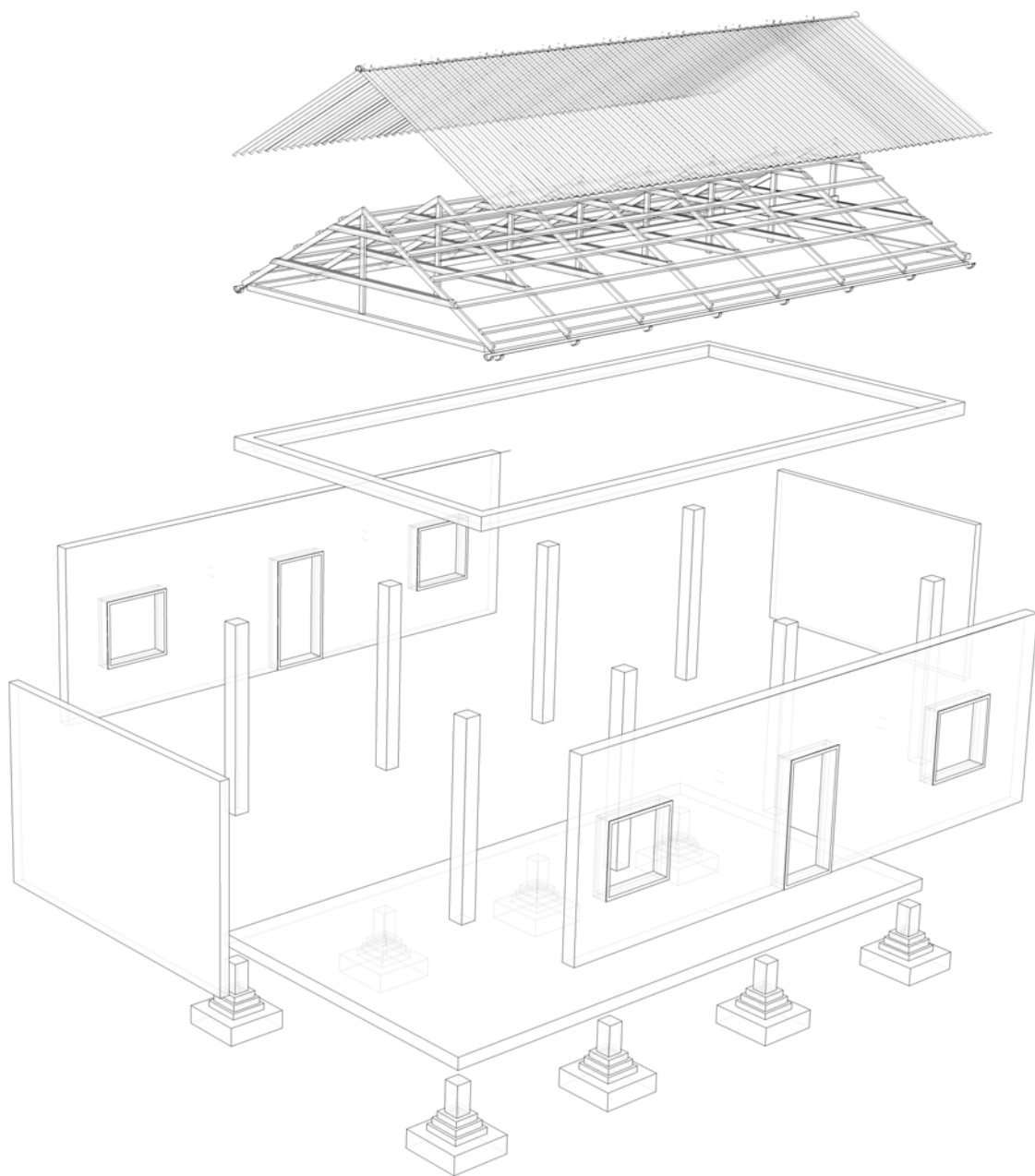




Understanding the opportunities
and challenges of compliance to safe
building codes for disaster resilience
in South Asia

grey

BUILDING HANDBOOK

the cases of Nepal and Bangladesh

Supported by a Collaborative Regional Research Programme
(CRRP) grant from the Asia-Pacific Network for Global Change
Research (APN)



Inspiring Excellence



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Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN)

UNDERSTANDING THE OPPORTUNITIES AND CHALLENGES OF COMPLIANCE TO SAFE BUILDING CODES FOR DISASTER RESILIENCE IN SOUTH ASIA

the cases of Bangladesh and Nepal

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PREFACE

This handbook has been produced in the Collaborative Regional Research Project “Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal” supported by the Asia Pacific Network for Global Change Research (APN). The project is led by the University of Newcastle, Australia, in partnership with Dhaka University and BRAC University in Bangladesh, and Tribhuvan University in Nepal.

The world is continually being barraged by disasters, often with the most severe impacts in developing countries. Poor populations living in unregulated settlements in these countries are disproportionately harmed and their informally constructed houses tend to be highly vulnerable. Building and land use regulation can prove to be a remarkably powerful tool for increasing people’s safety and resilience and limiting the risk that they face. However, many of the building codes in developing countries have been adapted from developed countries, but having significantly lower resources and weaker governance, the codes prove difficult to implement in the local socio-economic conditions.

It is therefore relevant to explore ways of achieving wider implementation of safe building codes, not only in the formal sector through regulatory enforcement, but also in the wider informal building activity through voluntary compliance.

To support this process, this ‘grey’ handbook has been produced, contextualised for the local context and achievable within the socio-economic constraints of developing countries. It includes a set of options to meet varying economic and environmental conditions and extensively uses visual material for ease of communication and comprehension. The handbook is targeted primarily for the informal building sector and is expected to support capacity building at the community level.

THE PROJECT

This project explores the opportunities and challenges to compliance of safe building codes for disaster resilience in South Asia, focusing on two countries of the region, Bangladesh and Nepal. Recent disasters in both countries highlight that the problem lies in non-compliance to building codes. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. There is thus a need for understanding how these codes might be more widely adopted to enable disaster resilience. Collaboration between universities in these countries with experience in this field addressed this need.

NEPAL

Nepal is characterized by a rugged topography, high relief, variable climatic conditions, with complex geological features. Furthermore, it lies in the tectonically active zone. Nepal faces risk from various types of hazards including earthquakes, floods, windstorms and landslides, and has experienced numerous disasters. The impacts of disasters are enhanced due to human activities such as unplanned urbanization and inadequate construction of buildings and infrastructure. Nepal endured severe earthquakes in 2015 when many buildings collapsed, killing the people inside them.

BANGLADESH

Bangladesh is one of the world's most vulnerable countries to natural hazards and climate change. The primary threats to Bangladesh are floods and cyclones, and earthquakes and fires pose significant risk in the rapidly growing unplanned urban areas. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a natural hazard to trigger a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1100 mainly women garment workers and injuring another 2,500, illustrates this point.

1

earthquake

2

flood

3

windstorm

4

fire

5

landslide

THE HANDBOOK

This handbook provides advice, guidance and necessary information on key issues associated with building in disaster-prone areas and for the planning, siting, design and construction of housing with improved resilience to common and recurrent hazard events. It is targeted for local builders and homeowners in Bangladesh and Nepal, to promote principles of safe design and construction. It aims to minimize vulnerability to hazards, so that houses will safeguard occupants and their assets. Since many construction concepts are not easy to describe, the handbook contains illustrations of good practice to facilitate understanding and to explain how to build better.

HOW TO USE THE HANDBOOK

The judgment, experience and choice of the implementer or user would play an important role in deciding which combination of FOUNDATION, POST, WALLS and ROOFING would be suitable, thus allowing flexibility in house design user participation.

This handbook can also serve as a training manual, where the trainer should facilitate discussion among stakeholders to decide upon appropriate house designs based on assessment of the different construction options for the main parts of a house provided here.

The tables below has been prepared to assist in this process.

BUILDING STEPS

01

PLANNING

Before considering to build a house it is necessary to ascertain the suitability of the location and its environment.

TOPOGRAPHY

elevation, slope, undulations, drainage, ground condition

SUBSOIL CONDITIONS

drainage paths, waterways, wetlands, coastline, canals or streams

ACCESSIBILITY

access to roads and related ground stability issues, communication and routes for evacuation

SHAPE

select simple symmetrical shapes which minimize development of tension effects.

Square and rectangular shapes are preferable.

02

FOUNDATION

The function of a building foundation is to support the building safely distributing all the loads acting on the structure including the weight of the building and foundation, live loads and external loads to the ground.

Foundation shall therefore be designed to :

1. contain any settlement in the ground with tolerable limits
2. have sufficient strength and rigidity to undergo significant deformation
3. be stable and durable

03

CORE

The core of the house suitable for structural loads, prevent from external conditions, provide ventilation and light.

