



Ministry of Infrastructure  
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**REPUBLIC OF RWANDA**



Rwanda Housing Authority  
P.O. Box 2469 Kigali

# **BASIC HOUSING CONSTRUCTION INSTRUCTIONS FOR PROTECTION AGAINST NATURAL AND MANMADE DISASTERS IN RURAL AREAS**

**Kigali, October 2012**

*Housing for Sustainable Development*

**REPUBLIC OF RWANDA**



**MINISTRY OF INFRASTRUCTURE  
RWANDA HOUSING AUTHORITY  
P.O.BOX:2469 KIGALI**

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## FOREWORD

Heavy rain with wind and storms have been some of the major disasters that have impacted People, property, infrastructures as well as environment. Rwanda is not an exception to these effects and that is why it is imperative to find solutions in order to reduce these effects.

The primary objective of this document is to reduce disaster risks caused by heavy rains with wind and storms. This document will be adapted to different regions that have sustained specific or multi hazards in identified Districts and Sectors leading to a sustainable reduction in loss of lives, properties and various other assets.

In order to meet the objectives set out in this document, efforts of relevant institutions and stakeholders have to be consolidated to address all risks identified and forecasted as a result of the findings from the situational analysis conducted in sampled Districts of the country.

Activities to mitigate disasters that cause loss of lives, damages to properties and infrastructure will be initiated by Rwanda Housing Authority in collaboration with relevant Ministries and institutions.

Damages caused due to the impact of natural phenomena such as the collapse of vulnerable building (houses), roofs being blown away by winds, etc... can

be avoided by raising basic construction skills among the rural population.

In rural areas of Rwanda, major housing construction is conducted with the help of local masons lacking the necessary required skills in civil engineering. These masons are usually not trained in a formal way and begin their career as means for survival. They build houses without guiding manuals, regulations and standards.

Following the abovestated issues, the need for capacity building is paramount.

The information provided in this document will foster change in mindsets and awaken responsibilities of all perspective users to actively get involved in implementation of instructions set out in it, with the ultimate goal of reducing disaster risks on houses and other infrastructure in rural areas.

**MUTAMBA Esther**  
**Director General**  
**Rwanda Housing Authority**

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## CHAP. I. INTRODUCTION AND RATIONALE FOR ACTION

Disaster risks and hazards reduction is one of Rwanda priorities to save lives and properties. It was identified that disasters caused by heavy rain with wind and storms causes enormous losses of lives, properties and infrastructure damages in different parts of the country. Response and recovery at different occasions when disasters struck bore costs in millions Rwandan francs, yet these losses could have been minimized or prevented if appropriate measures were taken; in this case compliance with basic housing construction regulations.

Developed in a widely consultative manner under the joint efforts of three Ministries namely: the Ministry of Disaster Management and Refugee Affairs (MIDIMAR), the Ministry of Infrastructure (MININFRA) and the Ministry of Local Government (MINALOC), these guidelines were elaborated following a situation analysis conducted in four Provinces, assessing affected and disaster prone areas in two Sectors per District in order to identify the main causes of houses destruction.

This document will serves as a guide in addressing the needs and rationale for safer house development in rural areas; recommending a series of suggested steps that highlight key points



that should be considered when planning a safer house construction and/or retrofitting initiative. Basic design principles and requirements a house building must meet to provide a greater level of protection for people and property as well as other infrastructure will be identified.

Finally, the document provides a list of key recommendations, technical and context-specific information on what will be followed in order to fully minimize all risks that come with disaster caused by heavy rain with wind and storms. Thus, houses constructed without consideration of disaster resilience and maintenance instructions will be under local government disapproval as habitable or ready for occupancy. Sustained life-long injuries and death of many will be prevented as instructions are implemented by different actors and communities.

## 1.1. CONTEXT AND JUSTIFICATION

Within a period of ten months (Dec/2010-Sept 2011), disasters produced a complex web of impacts, which spans many sectors of the economy. During this same period, Rwanda registered 43 losses of lives and 73 people were seriously injured. Besides, 1854 houses were destroyed by heavy rains in rural areas, 2, 989. 9 Ha of crops were damaged and 100 classrooms were completely destroyed in different parts of the country. As a result, the cost of the

intervention activities in terms of disaster response and recovery to assist the victims was estimated to more than 515,520,000 Rwandan francs (*MIDIMAR reports, May -September 2011*).

In mountainous regions of the Southern, Northern and Western Provinces, heavy rains and storms cause landslides and floods which constitute major hazards that lead to losses of lives, injuries and damages to property. The Eastern region of the country which has been experiencing rainfall shortage over the last decades is currently exposed to irregular heavy rains associated with strong winds and storms. This has destroyed the roofs of several houses and damaged several hectares of crops in different Districts of Eastern Province (*MIDIMAR reports, August, 2011*)

Different government interventions have been carried out in the last years to promote an adequate, safe and well maintained building infrastructure and services so as to effectively contribute to the socio-economic development of the country (*MININFRA, 2010*). A series of building documents have been issued including construction design manuals, guidelines, codes and standards of which the *Building control regulations and policies concerning human settlement, Urban housing and Construction in Rwanda* are parts thereof.

Therefore, to address the root source that makes people exposed to natural disasters by reducing their vulnerability, little has been done to diminish the number of houses destroyed by heavy rains with wind and storms in rural areas. This instruction document on construction adapted to all regions of Rwanda, aims at addressing the gap in reducing disaster incidents related to houses destroyed by heavy rains and wind with storms in rural areas of Rwanda.

## 1.2. GLOSSARY OF KEY TERMS

- a) **Competent authority:** the government's regulatory department responsible for building standards
- b) **Disaster:** It is a progressive or sudden, widespread or localized, natural or human-caused occurrence which causes or threatens to cause death, injury or disease, damage to property, infrastructure or the environment or disruption of the life of a community and is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their own resources.
- c) **Disaster Management:** means a continuous and integrated multi-sectorial, multi-disciplinary process of planning and implementation of measures aimed at

preventing or reducing the risk of disasters, mitigating the severity or consequences of disasters, emergency preparedness, a rapid and effective response to disasters and post-disaster recovery and rehabilitation.

- d) Drain:** Means a conduit or channel used for the drainage of building premises within the same cartilage.
- e) Earthquakes:** are defined as the sudden release of energy occurring from the collision or shifting of crustal plates on the earth's surface or from the fracture of stressed rock formations in that crust. It can also be defined as shaking and vibration at the surface of the earth resulting from underground movement along a fault plane or from volcanic activity.
- f) Floods:** Floods are defined as a large amount of water that covers an area that was dry before. It can also be defined as a state of high water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged.
- g) Foundation:** Means the members of a structure, the function of which is to distribute loads directly to the ground or that part of a building, which is in direct contact with and is intended to transmit loads to the ground;

- h) Foundation wall:** Means that portion of a wall between the foundation and the lowest floor above the foundation;
- i) Geological Hazard:** Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
- j) Hazard:** A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins- natural (geological, hydro-meteorological and biological) or induced by human processes.
- k) House:** Single family dwelling
- l) Joint:** Connection between two structural elements
- m) Landslides:** Landslides are described as the downward movement of soil and rocks resulting from naturally occurring vibrations, changes in water content, removal of lateral support, loading weight and weathering or human manipulation of water courses and the composition of the slope.

- n) Lintel:** A horizontal beam over a window or doorway
- o) Natural hazards:** Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. Natural hazards can be classified by origin namely-geological, hydro-meteorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.
- p) Public building:** Means a building to which the public have a right of access during all reasonable times for reasons that the building is used in accordance with its prescribed occupancy;
- q) Retaining wall:** Means a wall intended to resist the lateral displacement of earth materials;
- r) Safe building:** Constructing a building with a low vulnerability to natural hazards
- s) Storm:** is any disturbed state of an astronomical body's atmosphere, especially affecting its surface and strongly implying severe weather. It may be marked by strong wind, thunder and lightning (a thunderstorm), heavy precipitation, such as ice, or wind

transporting some substance through the atmosphere.

- t) Structural system:** Means the system of constructional elements and components of any building that is provided to resist the loads acting upon it and to transfer such loads to the ground upon which such building is founded;
- u) Wall:** Means a vertical load-bearing or non-load-bearing member of a structure whose length exceeds four times its thickness;
- v) Wind:** The horizontal movement of air created by differing pressures of adjacent air masses. Air moves from high to low pressure areas.

