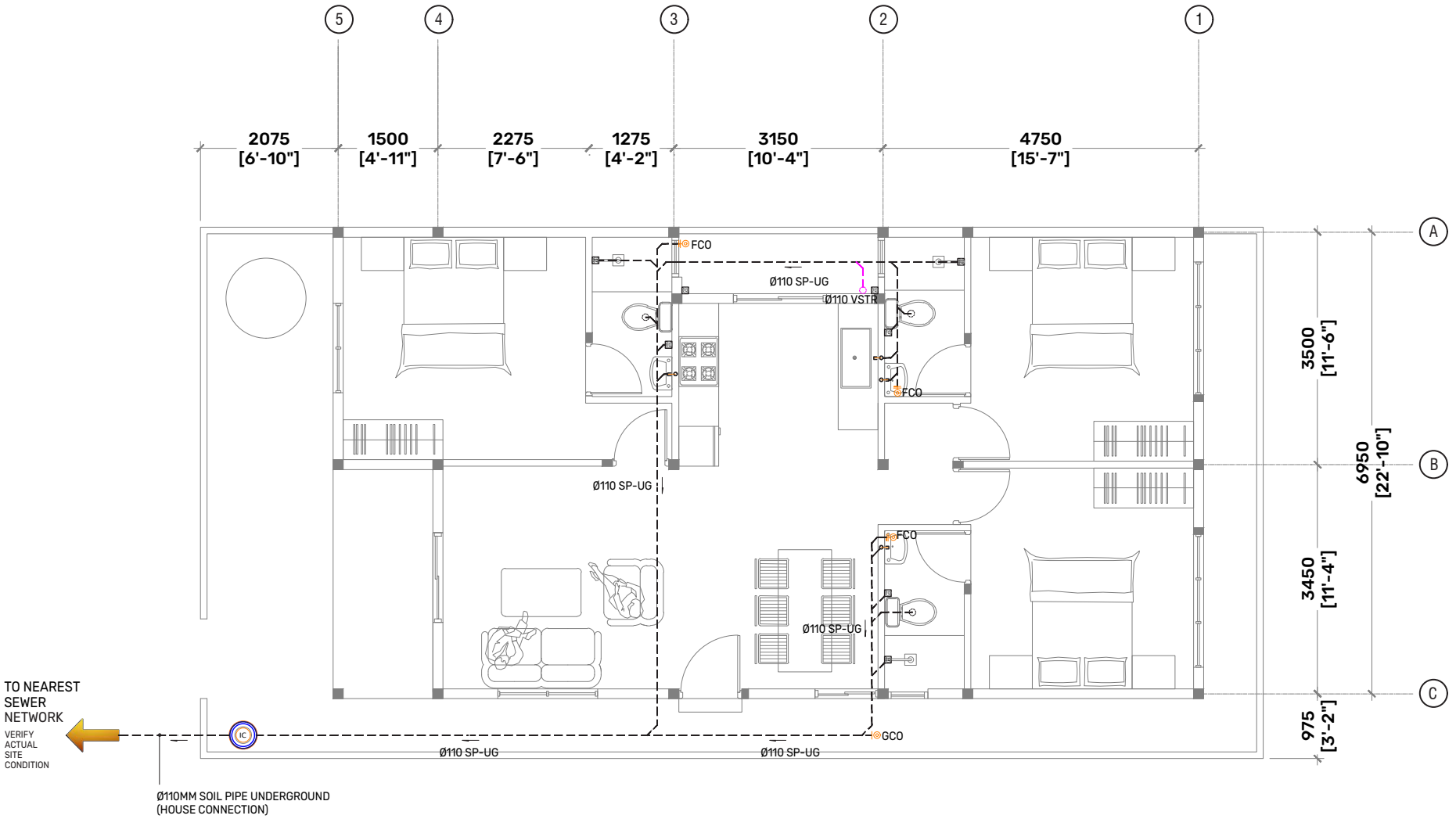
NOTE: The Solar Water Heater shall be installed based on the recommendations of the supplier such as the orientation, water demand and geographical location to maximize efficiency. The layout illustrates a typical installation in a resilient housing unit.