TYPE_1

R.C. concrete frame with brick walls

TYPE_2

load bearing brick walls

TYPE_3

timber frame with earth blocks or other infill

04

ROOF

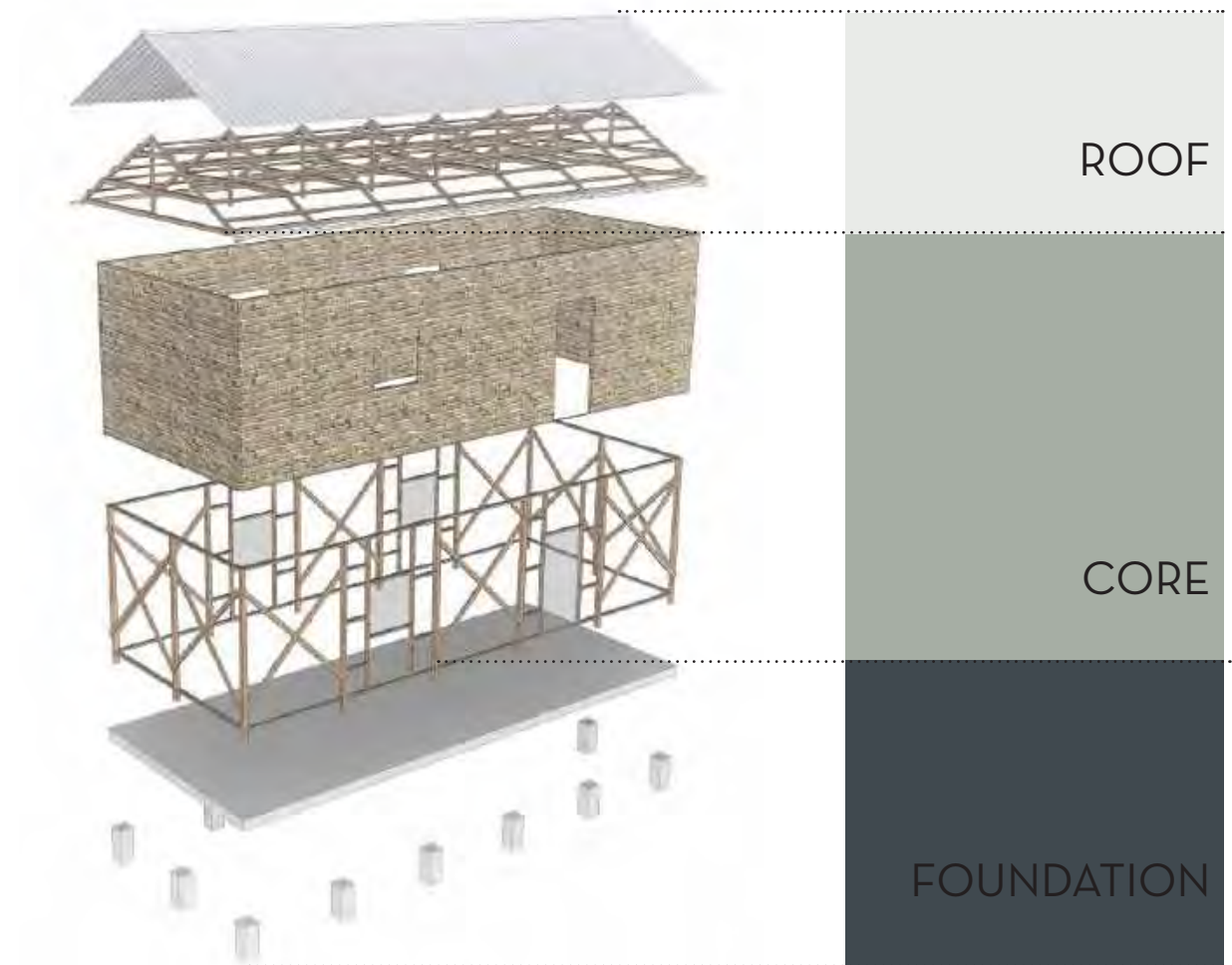
The roof may be constructed as a pitched roof with corrugated sheets or tiles as the roofing material or as a flat roof with a reinforced concrete slab.

TYPE_1

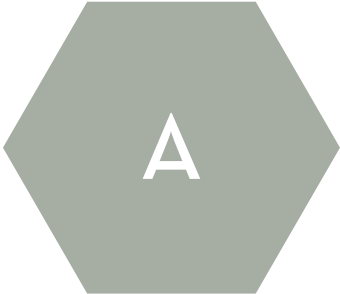
RC: reinforced concrete

TYPE_2

timber framing with CI sheets/ tiles



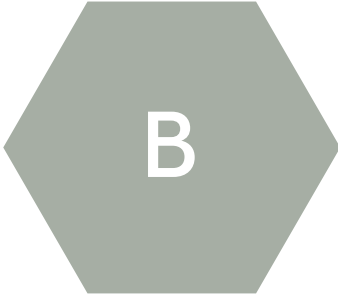
CONSTRUCTION OPTIONS

A large grey hexagon with a white letter 'A' in the center.

FOUNDATION

continuous

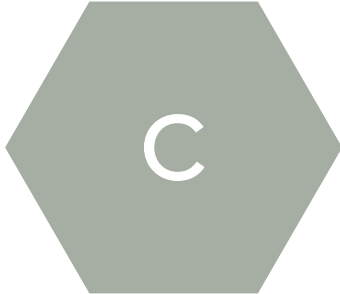
footing

A large grey hexagon with a white letter 'B' in the center.

POSTS

R.C. Post

timber

A large grey hexagon with a white letter 'C' in the center.

WALLS

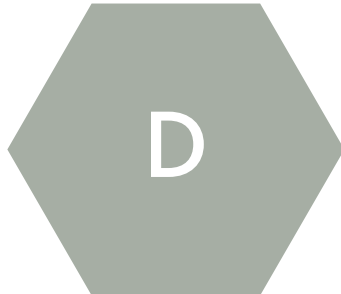
brick

concrete block

earth block

lightweight infill

bamboo

A large grey hexagon with a white letter 'D' in the center.

ROOFING

RC slab

timber frame
with CI sheets / tiles

rainwater gutter

01_ PLANNING

The form, degree of exposure, quality of construction, degree of structural integrity of the basic design all influence behavior of buildings under high wind stress.

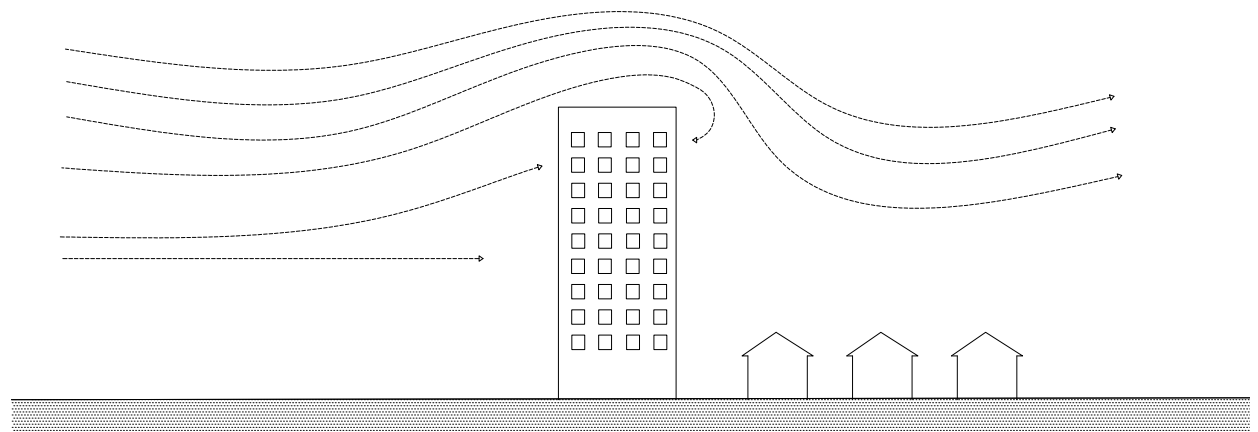
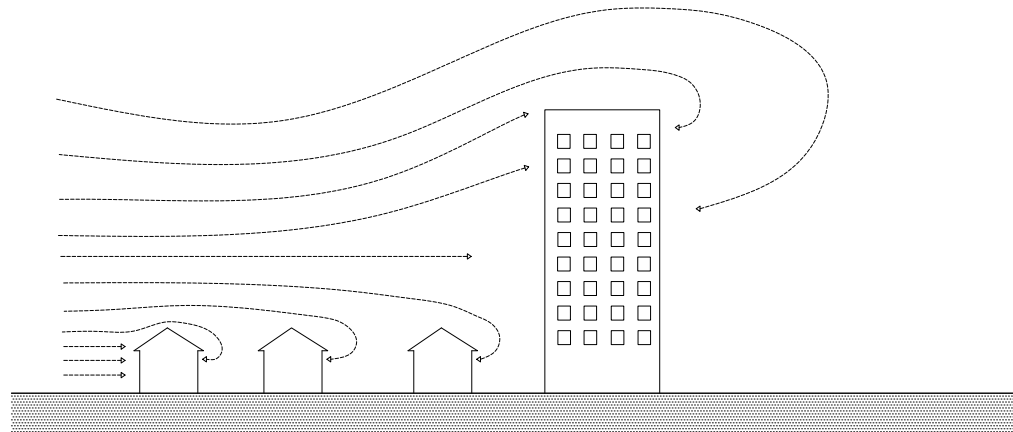
Tall buildings offer some protection to lower buildings during cyclonic wind.

Site planning in cyclone-prone areas should take into consideration possibility of using tall buildings as wind breaks.

Tall buildings can be the cause of wind eddies, reverse local winds, gusts and wind shadow suction areas.

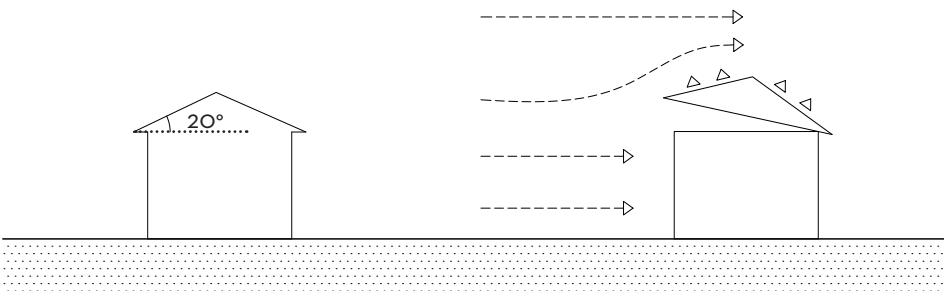
Sheltered sites reduce exposure to wind hazards. Avoid building near steep edges and steep sided valleys opening onto the sea.

Avoid linear-type development because wind forces through straight, open and parallel channels and increases in speed: “wind-tunnel effect”.