### 1.3. OBJECTIVES

The objectives stated in this document are divided into general objective and specific objectives to facilitate its implementation in order to prevent disaster effects resulting from heavy rains with wind and storms in rural areas.

#### 1.3.1. General objective

The main objective of this document is to prevent houses the destruction of houses and other infrastructure due to natural or Manmade disasters in different rural areas of the country.

### 1.3.2. Specific Objectives

1. To build strong and safe foundations, walls, roofs as well as maintenance systems to ensure safety of both people and properties in rural areas,
2. To establish principles that enforce the Rwanda Building Control Regulations so as to produce houses resilient to disasters in rural areas,
3. To reduce disaster risk incidents caused by heavy rains with wind and storms especially in rural areas,
4. To encourage rural community participation in disaster risk reduction activities within their respective areas.



## CHAP. II. MAIN CAUSES OF HOUSES DESTRUCTION IN ALL ASSESSED RURAL AREAS

A situation analysis was conducted throughout the country, viewing areas that have been affected or prone to heavy rains with wind and storms and the following can be considered to be the main causes of house destruction in rural areas:

- ✓ Most affected rural people have no financial resources to build houses resilient to heavy rains with wind and storms within their respective areas,
- ✓ Building Control regulations are not enforced and implemented at local levels,
- ✓ Construction manuals available at the District level not utilized and enforced in village/rural areas housing development,
- ✓ Lack of technical know-how in terms of house construction,
- ✓ The magnitude of heavy rains with wind and storms,
- ✓ People's mindset,
- ✓ Construction location(Houses are built in swampy areas , steep areas and areas exposed to landslides and floods ),
- ✓ Inadequate wind breakers (lack of trees),

- ✓ Excavated areas not protected,
- ✓ Weak construction materials(like carpentry materials, etc),
- ✓ Most of foundations are not strong enough and not protected(no walk way, no plaster),
- ✓ No drainage system to evacuate rain/roof water,
- ✓ Roofs trusses are not tied to elevation structures,
- ✓ Most of houses in rural areas are made of wood with wooden foundations,
- ✓ Houses not built with wind direction consideration,
- ✓ Inadequate house maintenance/house rehabilitation system of houses ,
- ✓ Lack of adequate follow up on houses provided to local community;
- ✓ Lack of maintenance of public infrastructures (Schools, Health Centers, Markets, Bridges etc.)

## CHAP. III. BASIC CONSTRUCTION INSTRUCTIONS

### 3.1. INTRODUCTION

Basic construction instructions have been written according to different categories of houses found in surveyed areas around the country.

A special attention has also been given to the type of materials the houses are made of.

- Category A: Houses constructed in burnt bricks or cement blocks;
- Category B: Houses constructed in mud mortar blocks;
- Category C: Houses constructed in processed wood (mostly timber-Imbaho);
- Category D: Houses constructed in wood logs/wooden sticks (ibiti).

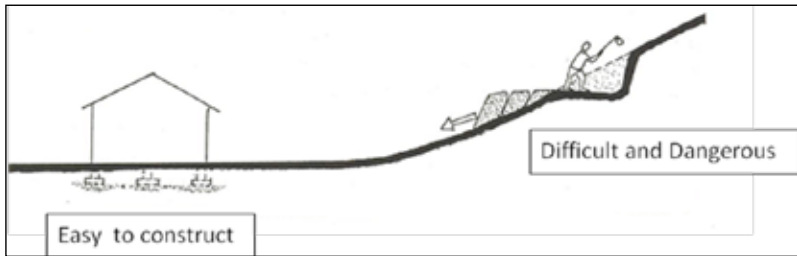
### 3.2 INSTRUCTIONS ON SITE LOCATIONS(for all categories)

The following criteria should be considered when selecting a site for house construction:

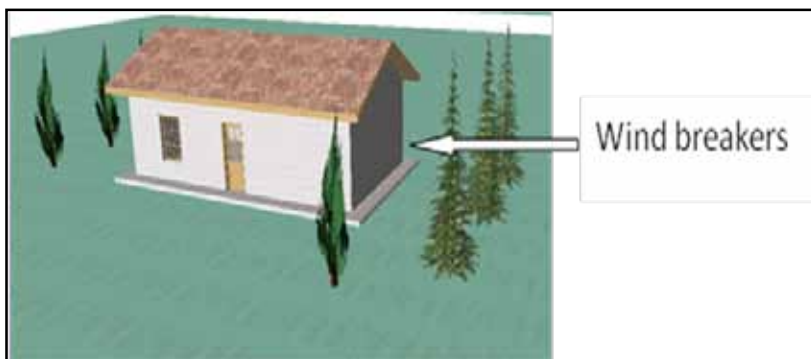
- The land should be higher than the last recorded flood level in the area.
- The house should be easily accessible and there should not be any actual or perceived barriers to access.
- Building housing on land that was previously abandoned/ polluted water body or garbage disposal site should be avoided because of dangers of groundwater contamination, land settlement and consequent damages to houses, especially during flood.
- The space around the land should be opened as much as possible to allow adequate air flow, ventilation and light.
- There should be a nearby ditch, canal or other appropriate place for drainage of water away from the site.
- The site should not to be located on slopes exceeding 40%.

In the case of selecting location of land to settle a new community, proximity to different infrastructure and employment opportunities should be considered.

- Houses must be located away from places subject to landslides.



- Construct house at least 2m away from top of slope and 2m away from the cut.
- Houses are not to be constructed in swampy areas and on unconsolidated soils; therefore, any housing construction activities on such hazardous areas is not allowed.
- Retaining walls should be constructed to support very steep cut slope.
- In area prone to strong wind, Wind Breakers (Trees) must be used to reduce the wind velocity.



### 3.3 INSTRUCTIONS ON SITE PREPARATION (for all categories)

Four basic steps should be followed:

1. Leveling (achieving appropriate level);
2. Dressing (adding soil to raise level);
3. Turfing (planting soil-binding vegetation);
4. Compaction (consolidating loose soil).

#### NOTE

- It is important to remember that the soil should be thoroughly compacted to reduce subsequent settlement. Nonetheless, some settlement is to be expected; therefore, the site should be raised to such an extent that even if some settlement occurs, it would still be above flood level.
- The bottom of drains should have a V formation to minimize water accumulation due to improper fall or debris in the drain

### 3.4. INSTRUCTIONS AS PER HOUSE CLASSIFICATION

#### **CLASS A : HOUSES CONSTRUCTED WITH BURNT BRICKS OR CEMENT BLOCKS**

##### **FOUNDATION**

- Foundations must be built on solid ground after excavation and testing on the ground(Fig. A1)

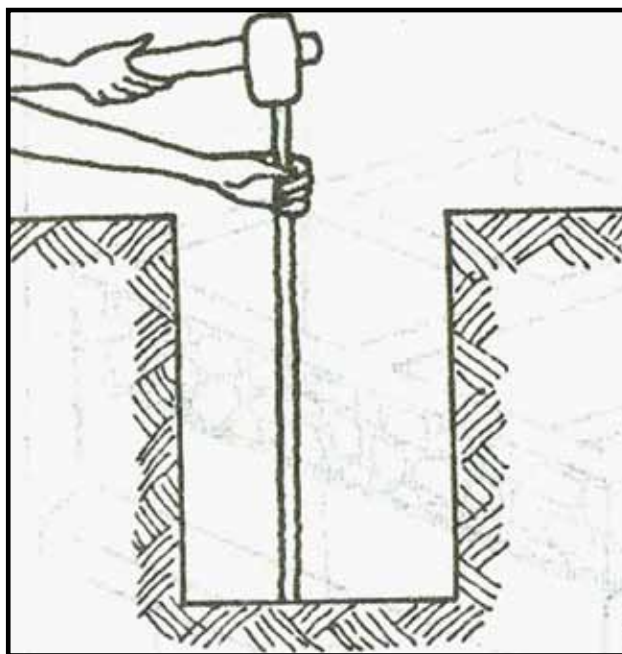


Fig.A1

- Anti-termites products should be used to protect insect or fungal attack.
- Only broken hard rock should be used in foundations, not unbroken rounded river stones or rounded seashore stones.
- Sufficient cement mortar of  $250\text{kg/m}^3$  (1:4 ratios) is needed to join stones used in the foundation into one solid foundation that will not subside unequally

### **Building materials:**

- **Sand:** Must be coarse, clean and without stones. It should not contain dust. It must never be coral sand, and if it is from the lake shore it must be thoroughly washed first and should contain no shell or coral fragments.