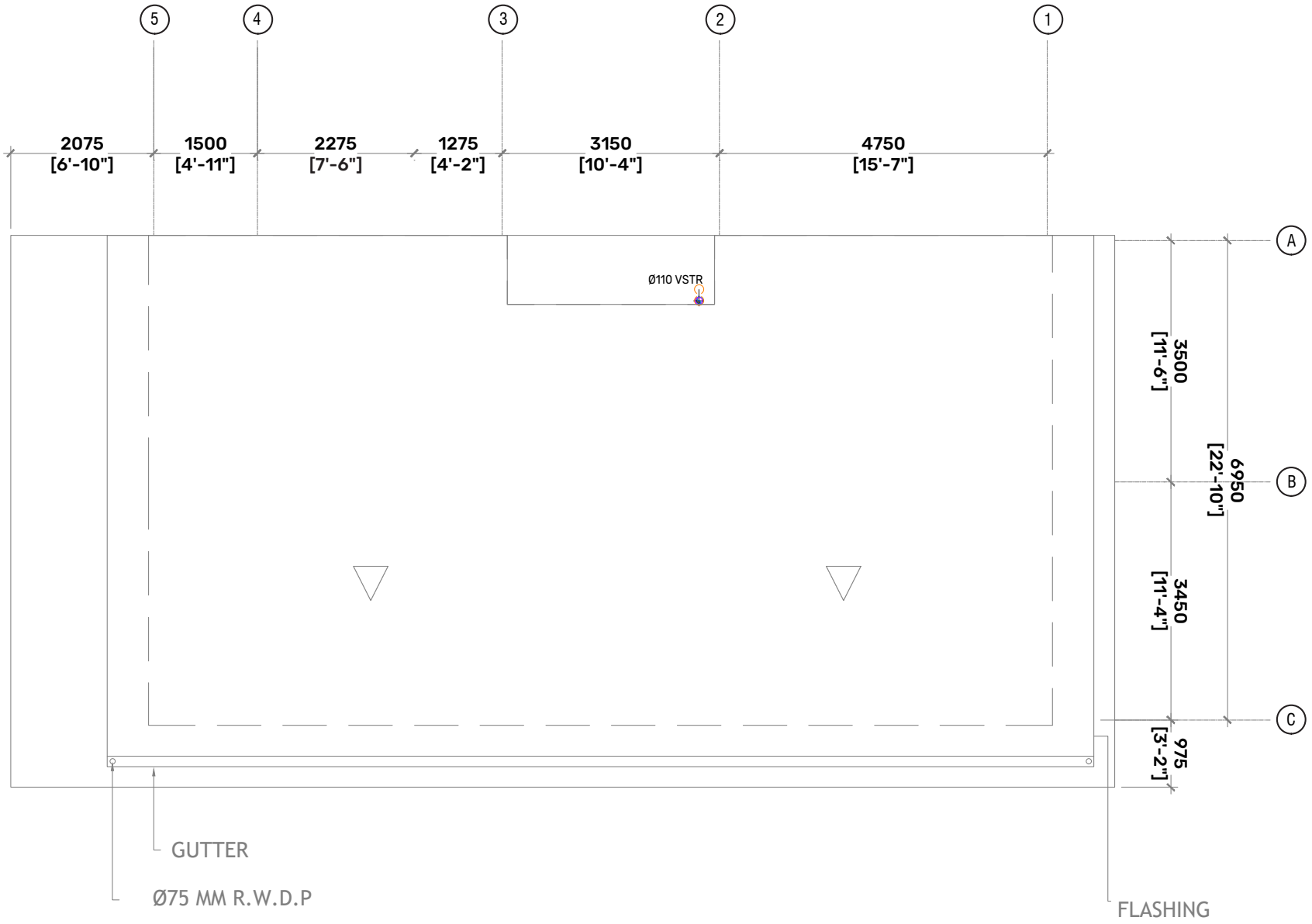
Sewer, waster and vent system legend:

Symbol	Description	Symbol	Description
	SOIL, WASTE AND VENT SYSTEM		
	Soil pipe	SP / SS	Soil pipe / soil stack
	Waste pipe	WP / WS	Waste pipe / Waste stack
	Vent pipe	VP / VS	Vent pipe / Vent stack
	AC Condensate drain pipe	VSTR	Vent stack thru roof
	Stack	ACDP	AC drain pipe
	Vent stack thru roof	FCO / GCO	Floor clean out / ground clean out
	Ground or floor clean out	CCO	Ceiling clean out
	Ceiling clean out	WCO	Wall clean out
	Wall clean out	FG / FD	Floor gully / Floor drain
FD	Floor drain or gully	OGI	Oil and grease interceptor
	Commercial kitchen floor drain	AC	Above ceiling
	Commercial kitchen through/kettle trench drain, SS	US	Under slab
SLOPE	Slope - Flow direction	UG	Underground
OGI	Oil and grease interceptor	BTD	Bath tub / Tub drain
IC	Inspection chamber manhole	OF	Overflow

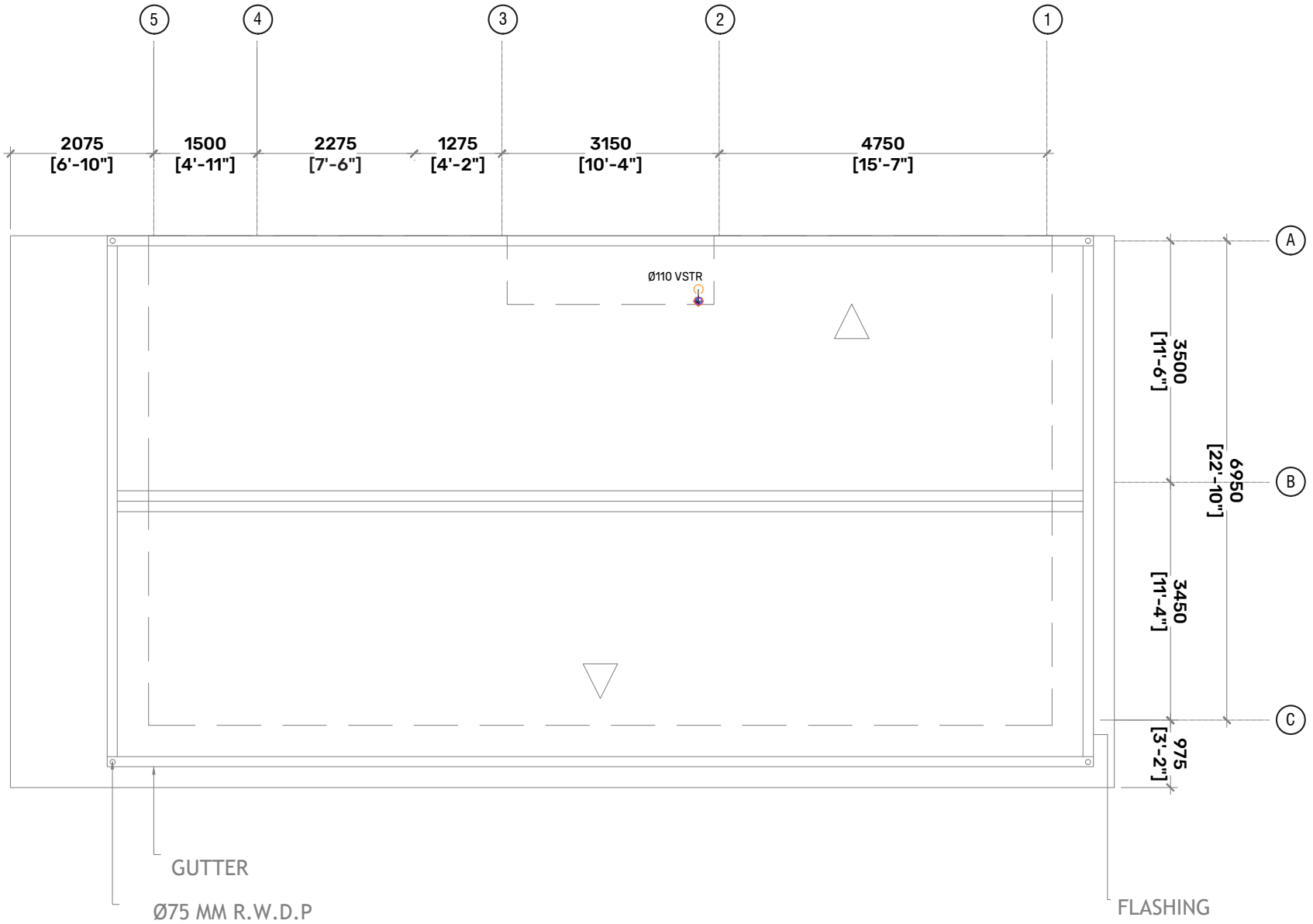
SWV System at Ground Floor



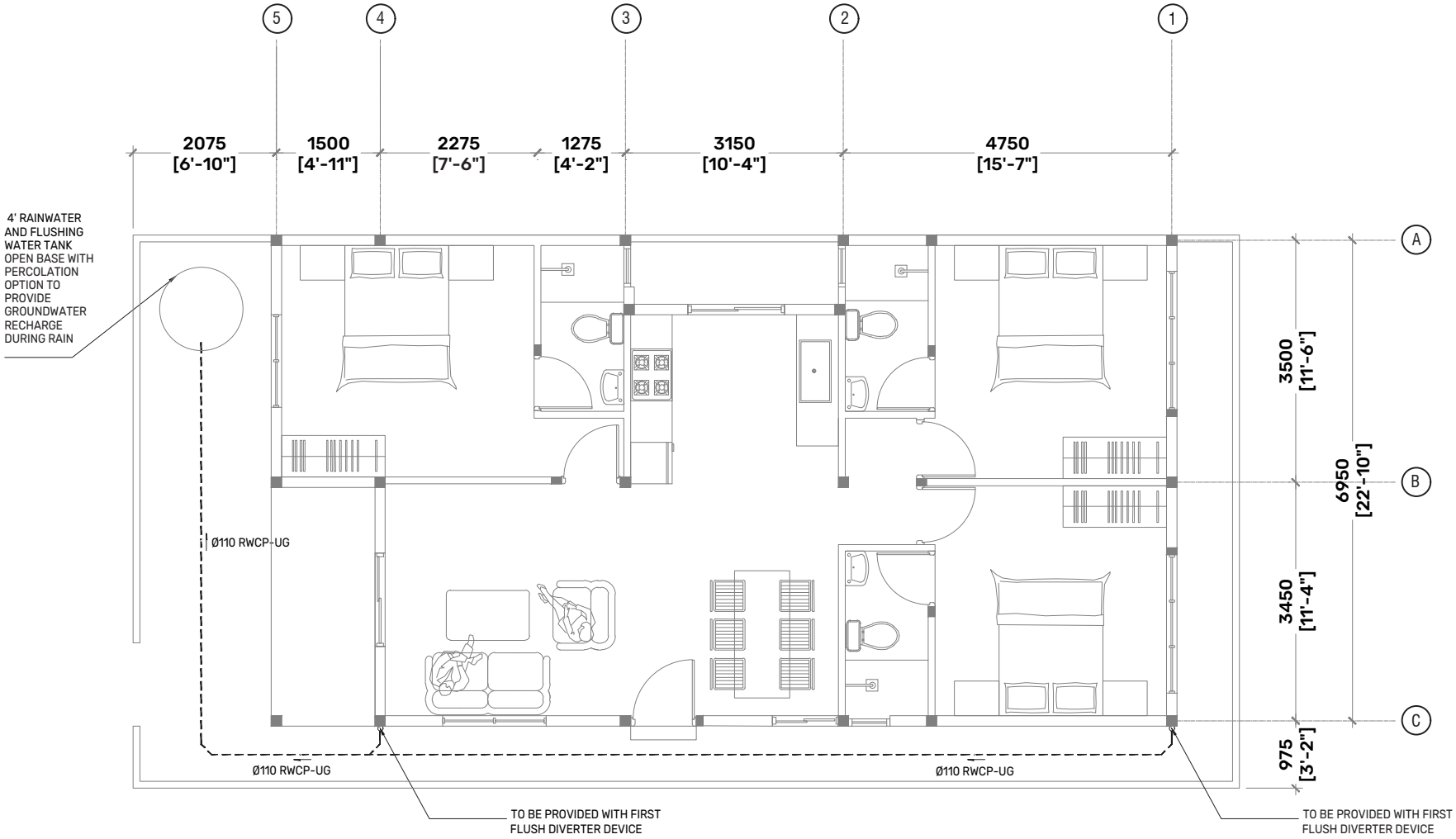
VSTR - For Roof Option A



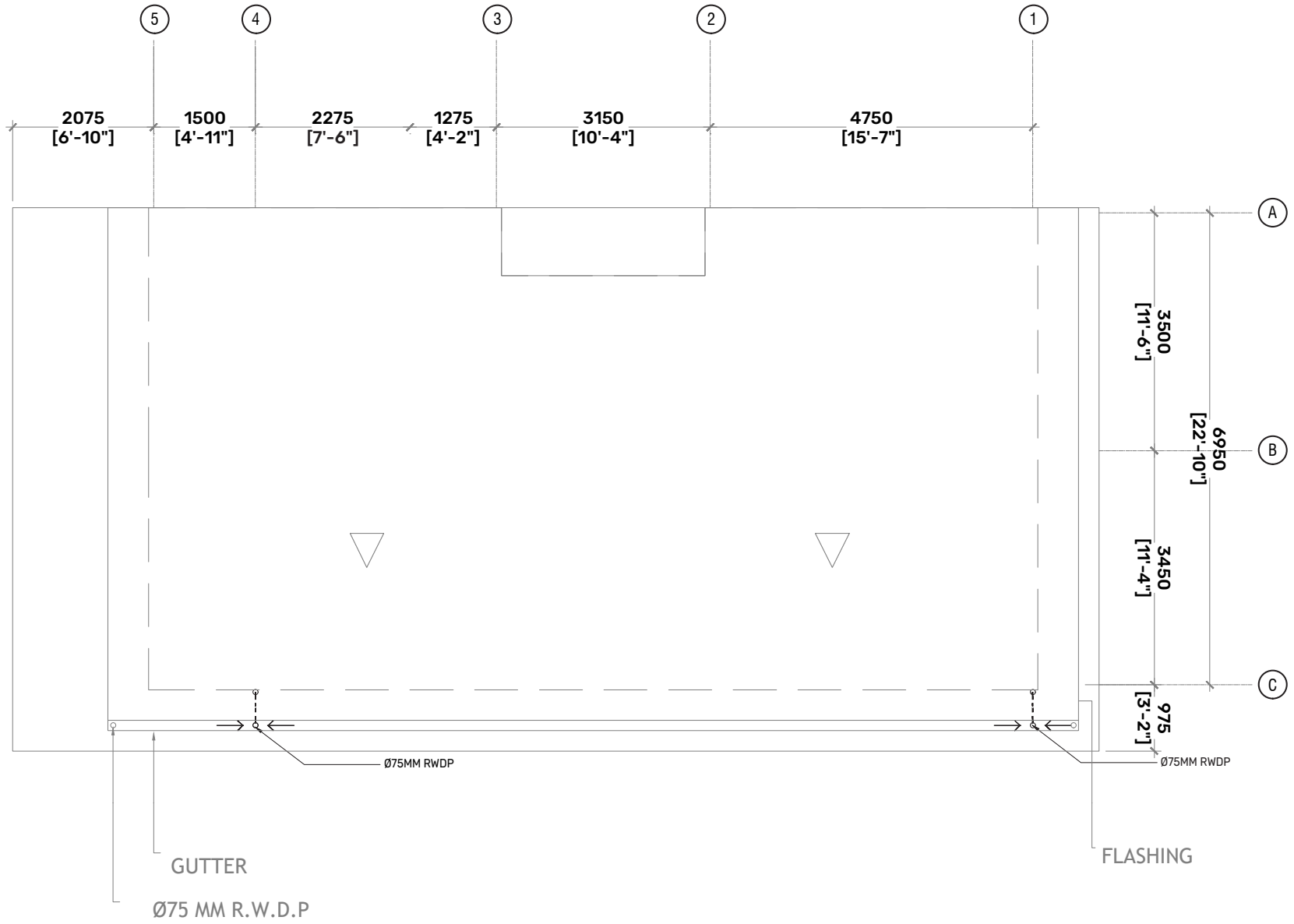
VSTR - For Roof Option B



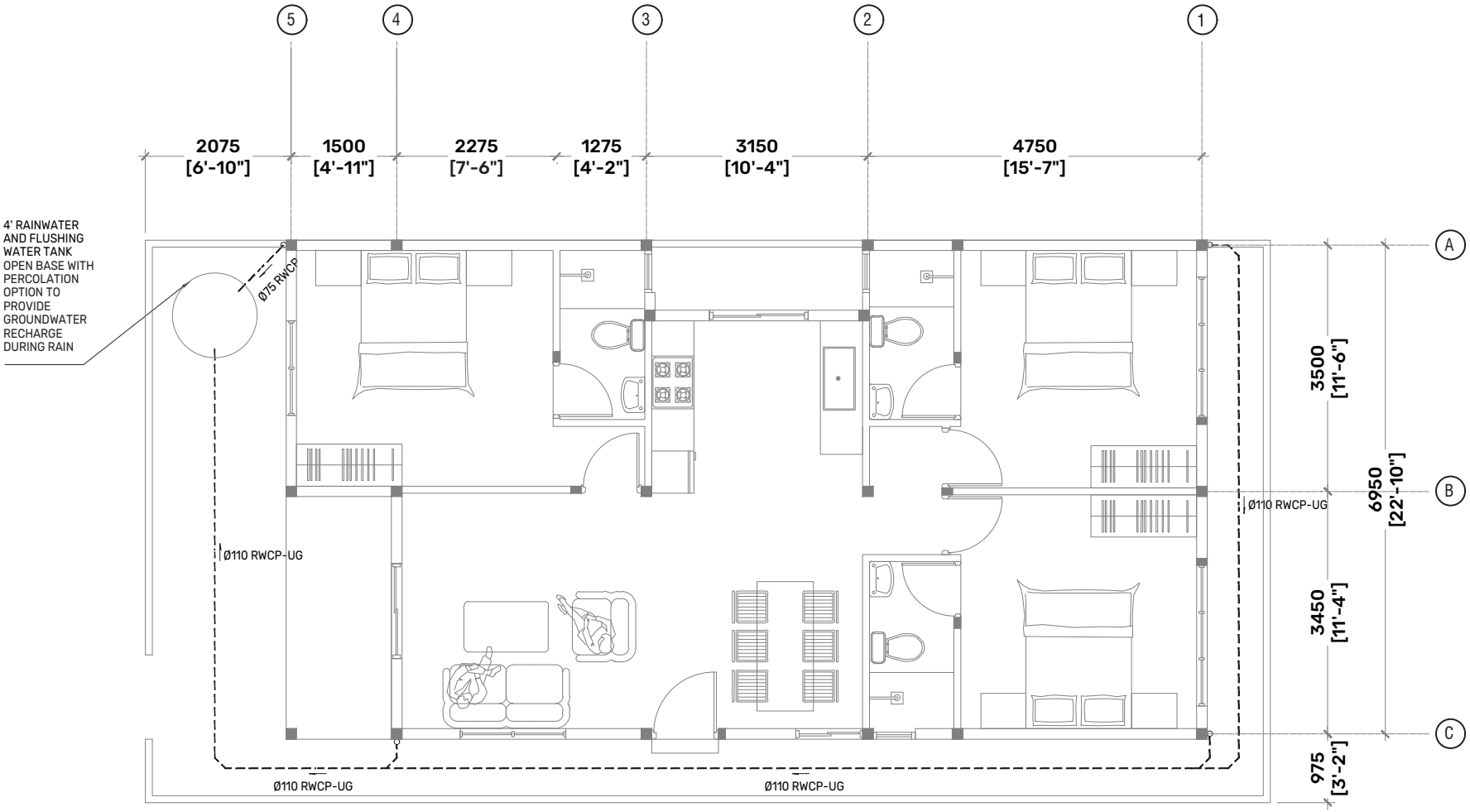
Drainage Layout - For Roof Option A