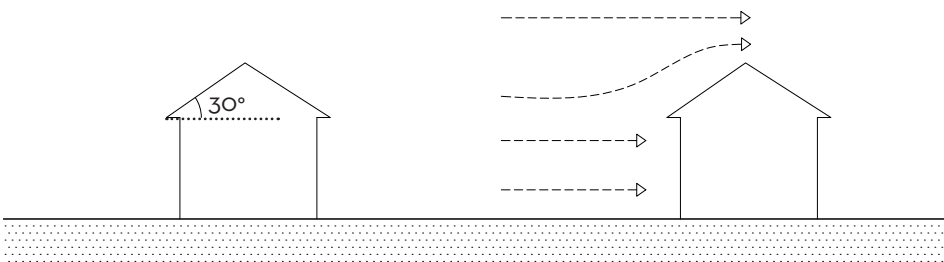




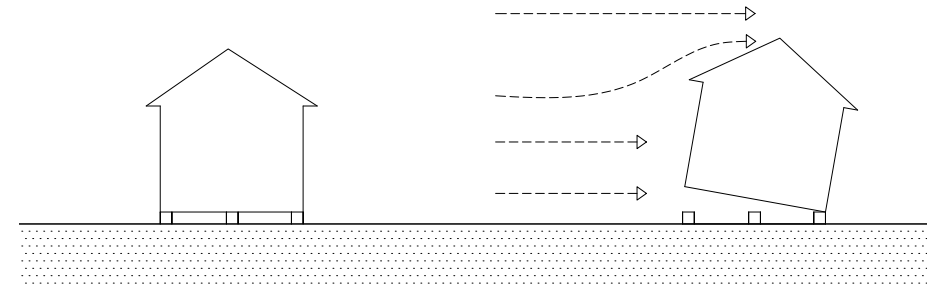
A steeply pitched roof receives high wind loading and may blow in.



A low pitched roof receives high suction and may blow off.



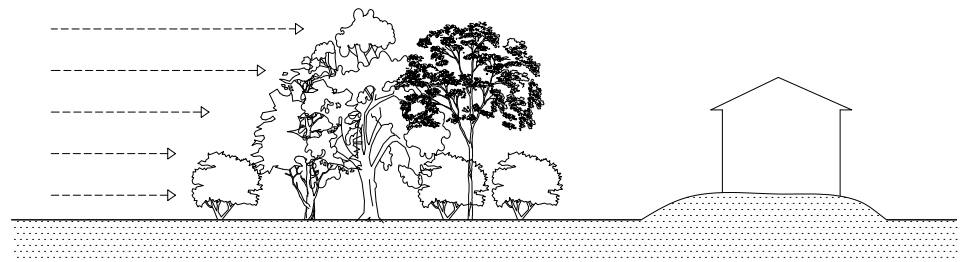
A 30° pitched roof receives least wind stress.



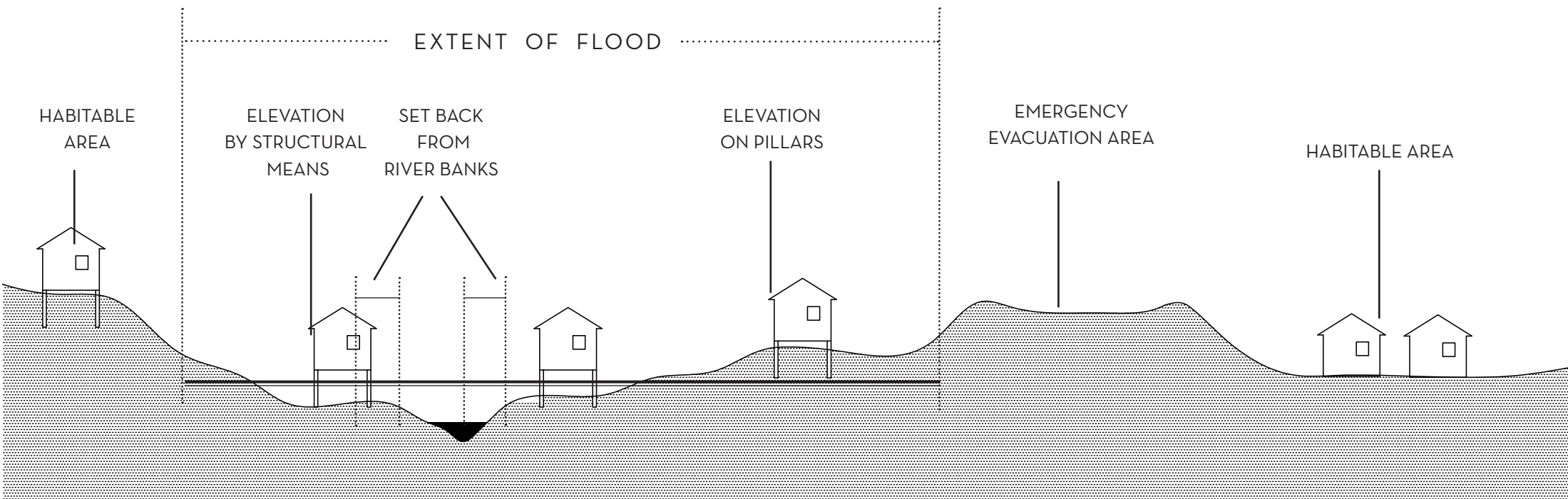
Well-constructed buildings which are not well-anchored down to their foundations may overturn.



Buildings without well-connected stiffened joints may distort.



Building shielded by vegetation placed at distance equal to tallest wind-break tree at full growth and built upon raised plinth is well-protected against wind and flood.



The choice of site for a building is mainly concerned with the stability of the ground as well as to avoid the full force of the wind or flood.

Simple rectangular shapes behave better in an earthquake than shapes with projections.

Torsional effects of ground motion are pronounced in long narrow rectangular blocks.

Therefore, it is desirable to restrict the length of a block to three times its width. If longer lengths are required two separate blocks with sufficient separation between should be provided.

Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block.

Embankment to protect the area from cyclone storm surge and wave uprush. Rocks placed on seaward side to break wave strength. Other side to be planted with trees with deep roots to bind soil and prevent erosion.

Cyclonic effect may persist inland, especially through river estuaries. May lead to flooding, therefore need for flood-proofing with emergency evacuation route and shelter zone / refuge area.

o2_ FOUNDATION

A

continuous

Mixture of earth and cement to create a typical earthen plinth.

The proportion of cement should be at least 5%.

3 weeks curing by water should be done.



B

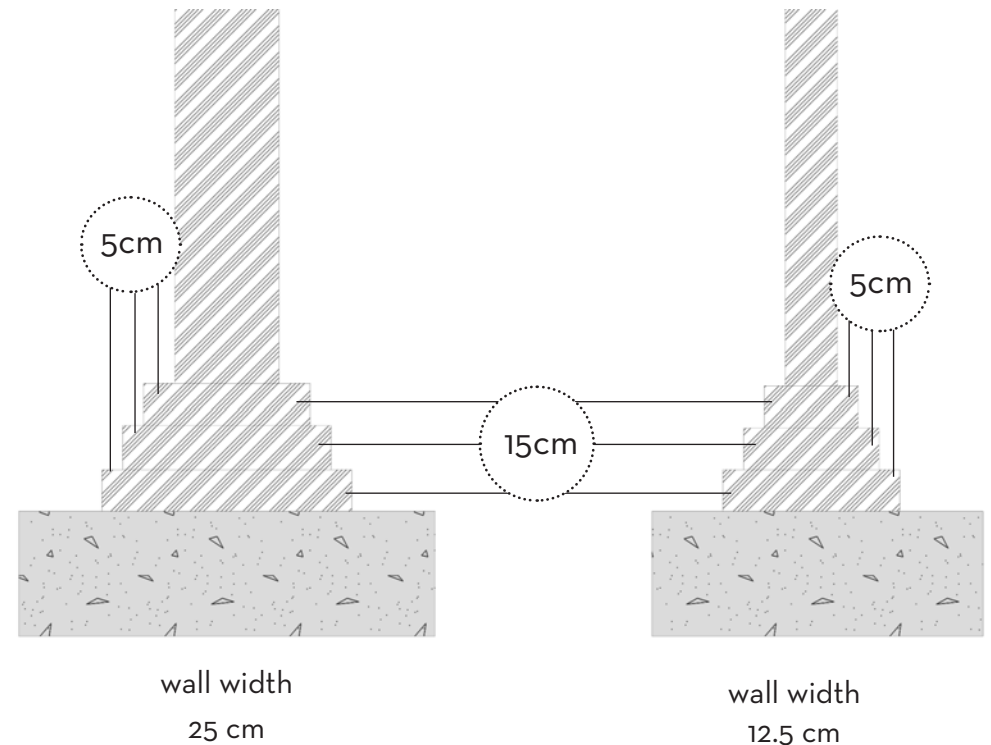
footing

COLUMN FOOTING

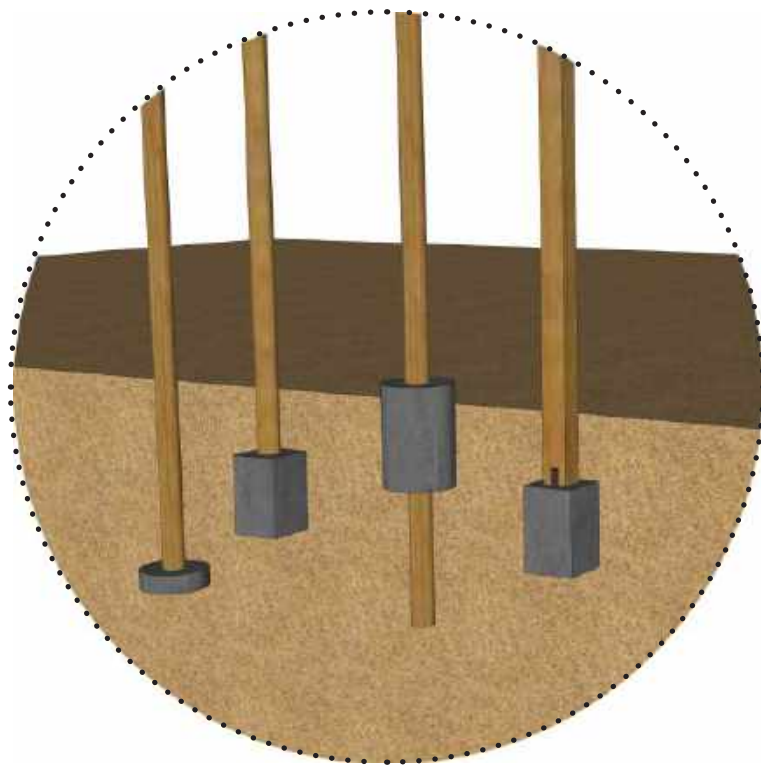
- Independent footing provided under a column.
- Distributes concentrated loads uniformly to the soil.
- Square, rectangular or circular in plan.
- Depending upon load and bearing capacity of soil, footing can be of brick or stone masonry, RC, etc.