If the sand comes from a dirty or sea water source, it must be washed. The recommended size of the sand is  $0 \leq d \leq 1\text{cm}$

- **Gravel:** Must contain broken stones and not plain rounded river stones. The maximum stone size for house construction concrete is 2cm.
- **Water:** Must be clean and free of salt and algae



- **Concrete:** No vegetation matter is to be mixed into concrete( grass, wood, leaves, roots, etc).
- If the solid ground is found at a depth  $d=60\text{cm}$ , then the width =  $2 \times \text{Wall Thickness}$  (Fig. A2).

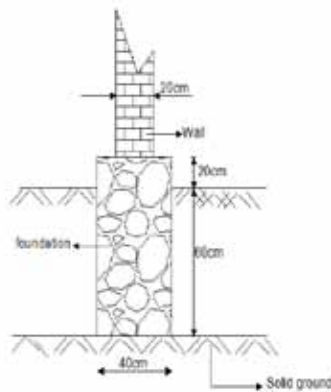


Fig. A2

- In case at  $d = 60\text{cm}$  and the ground is not solid enough, then the recommended depth is  $d=100\text{cm}$  and the width of the base =  $3 \times \text{Wall Thickness}$ (Fig.A3).

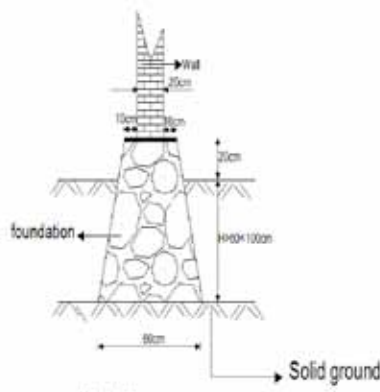


Fig.A3

- In this case the foundation can be tapered (Fig. A4) or built in 2 steps with different sizes (Fig. A5) or in one block having the same size throughout.

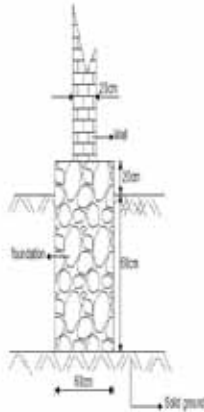


Fig. A4

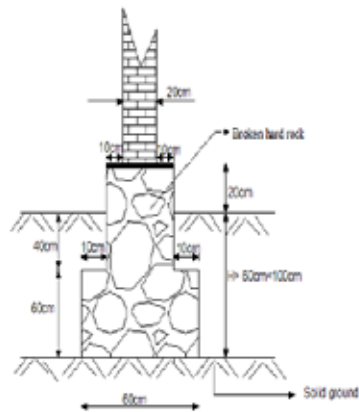
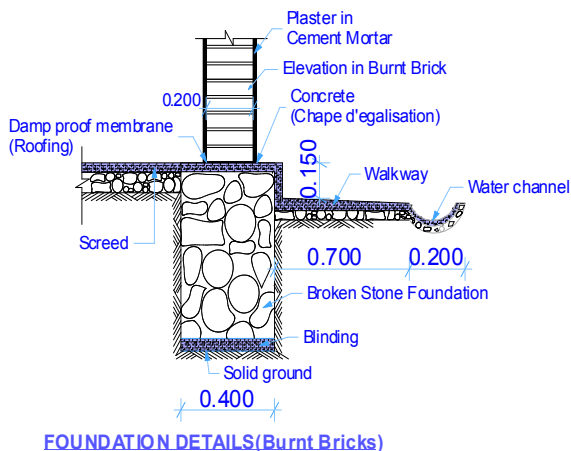


Fig. A5

## WALLS

- Mortar should be laid on top of foundation (chape d'egalisation) to have horizontal surface and a damp proof membrane to prevent water from ascending to the wall;
- Burnt bricks must be properly burnt and made of good quality clay
- Thickness of 20cm is recommended (Fig. A6)

Fig.A6



- Cement blocks must be made of a mixture of cement and sand at a ratio of 1:5;
- Cement mortar of 250kg/m<sup>3</sup> (1:4)
- Plastering is optional
- In case the walls have not been plastered, the joint must be filled properly by the cement mortar at a ratio of 1:3
- Walls should be joined to the roof structure with 6mm diameter bars, or a bunch of at least 6 twisted (galvanized iron) metal straps (impurumpuru) to strengthen each other at a minimum depth of 60 cm from the roof structure in order to form a monolithic structure (Fig. A7.a).

**Connection roof - wall in area not  
prone to strong wind: categ. A**

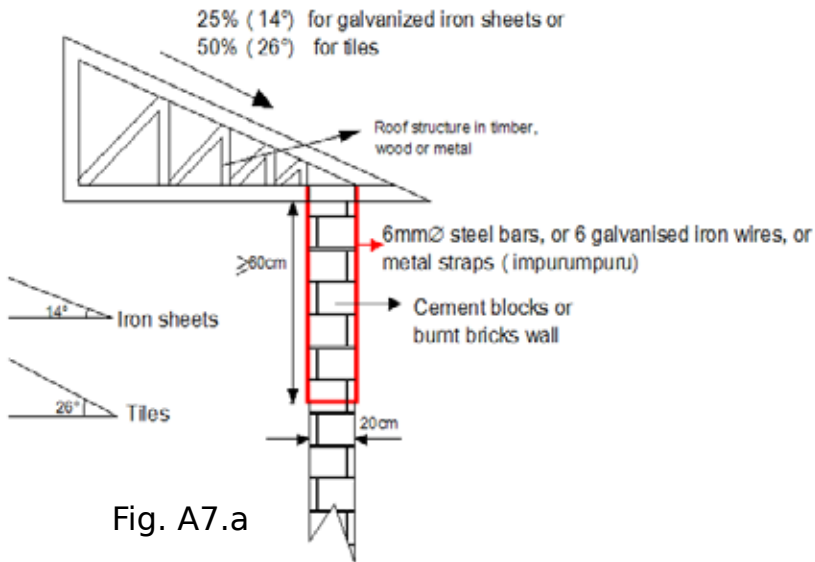


Fig. A7.a

- In areas prone to strong winds and earthquakes, houses should have a reinforced concrete structure(Fig A8).
- In case the building has been reinforced, walls must be tied into the building structure using metal hooks or reinforcement bars placed at minimum intervals of 60 cm so that they cannot move separately when the force of nature impact them . (Fig. A7.b).

### Connection roof - wall in area prone to strong wind: categorie A

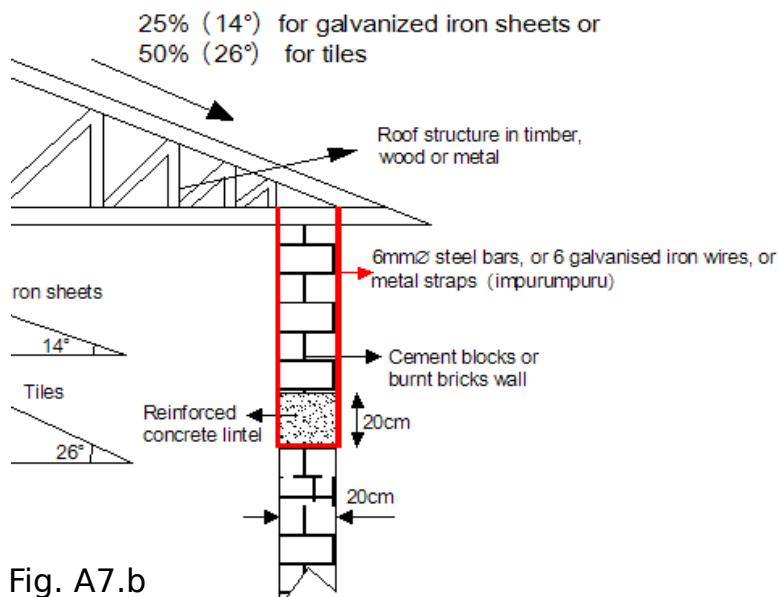


Fig. A7.b

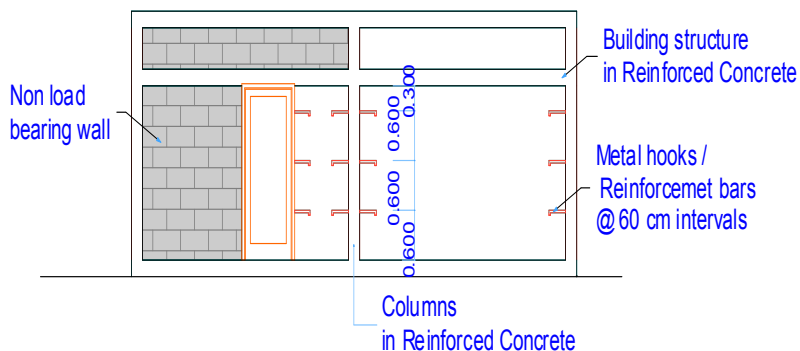


Fig. A8

## ROOFS

- A strong roof should provide lasting weather protection.
- Roof truss ties: Flexible but strong roof trusses enhance safety
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility so as to prevent collapse under the force of nature.
- The roof structure can be in timber, wood logs coated with anti-termites product and metal painted with rust proofing