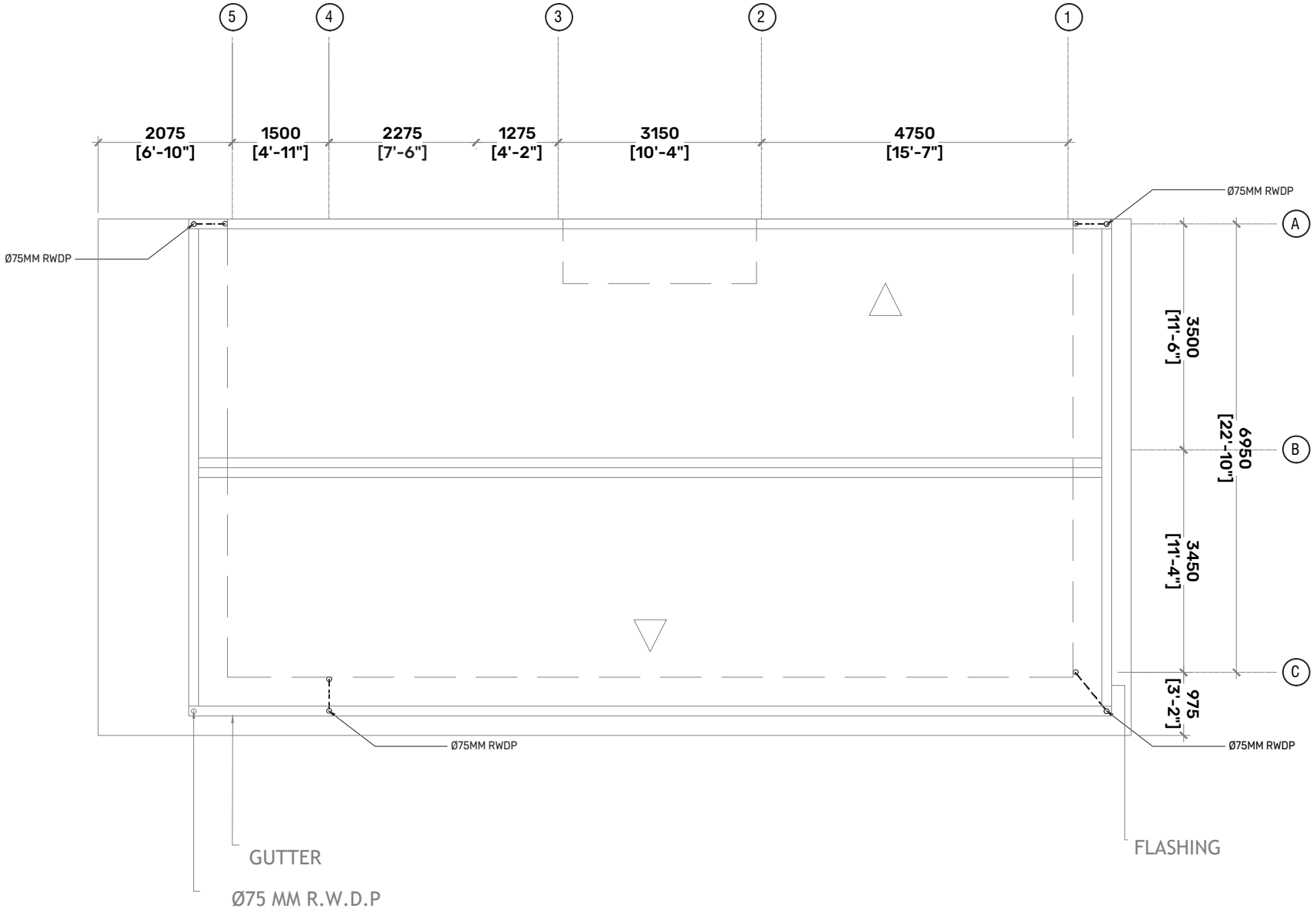
Roof Drain - For Roof Option A



Drainage Layout - For Roof Option B



Roof Drain - For Roof Option B



Annex C:

Things To Include In a Contract

Things To Include In a Contract

As a minimum, we recommend incorporating the following components in a contract between the homeowner and contractor.

- Parties Involved: Names, identification, contact details of the homeowner and builder.
- Project Description: single-family house, located in (address), total area, number and type of spaces, type of roof (timber + sheeting / slab), masonry walls, plasters.
- Set of drawings if possible.
- Outline of services to be provided (e.g. site preparation, foundation, walling, roofing, plumbing, electrical, etc.)
- Timeline: Start date and estimated completion date.
- Cost and Payment Terms: total project cost, payment schedule (e.g., deposit, progress payments, final payment, liquidated damages).
- Materials and Specifications: List of materials to be used with estimated quantities.
- Contractors liability during construction including termination before completion.
- Agreement on minimum site safety measures to be adopted and respected (e.g. use of PPE while being on site)
- Signatures: of the homeowner and builder, along with the date.

Note: Please note that it is still recommended to draw up a contract with a lawyer to ensure protection for both parties.

Ministry of Construction and Infrastructure, Republic of Maldives

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Technical Consultants:

Build Change

Riyan Private Limited