WALL FOOTING & RC FOOTING

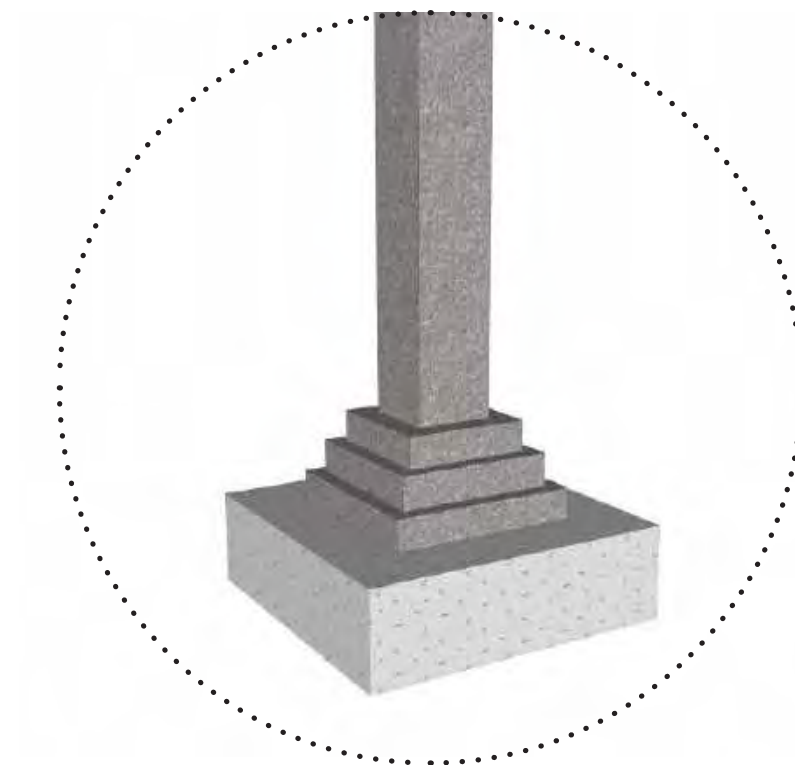
- Several courses of bricks, lowest course twice the wall thickness above.
- 5 cm offset to achieve widened base; each course 1 brick thick, in some cases bottom courses 2 bricks thick.
- Bed of lean concrete, 15 cm deep minimum, projection on each side 10-15 cm; depth of bed should not be less than its projection beyond base wall.
- Concrete bed provides a plain surface to start the wall footing; rectifies inequalities of excavation and bridges over soft patches in the soil below.
- RC footing if heavy load and bearing capacity of soil is low; otherwise massive structure is needed and would be uneconomical.
- 7-8 cm lean concrete bed below RC footing.



TYPES OF FOOTINGS



TIMBER/ BAMBOO POSTS



CONCRETE/ BRICK POSTS

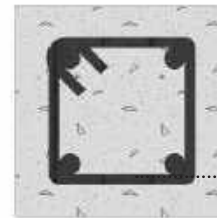
03_ POSTS

C

R.C. concrete posts

1. The proportions of the concrete mix are usually kept "1 : 2 : 3" or "1 : 2 : 4" by volume of "cement : sand : aggregate".
2. The reinforcement may be any of the following: a) Mild steel and medium tensile steel bars. b) High strength deformed steel bars.
3. All reinforcement should be free from loose rust and coats of paints, oil, mud or any other substance which may destroy or reduce bond with concrete. Use four steel 15mm diameter re-bars, tied together with 6mm diameter stirrups and 8-10inch normal spacing.
4. Square post shape at least 20x20cm and distance between them not more than 3m.
5. Concrete frame needed to bond the walls and used as a base for the roof. Otherwise a roof slab could function as well.
6. Perimeter concrete banding on top of openings.

DETAILS



plan

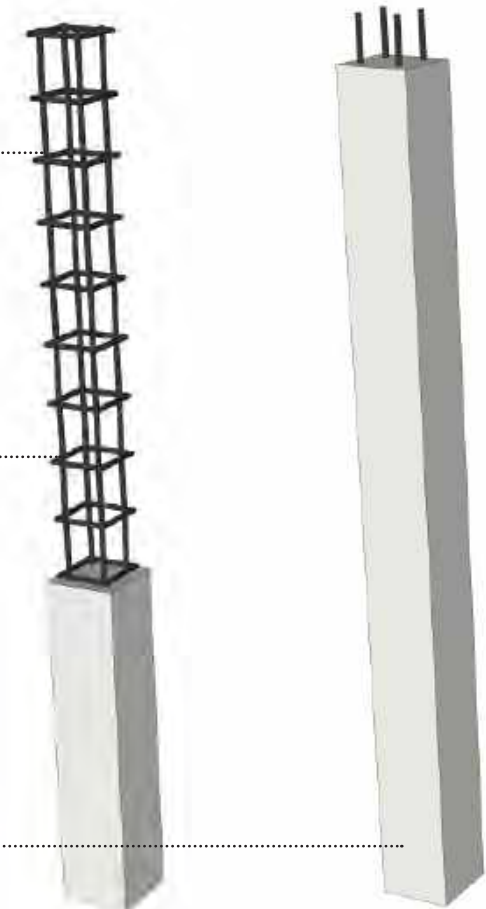


section

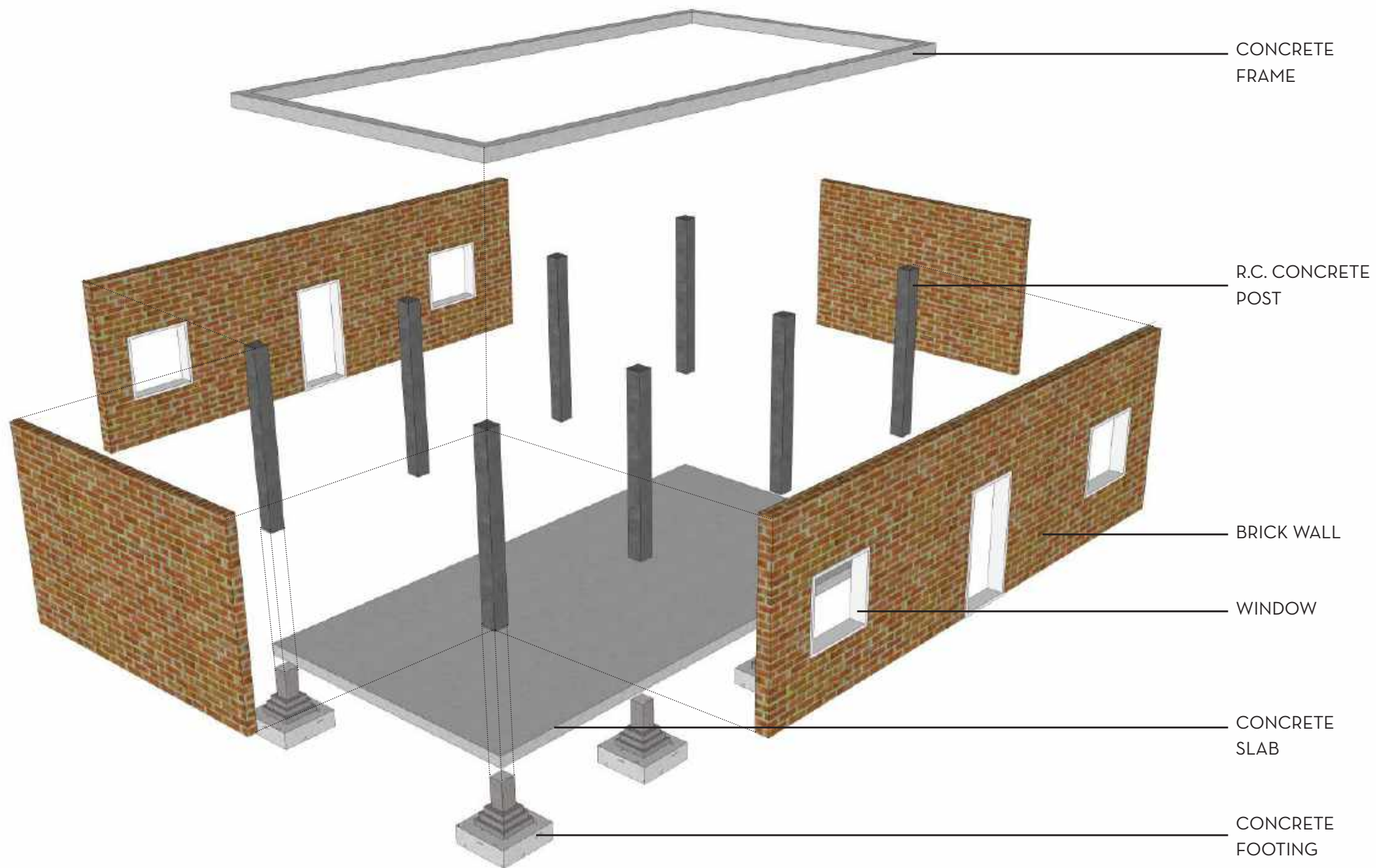
steel stirrups
1/4"

reinforcement
3/8" or 5/8" steel bar

concrete
square post



axonometric



04_ WALLS

A

load bearing walls

Masonry strengthened by mild steel bars, hoop iron, expanded mesh or bars. Resistant to tensile, compressive and shear stresses.