### Minimum roof slope(Fig A9)

- Galvanized iron sheets : 25% or 14°
- Tiles: 50% or 26°

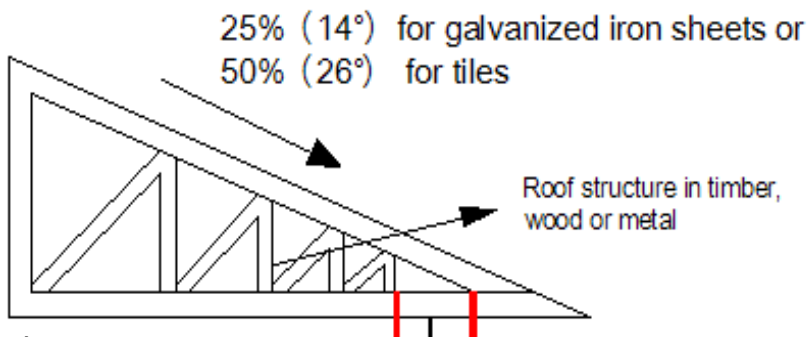


Fig. A9

## Orientation:

- Roof structure should be placed such that it faces the opposite direction of the wind.
- In case this is not possible, the roof should be hidden behind a parapet wall.
- The wall facing the main wind direction should be raised up at a minimum of 20cm above the roofing material; the latter should be inserted into the wall to avoid any leakage(Fig. A10)
- The roof structure can be in timber, or wood logs coated with anti-termites product or metal tubes painted with rust proofing.
- Gutters should be used to collect rain water from the roof the reservoir to provide a source of good household /gardening water. (Fig. A11)

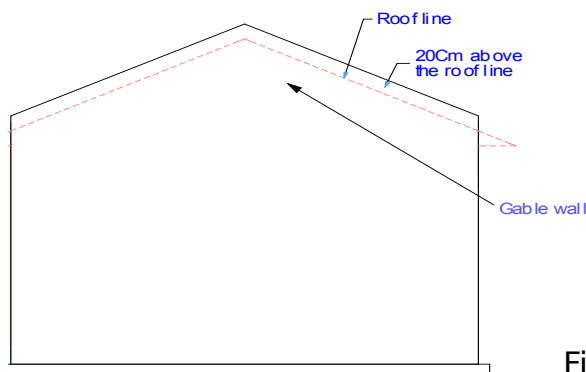


Fig. A10

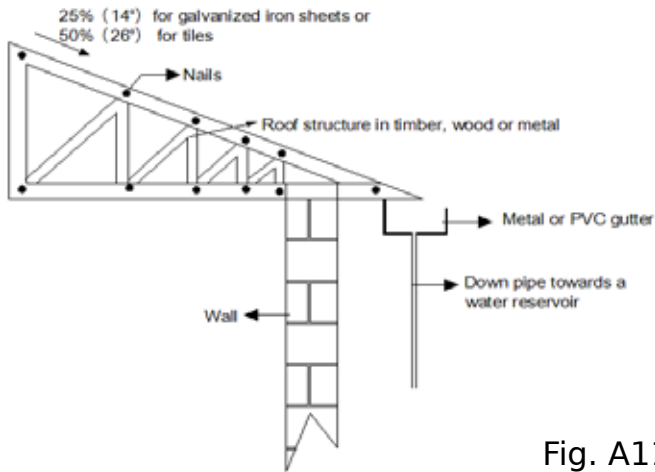


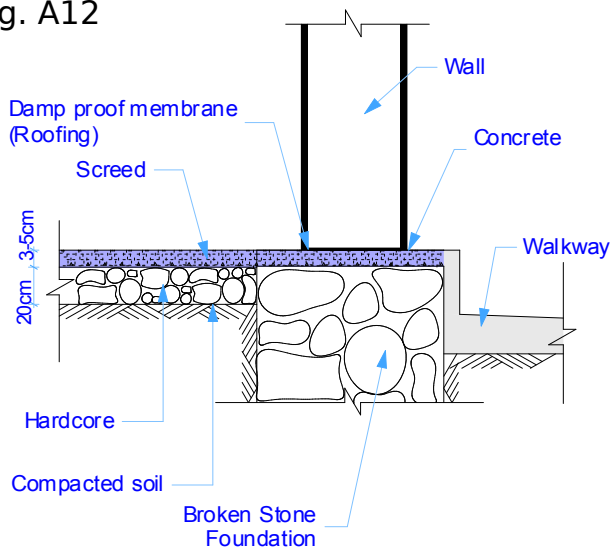
Fig. A11

## PAVEMENT AND WALK WAY

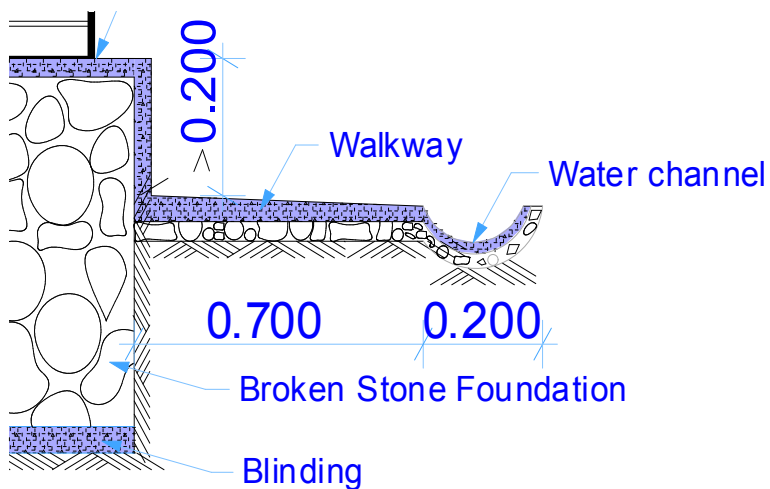
- The following layers should be respected (Fig. A12):
  - i. Ground beneath should be well compacted
  - ii. 20cm thick hardcore made of broken stones or burnt bricks
  - iii. 3-5cm thick cement screed
  - iv. Floor finish which can be tiles, cement, timber, etc



Fig. A12



## PAVEMENT DETAILS



## **DRAINAGE**

- A drainage system must be part of each house design; this must include drainage for rain water not collected and household water;
- All drains must be connected to a common drainage system;

Drains must be covered or have bridges for access across them, where needed. The cover can be reinforced concrete slabs, metal tubes or bars welded together or timber

## **CLASS B : HOUSES CONSTRUCTED WITH MUD MORTAR BLOCKS**

### **FOUNDATION**

- Foundations must be built on the solid ground after excavation and testing on the ground(Fig. B1)