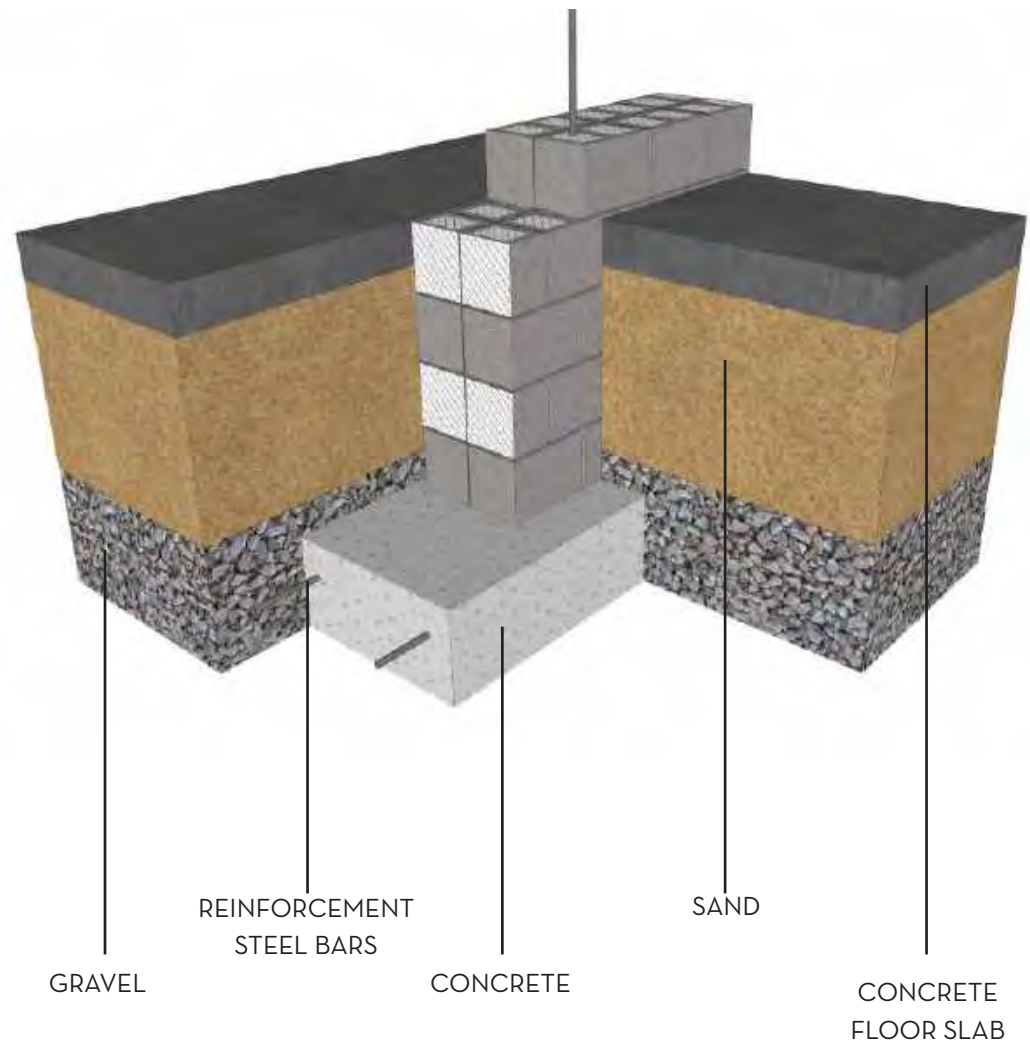
Ability to resist lateral forces: seismic and cyclonic areas.

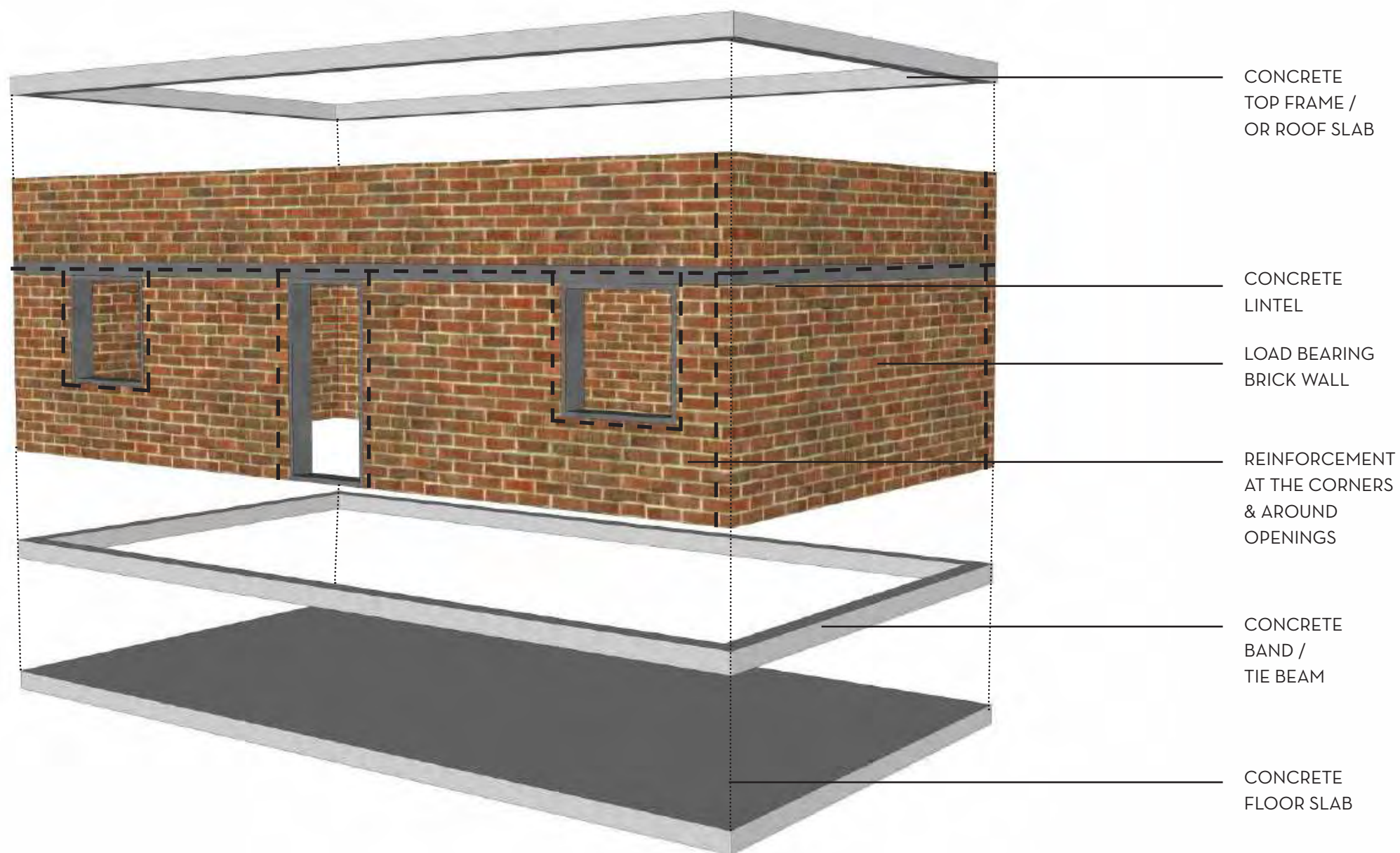
For long walls without junctions or openings, reinforced sections constructed at intervals <1.2m for hollow block, 2.0m for solid block walls.

15-25 cm cover around reinforcement for corrosion prevention.

Also reinforced brick columns and floor slabs.

Concrete strip footings for masonry walls with reinforcing bars at every corner and intersection between walls, each corner of doors and large openings and intermediate positions <1.2m apart.



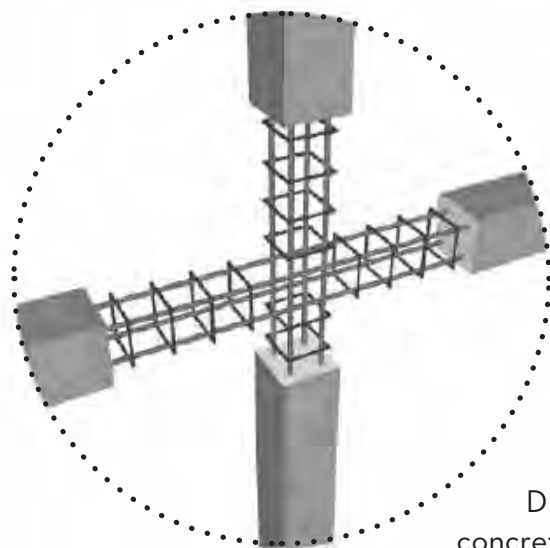


B

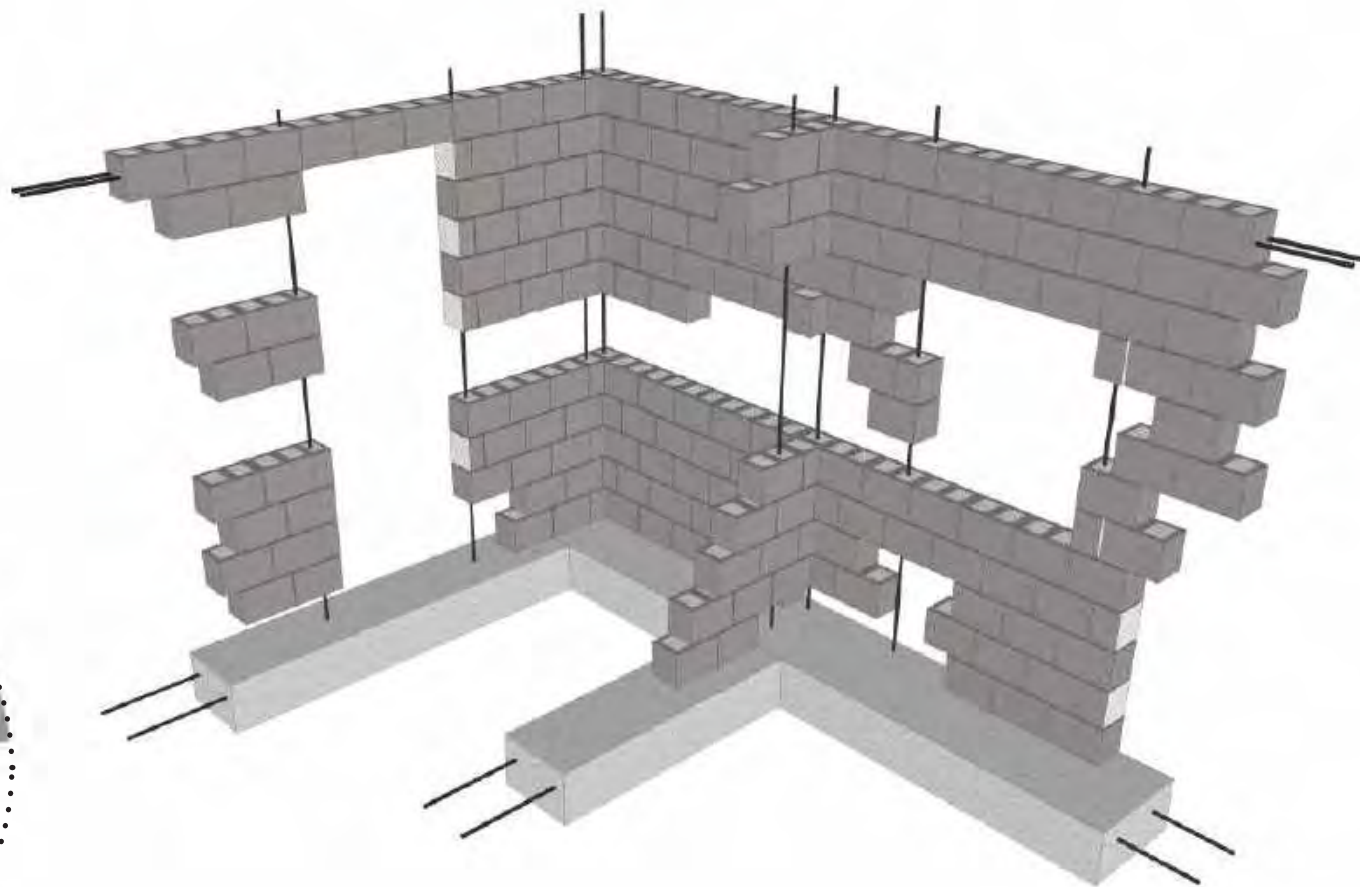
reinforced masonry

Masonry walls must be reinforced at all corners and junctions and sides of doors and window openings.

Strengthening masonry buildings against earthquakes by providing horizontal and vertical reinforcement.



DETAIL
concrete joint with
reinforcement

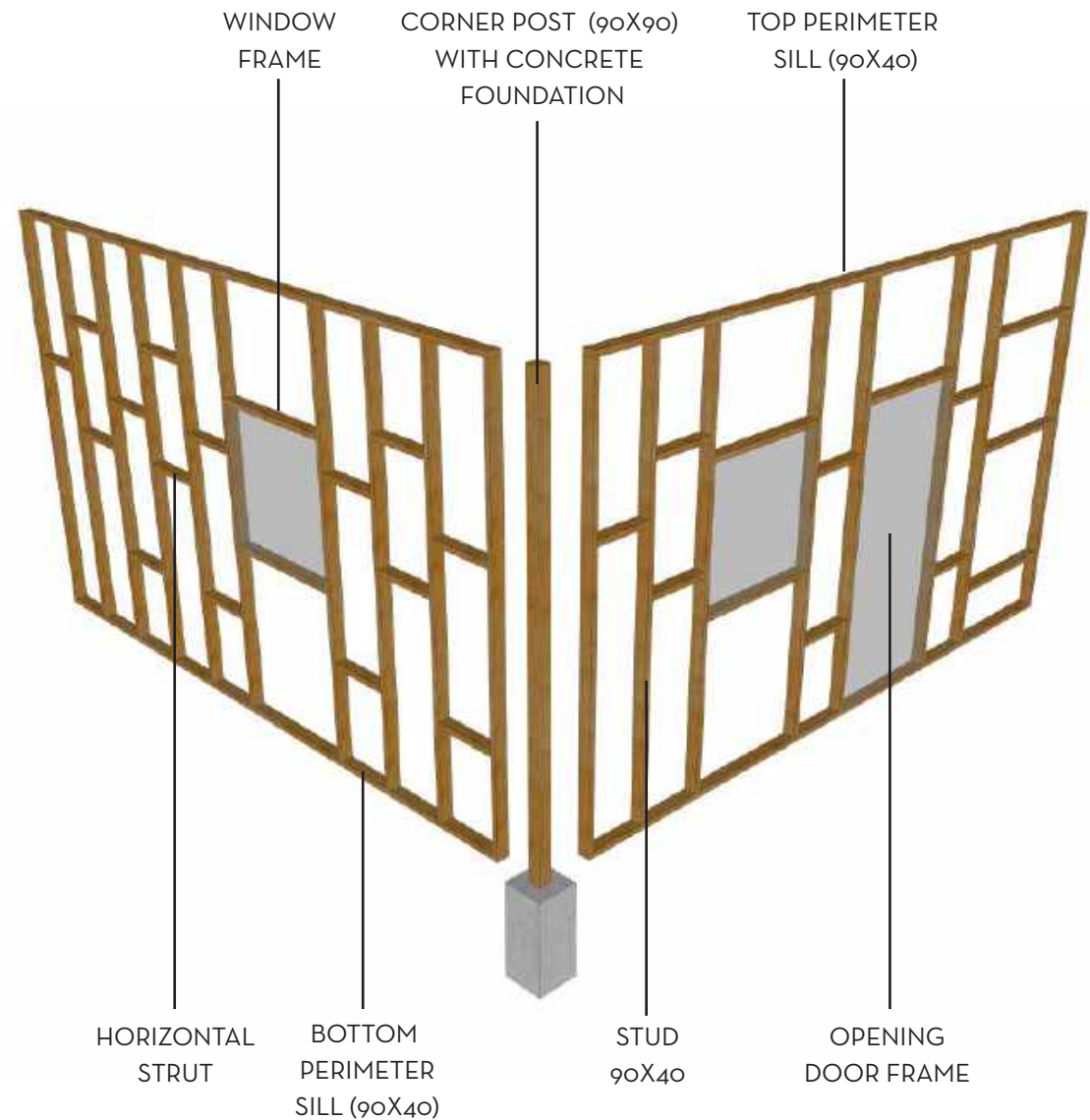


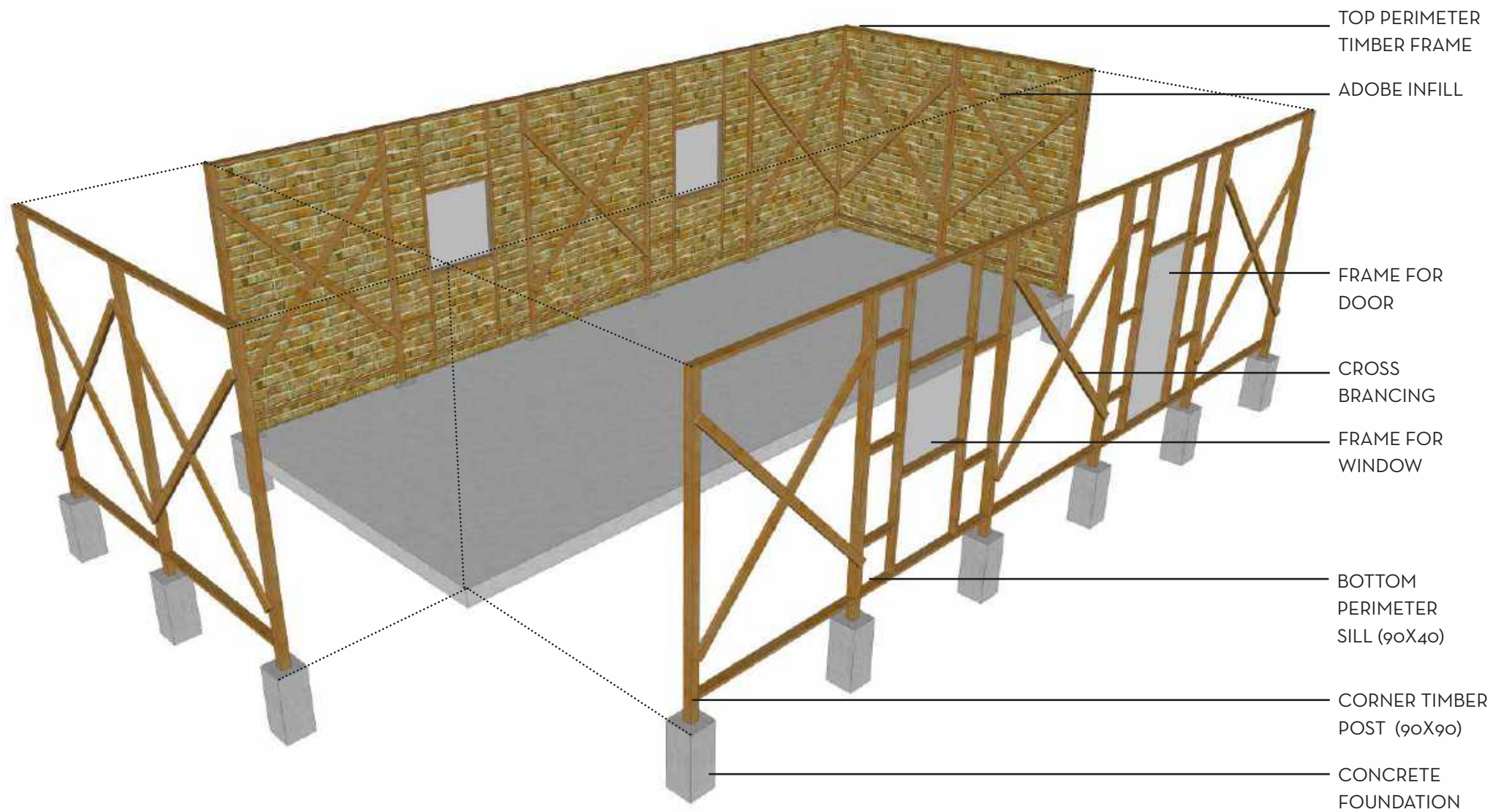
C

timber frame

Stud-wall construction consists of timber studs and corner posts framed into sills, top plates and wall plates. Horizontal diagonal braces are used to stiffen the frame against lateral loads due to earthquake and wind. The wall covering may consist of matting made from bamboo, reeds, and timber boarding or the like.