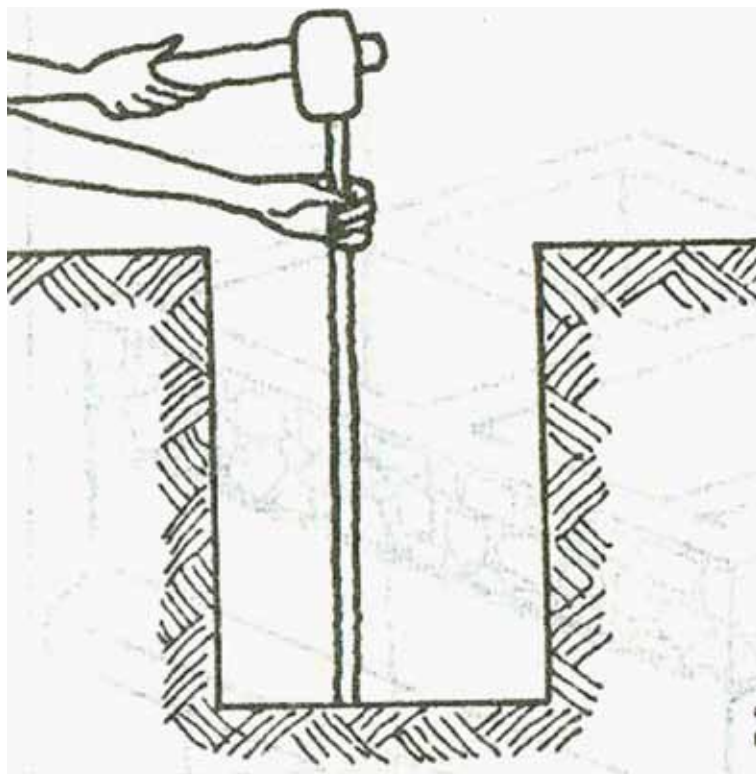


Fig.B1

- Anti-termites product should be used to protect insect or fungal attack.
- Only broken hard rock should be used in foundations, not unbroken rounded river stones or rounded seashore stones.
- Sufficient cement mortar of  $250\text{kg/m}^3$  (1:4 ratios) is needed to join stones used in the foundation into one solid foundation that will not subside unequally

### **Building materials:**

- **Sand:** Must be coarse, clean and without stones. It should not contain dust. It must never be coral sand, and if it is from the lake shore it must be thoroughly washed first and should contain no shell or coral fragments. If the sand comes from a dirty or sea water source, it must be washed. The recommended size of the sand is  $0 \leq d \leq 1\text{cm}$
- **Gravel:** Must contain broken stones and not plain rounded river stones. The maximum stone size for house construction concrete is 2cm.
- **Water:** Must be clean and free of salt and algae

- **Concrete:** No vegetation matter is to be mixed into concrete( grass, wood, leaves, roots, etc).
- **Note:** The foundation should be raised up at minimum of 20 cm above the ground level (Fig.B2)

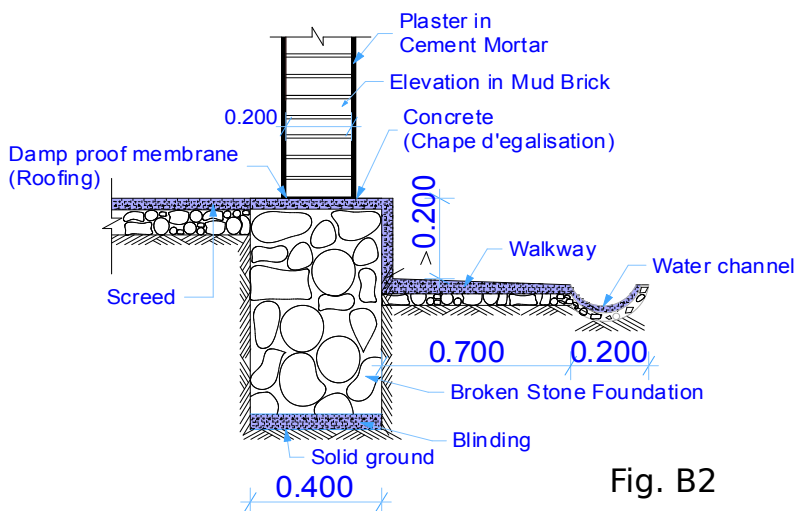


Fig. B2

### FOUNDATION DETAILS(Mud Bricks Wall)

## Foundation Masonry Width

- If the solid ground is found at a depth  $d=60\text{cm}$ , then the width =  $2 \times \text{Wall Thickness}$  (Fig. B3).

Fig. B3

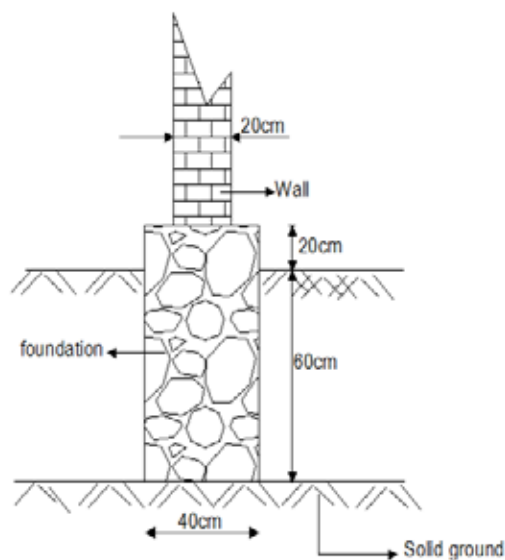
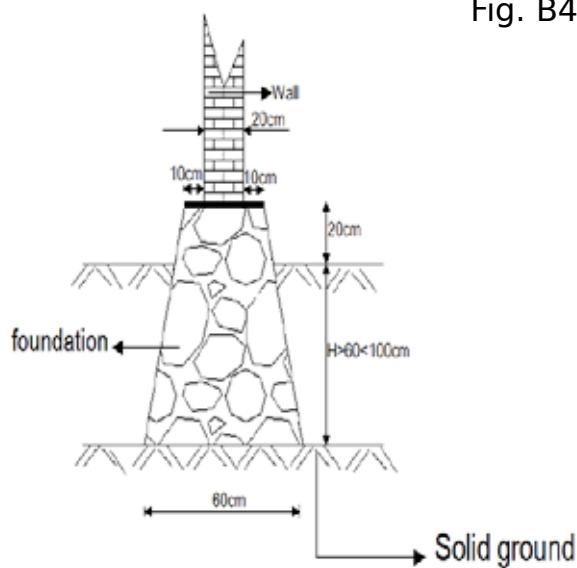


Fig. B4



- In case at  $d = 60\text{cm}$  and the ground is not solid enough, then the recommended depth is  $d=100\text{cm}$  and the width of the base =  $3 \times$  Wall Thickness(Fig.B4).
- In this case the foundation can be tapered (Fig. B5) or built in 2steps with different sizes (Fig. B6) or in one block having the same size throughout.

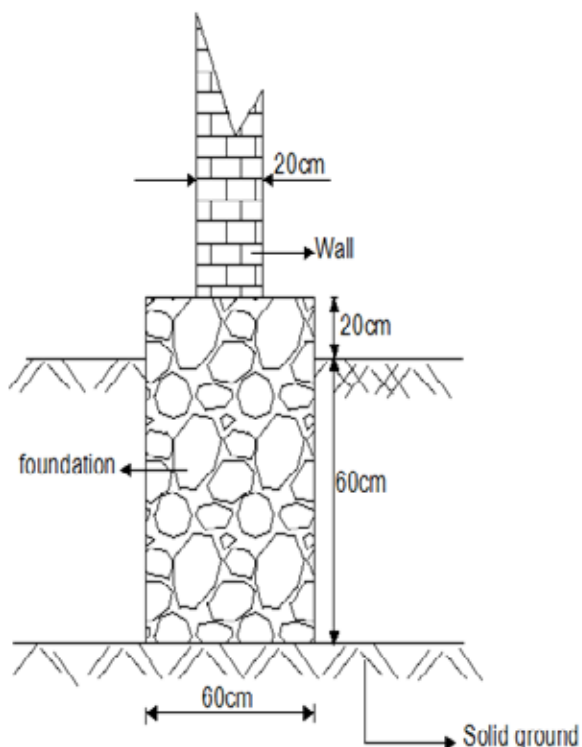


Fig. B5

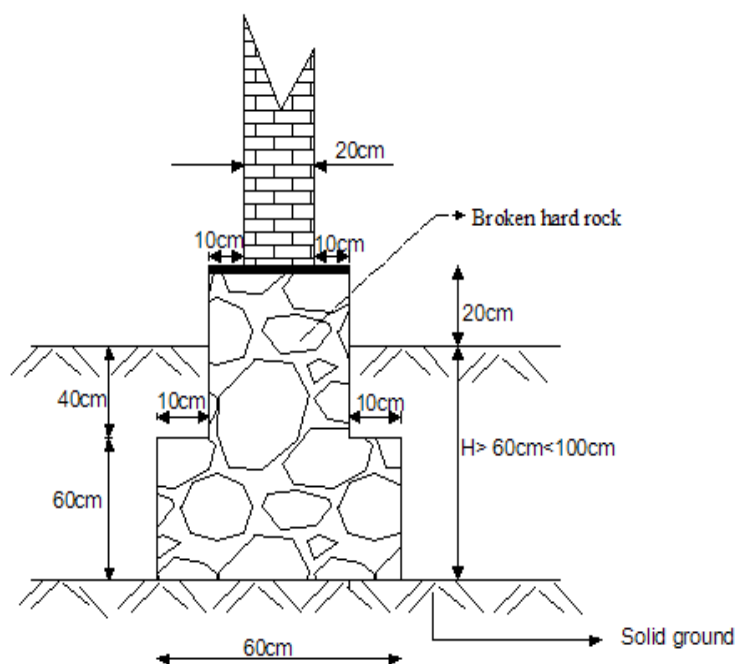


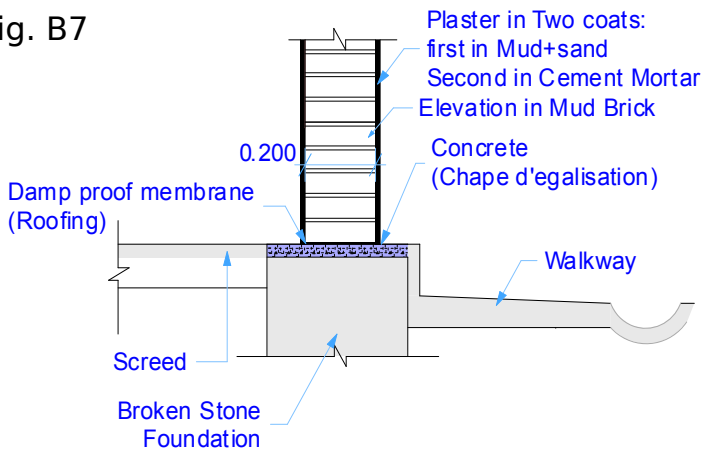
Fig. B6



## WALLS

- Mortar should be laid on top of foundation (chape d'egalisation) to have horizontal surface and a damp proof membrane to prevent water from ascending to the wall;
- Thickness of 20cm is recommended(Fig.B7)

Fig. B7



### WALL DETAILS(MUD BRICS)

- Plastering:
  - 1<sup>st</sup> coat: A mixture of mud and sand at a ratio 1:2 is to be used in case of clay soil and at a ratio of 1:1 in case of normal soil

- 2<sup>nd</sup> coat: cement sand mortar should be applied after one month when the previous coat has completely dried.
- Walls must be maintained by renewing the plaster when the previous has been damaged
- Walls should be joined to roof structure with 6mm diameter bars, or A bunch of at least 6 twisted (galvanized iron), metal straps (impurumpuru) to strengthen each other at a minimum depth of 60 cm from the roof structure in order to form a monolithic structure.
- In areas prone to strong winds and earth quakes, houses should have a reinforced concrete structure(Fig.B8).
- In case the building has been reinforced, walls must be tied into the building structure using metal hooks or reinforcement bars placed at minimum intervals of 60 cm so that they cannot move separately when the force of nature impact them . (Fig.B9).

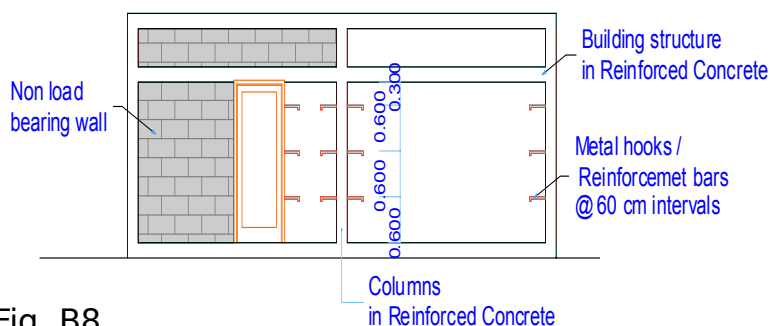


Fig. B8

**Connection roof-wall in area not prone to strong wind: Cat. B**

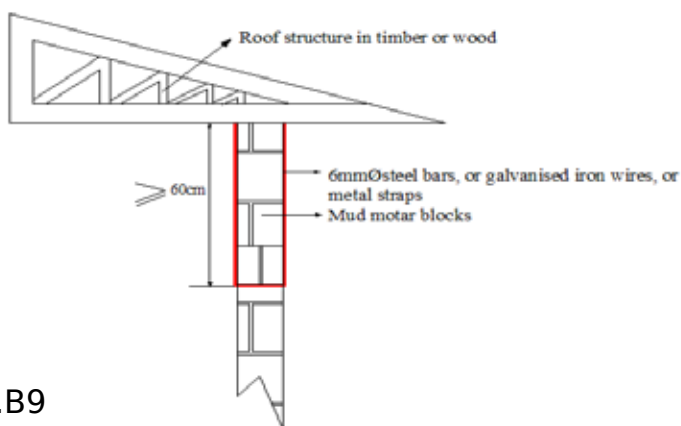


Fig.B9

## ROOFS

- A strong roof should provide lasting weather protection.
- Roof truss ties: Flexible but strong roof trusses enhance safety

- The joints of wooden roof trusses must be bolted together and tied with metal straps to provide flexibility so as to prevent collapse under the force of nature.
- The roof structure can be in timber, wood logs coated with anti-termites product and metal painted with rust proofing
- A hipped roof is recommended to protect walls from rain water penetration and for wind resistance(Fig.B10).
- A Roof Eave of a minimum 35cm is recommended.



**HIPPED ROOF**

Fig.B10

**Minimum roof slope(Fig.B11):**

- Galvanized iron sheets : 25% or 14°
- Tiles: 50% or 26°

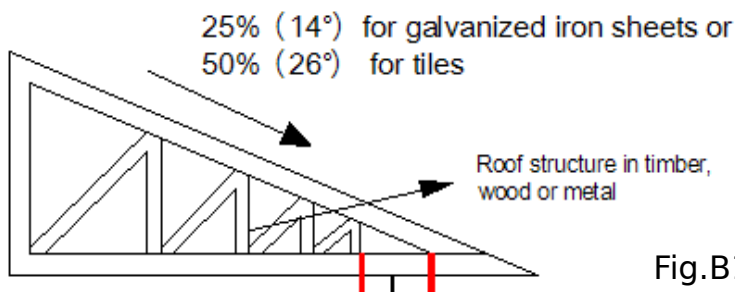


Fig.B11

**Orientation:**

- Roof structure should be placed such that it faces the opposite direction of the wind.
- In case this is not possible, the roof should be hidden behind a parapet wall.
- The wall facing the main wind direction should be raised up at a minimum of 20cm above the roofing material; the latter should be inserted into the wall to avoid any leakage(Fig B12).
- Gutters should be used to collect rain water from the roof to provide a source of good household/gardening water(B13).
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility and strength to enhance the safety of the building.

- The roof structure can be in timber, or wood logs coated with anti-termites product or metal tubes painted with rust proofing.