1. The dimension of the sill is 40 x 90 mm, 90 x 90 mm or larger. The sill is connected to the foundation by anchor bolts whose minimum diameter is 12 mm and length 350 mm. The anchor bolts are installed at both sides of joints of sills and at the maximum spacing is 2 m.
2. The minimum nominal dimension of studs is 40 x 90 mm. The maximum spacings of these studs vary from 0.5 to 1. If studs are 40x90 then spacing should be 0.5m, if 90 x 90 mm studs are used the spacing may be doubled, but the interior or exterior linings might need to be thicker.
3. Storey height should not be more than 2.7 m. For 2 storey houses studs should be placed every 0.5m.
4. The tops of studs are connected to top plates whose dimension is not less than the dimension of the stud.
5. Wall framing consisting of sills, studs and top plates should have diagonal braces, or sheathing boards so that the framing acts as a shear or bracing wall. In case no sheathing boards are attached, all studs should be connected to the adjacent studs by horizontal blockings at least every 1.5 m in height.





05_ ROOF : BASIC PRINCIPLES

aerodynamic roof form

1. Roof pitch 30-40 degrees to reduce effects of suction and uplift.
2. Hipped instead of gable roof. If gable, then end tied down firmly to rest of structure. Lean-to should be avoided.
3. Overhang < 2'-6", vents in roof and masonry parapet.
4. RC roof provides superior protection. Need for adequately braced.

roof connected to structure

1. Rafters at recommended spacing
2. Cross bracing in plane of roof and ceiling.
3. Strong connections between roof and vertical structure. Metal straps, bolts with washers on both ends instead of simple nails.

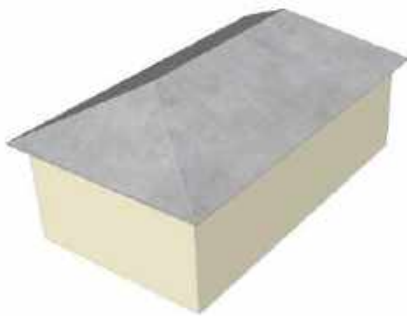
well-fixed roof covering

1. CI sheet screwed at every corrugation. Tiles fastened individually.
2. Use of J-hook bolts and threaded / twisted roofing nails.

regular maintenance

1. Should make regular checks, especially around ridge and corners
2. Replace weakend members and repair loose members.
3. CI sheets should be tied strongly to structural frame to resist uplift by strong wind.