Fig.B12

**Connection roof-wall in area prone to strong wind: Cat. B**

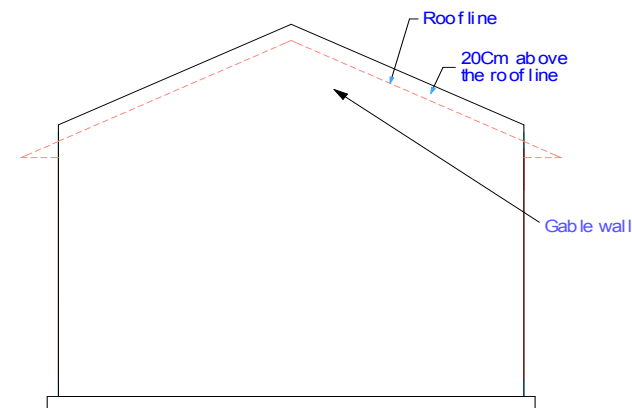
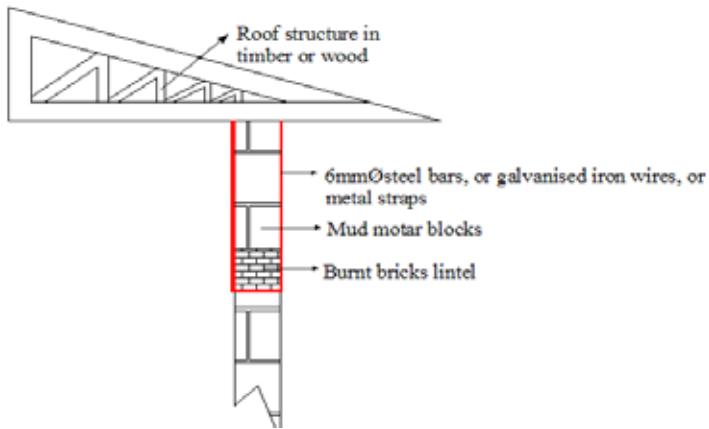
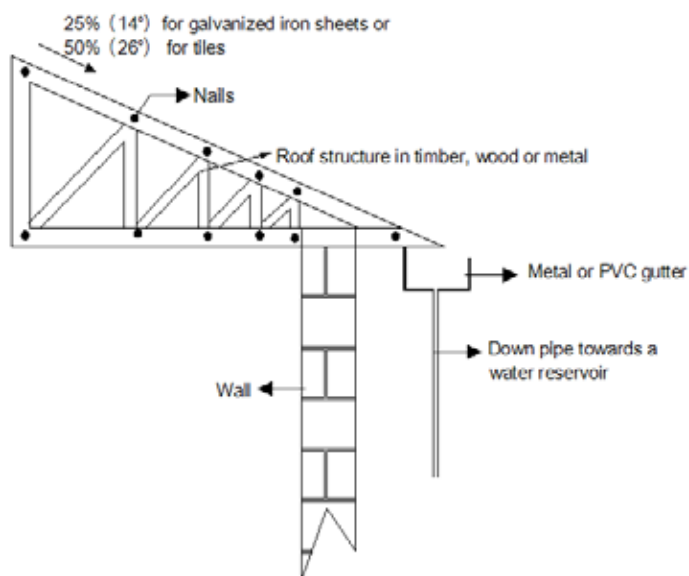


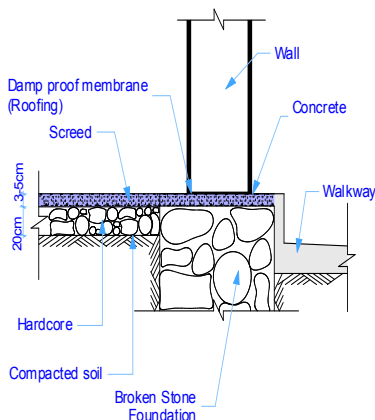
Fig.B13



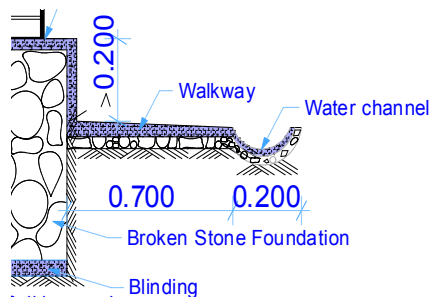
## PAVEMENT AND WALK WAY

- The following layers should be respected(B14):
  - i. Ground beneath should be well compacted
  - ii. 20cm thick hardcore made of broken stones or burnt bricks
  - iii. 3-5cm thick cement screed
  - iv. Floor finish which can be tiles, cement, timber, etc

Fig.B14



### PAVEMENT DETAILS





## **DRAINAGE**

- A drainage system must be part of each house design; this must include drainage for rain water not collected and household water;
- All drains must be connected to a common drainage system;

Drains must be covered or have bridges for access across them where needed. The cover can be reinforced concrete slabs, metal tubes or bars welded together or timber

## CLASS C : HOUSES MADE OF TIMBER(IMBAHO)

### FOUNDATION

- A stone foundation only under burnt brick columns is recommended (Fig C1).
- Anti-termites product to protect insect or fungal attack after excavation.
- Wooden rafters pressed into the ground up to a minimum depth of 40 cm after being coated with molten bitumen (vidange) to protect them from dampness (Fig.C2)
- Sheeting to improve water tightness of the wooden rafters.

Fig.C1

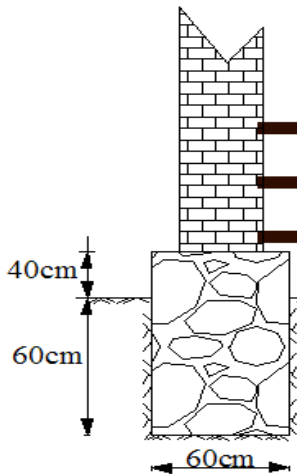
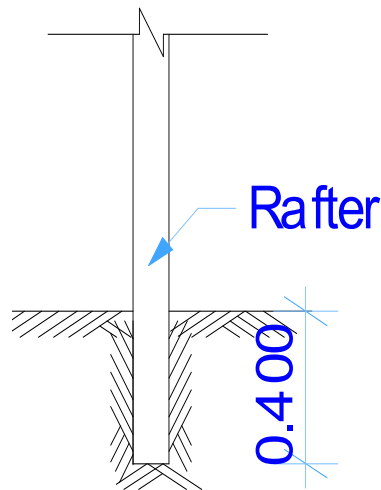


Fig.C2



## WALL

- Walls must be maintained by being coated as need arises.
- Walls should be joined to roof structure using 12 nails and metal straps (impurumpuru), 6mm diameter bars, a bunch of at least 6 twisted (galvanized iron) to strengthen each other at a minimum height of 60 cm from the roof structure.
- Vertical wooden rafters must be placed at 60cm intervals;
- Burnt bricks columns supported by a stone foundation must be put at the corners of the house with a metal tube in the center; this one must be anchored in the foundation (Fig. C3).

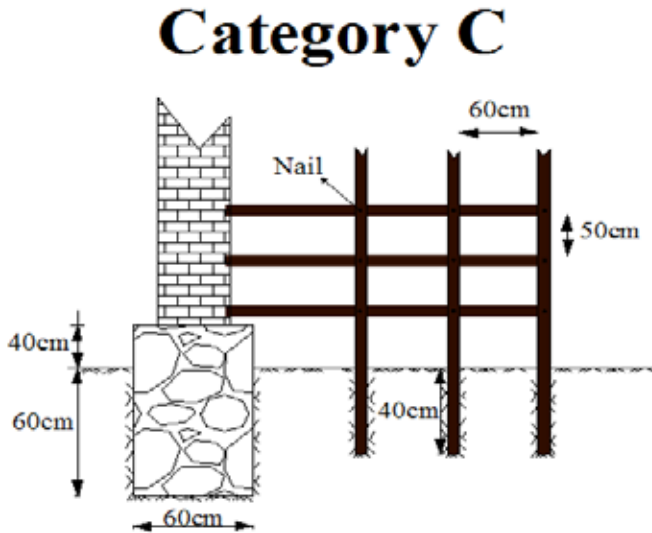
Section of columns: 30cm x 30cm

Foundation: 50cm x 50cm x 60cm(minimum depth)

Tube: 6cm x 4cm and 2mm thick

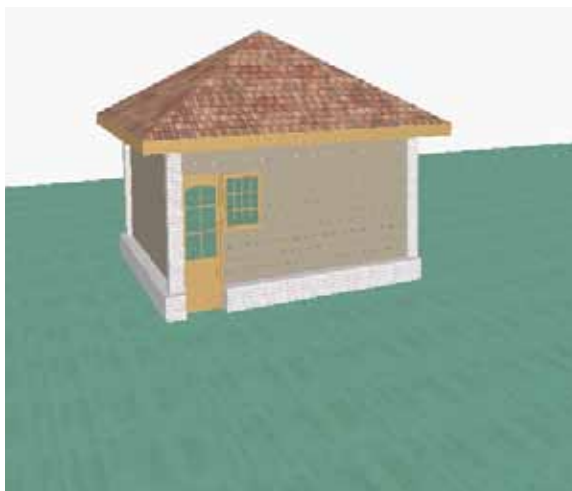
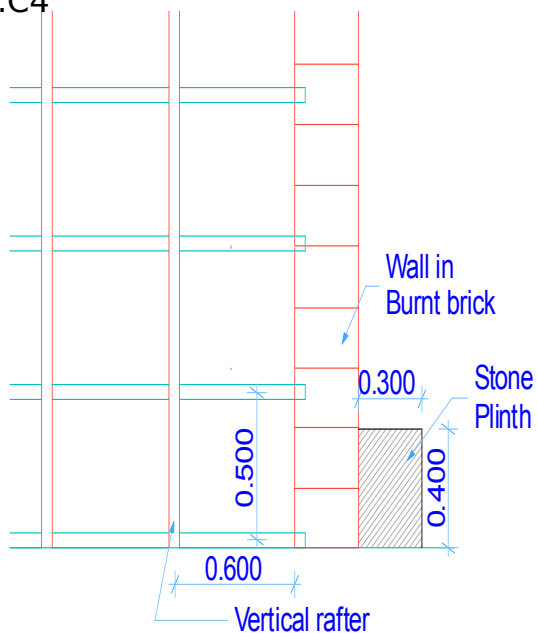
Cement mortar : 250kg/m<sup>3</sup> (1:4)

Fig.C3



- Horizontal wooden rafters must be placed at 50cm intervals and must be anchored in the burnt bricks columns.
- Walls are made of wooden boards nailed on the rafters.
- The bottom part of the rafters pressed into the ground should be checked and replaced in case they are defected.
- A stone plinth 40 cm high and 30 cm wide must be built around the house to prevent rain water penetration(Fig.C4).