SHAPES OF ROOF



hipped roof



gable roof



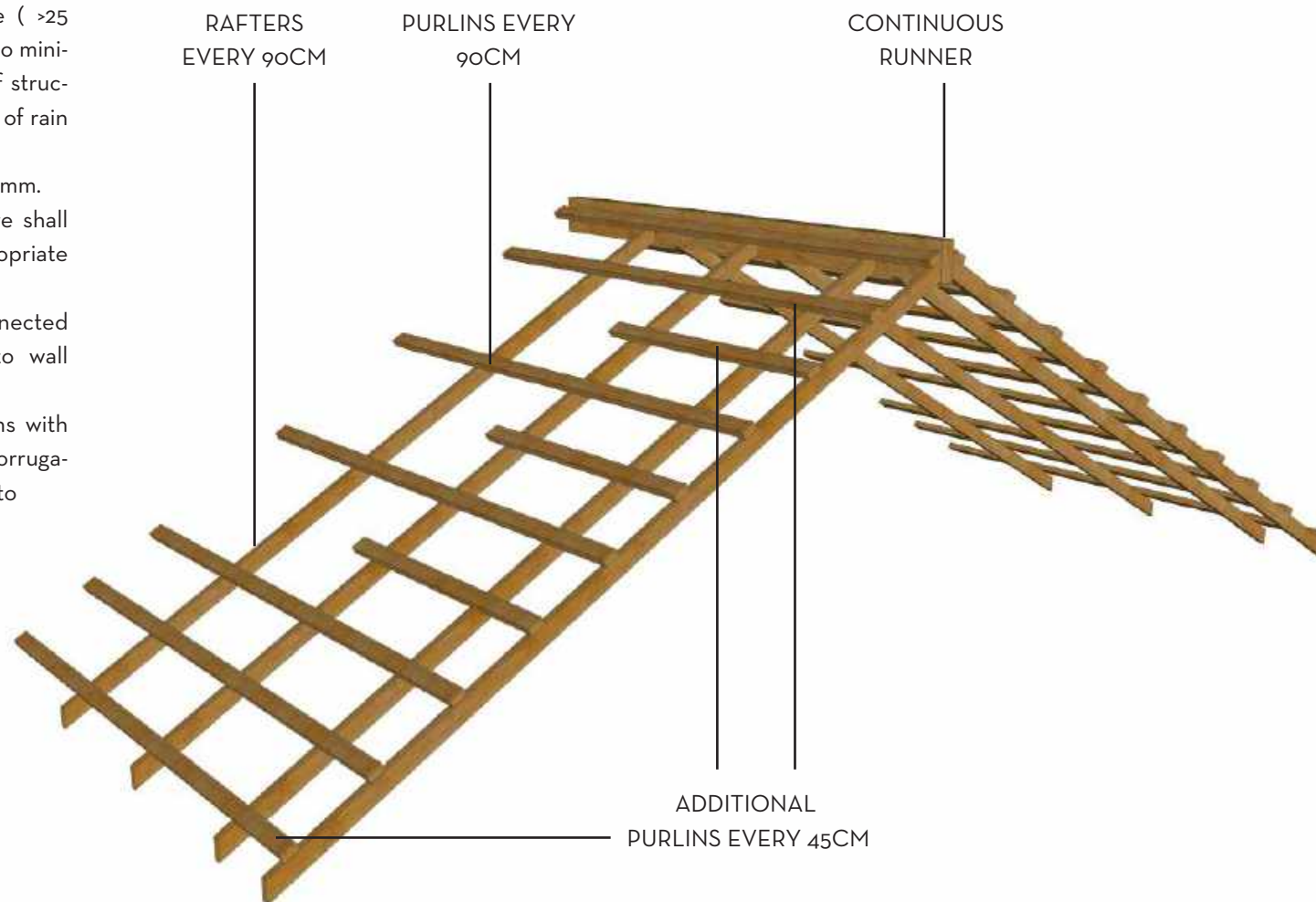
lean-to roof

A

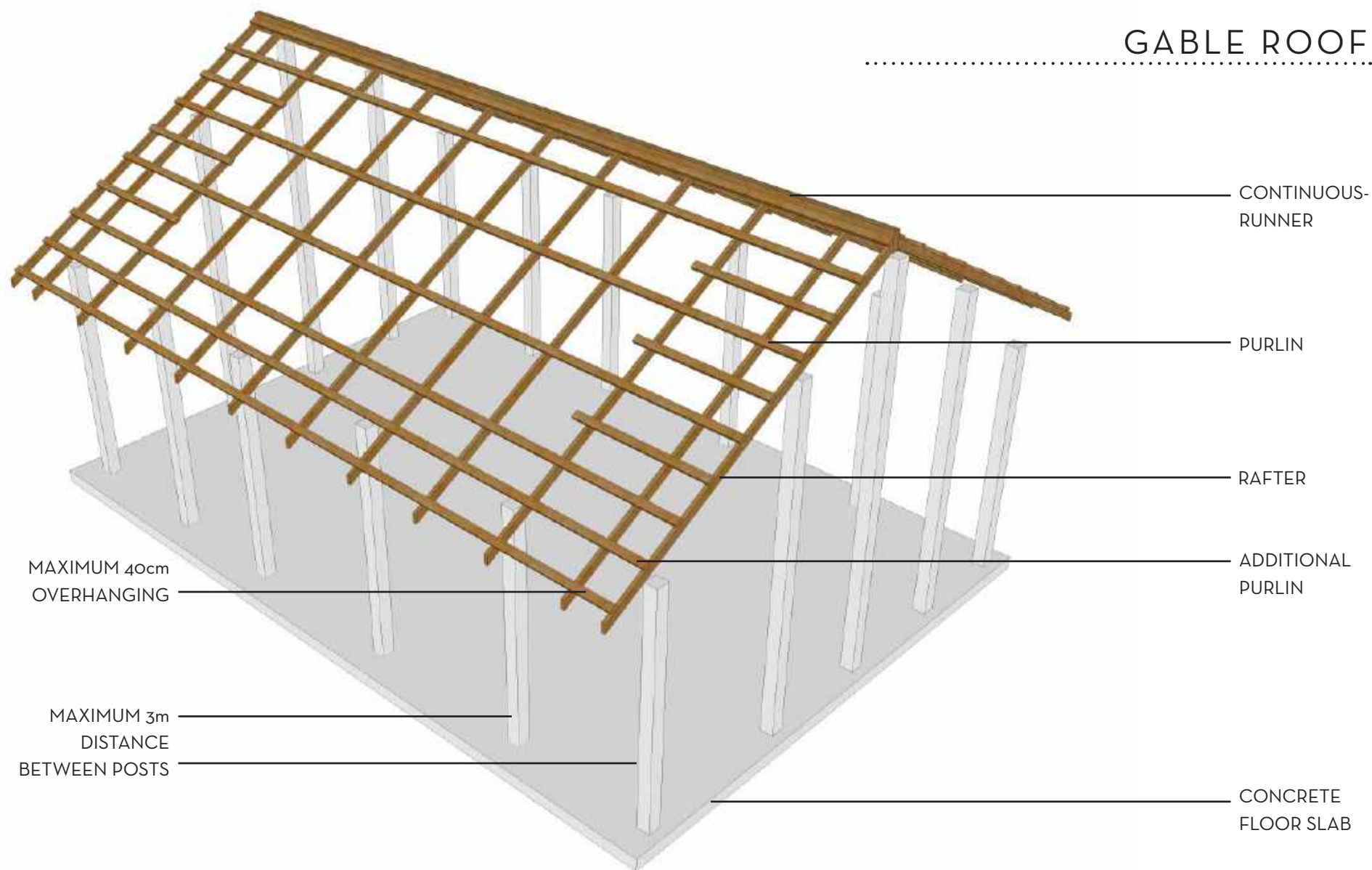
timber frame structure

Pitched roofs with adequate slope (>25 degrees) shall be provided in order to minimize uplift forces acting on the roof structure and to provide proper drainage of rain water.

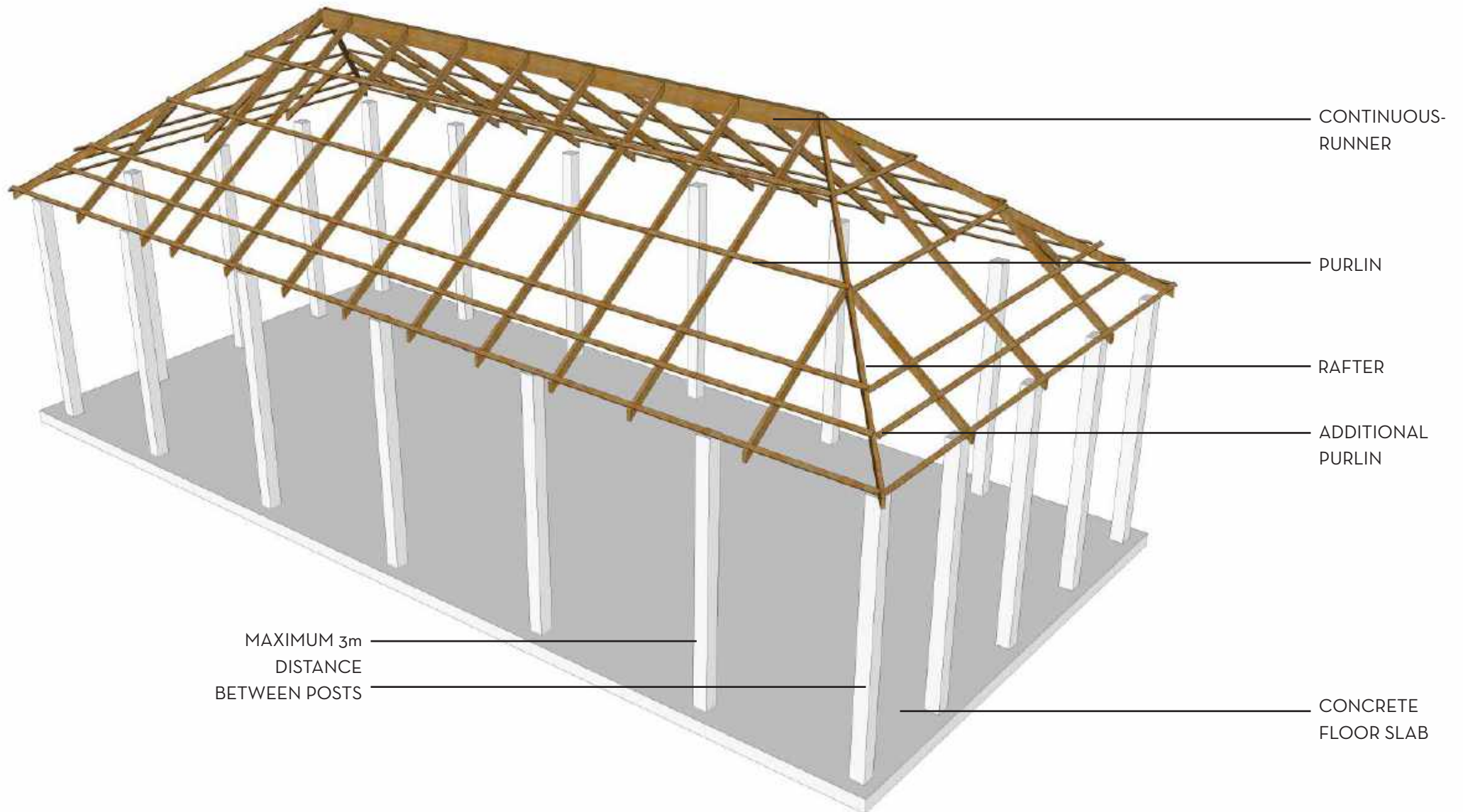
1. Maximum overhang should be 600mm.
2. Timber used in the roof structure shall be hardwood treated with an appropriate wood preservative.
3. Roofing elements should be connected properly: purlin to rafter, rafter to wall plate, wall plates to posts.
4. Every sheet to be fixed to purlins with hook bolts or twisted nails at each corrugation. More frequent fixings at edges to prevent uplift.



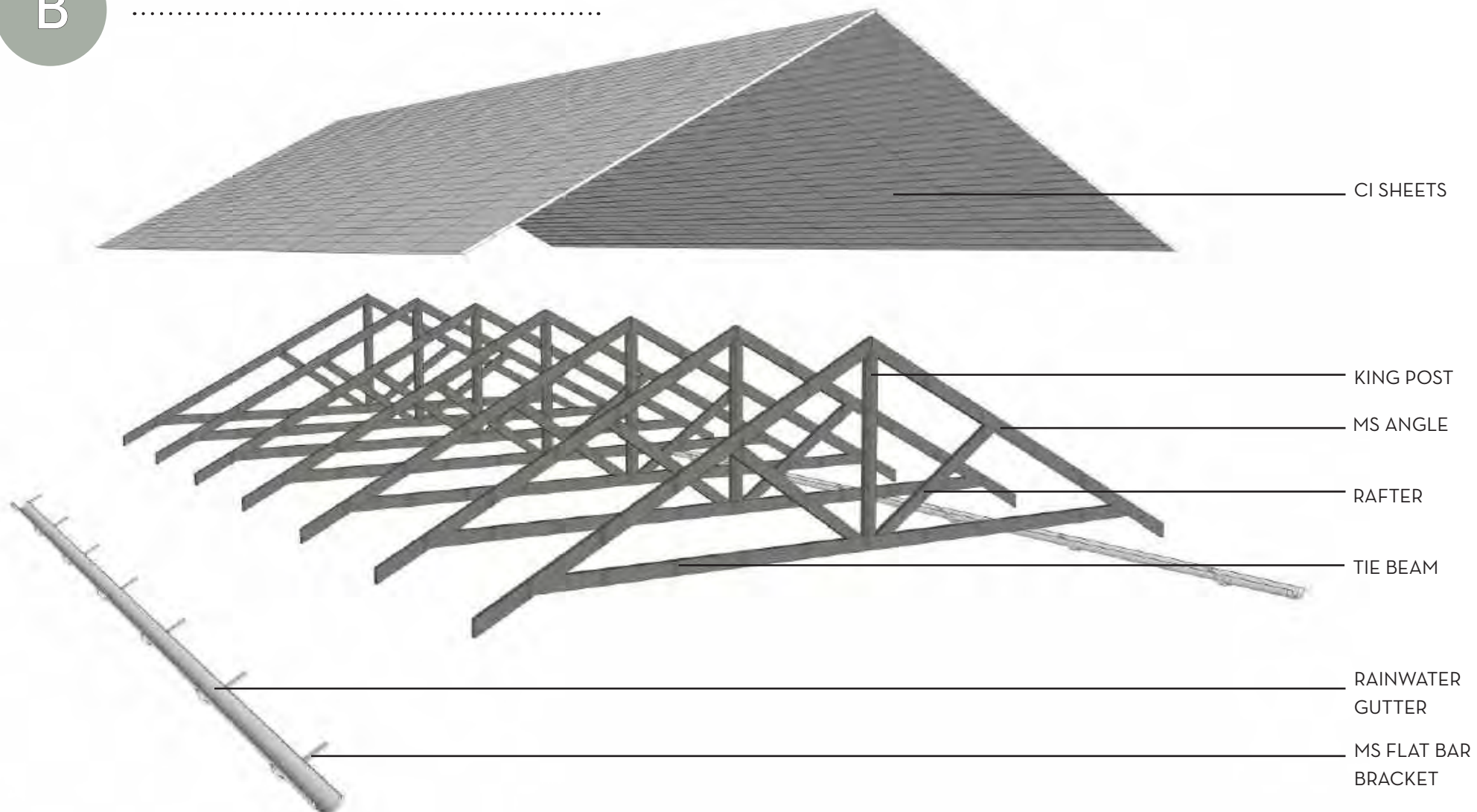
GABLE ROOF



..... HIPPED ROOF



B

metal structure



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