Fig.C4



## ROOFS

- A strong roof should provide lasting weather protection.
- Roof truss ties: Flexible but strong roof trusses enhance safety
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility so as to prevent collapse under the force of nature.
- The roof structure can be in timber, wood logs coated with anti-termites product and metal painted with rust proofing.
- The recommended roof covering materials is Iron Sheet.

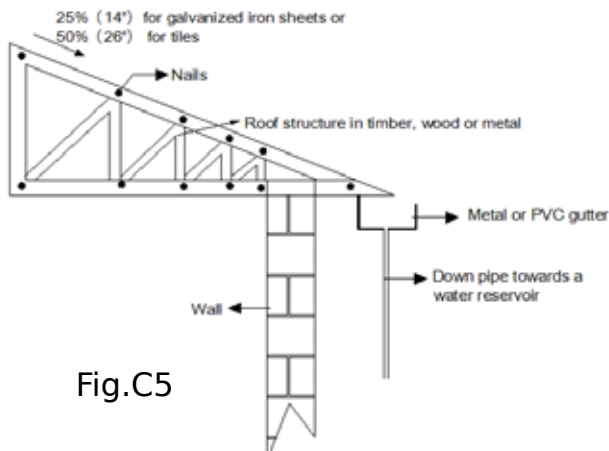
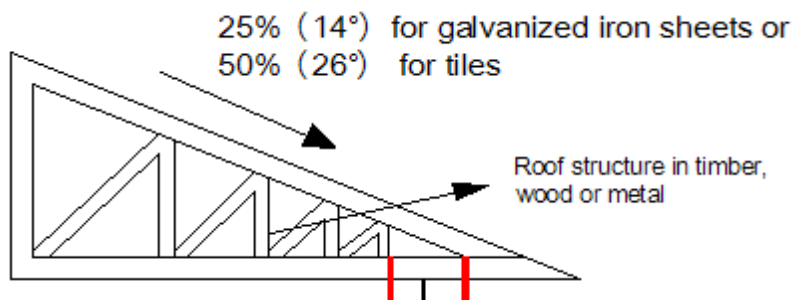


Fig.C5

## Minimum roof slope(Fig.C6):

- Galvanized iron sheets : 25% or  $14^{\circ}$
- Tiles: 50% or  $26^{\circ}$

Fig.C6



## Orientation:

- Roof structure should be placed such that it faces the opposite direction of the wind.
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility and strength to enhance the safety of the building.
- The roof structure can be in timber, or wood logs coated with anti-termites product or metal tubes painted with rust proofing.
- Gutters should be used to collect rain water from the roof the reservoir to provide a source of good household /gardening water. They

prevent creation of furrows around plinth by rain falling down from roof eaves and rainwater splashing on walls (Fig. C5)

- A hipped roof is recommended to protect walls from rain water penetration and for wind resistance(Fig.C7)
- A Roof Eave of a minimum 35cm is recommended.

Fig.C7



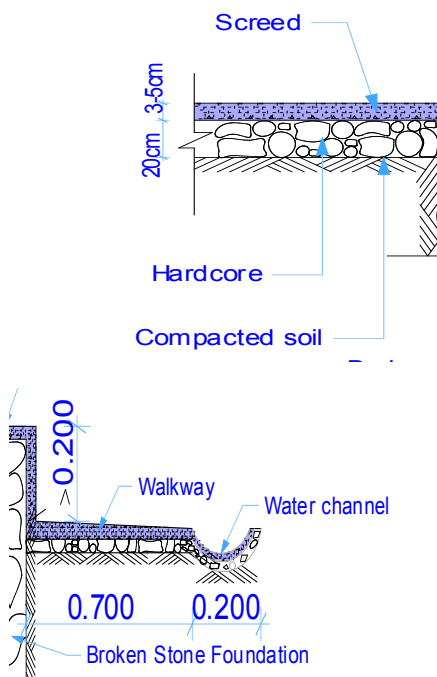
**HIPPED ROOF**



## PAVEMENT AND WALKWAY

- The following layers should be respected:
  - i. Ground beneath should be well compacted
  - ii. 20cm thick hardcore made of broken stones or burnt bricks
  - iii. 3-5cm thick cement screed
  - iv. Floor finish which can be tiles, cement, timber, etc

Fig.C8



## **DRAINAGE**

- A drainage system must be part of each house design; this must include drainage for rain water not collected and household water;
- All drains must be connected to a common drainage system;

Drains must be covered or have bridges for access across them, where needed. The cover can be reinforced concrete slabs, metal tubes or bars welded together or timber

## CLASS D : HOUSES MADE OF WOOD LOGS/ WOODEN STICKS(IBITI).

### FOUNDATION

- A stone foundation will be built only under the burnt brick columns(Fig.D1)
- Anti-termites product should be used to protect insect or fungal attack after excavation.
- Timber posts must be embedded into the ground at a minimum depth of 50cm and 30cm of intervals after being coated with molten bitumen (vidange) to protect them from dampness.
- Sheeting can be used to improve water tightness of the timber posts.

Fig.D1

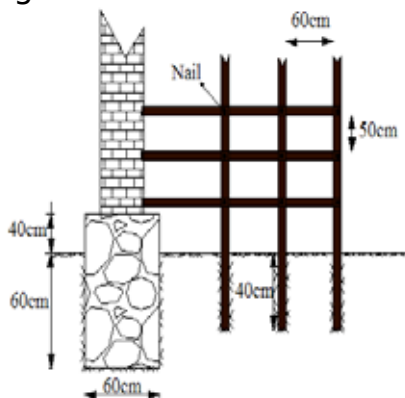
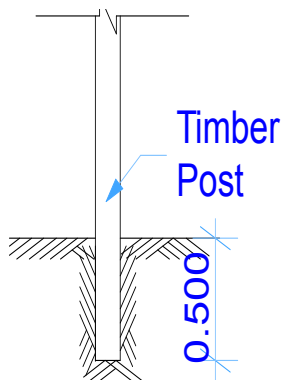


Fig.D2



## WALLS

- These walls are made of Vertical elements and double layer of horizontal elements with earth infill.
- The Cross-Bracings can be used to increase the stability and wind resistance of the structural frame.
- Metal straps (impurumpuru), Galvanized wires should be used for tying the elements of the structural frame.
- Vertical elements are placed at 30cm intervals whereas the double horizontal elements are at 25cm spacing.
- The space between the frameworks should then be filled with earth (preferably cement stabilized) by hand in lumps and packed down tightly so that it pushes out between the slats.
- Walls should preferably be not less than 20cm thick.
- Diagonal bracing is used to prevent “racking”, or movement of structural vertical beams or posts.
- Walls must be maintained by being regularly plastered.

- Walls should be joined to roof structure with 6mm diameter bars, a bunch of at least 6 twisted (galvanized iron) metal straps (impurumpuru) to strengthen each other at a minimum height of 60 cm from the roof structure. In areas prone to strong winds the bars should be tied to the lintel.
- Plastering: -1<sup>st</sup> coat: A mixture of mud and sand at a ratio 1:2 is to be used in case of clay soil and at a ratio of 1:1 in case of normal soil.
  - 2<sup>nd</sup> coat: cement sand mortar should be applied after one month when the coat has completely dried.

## ROOF

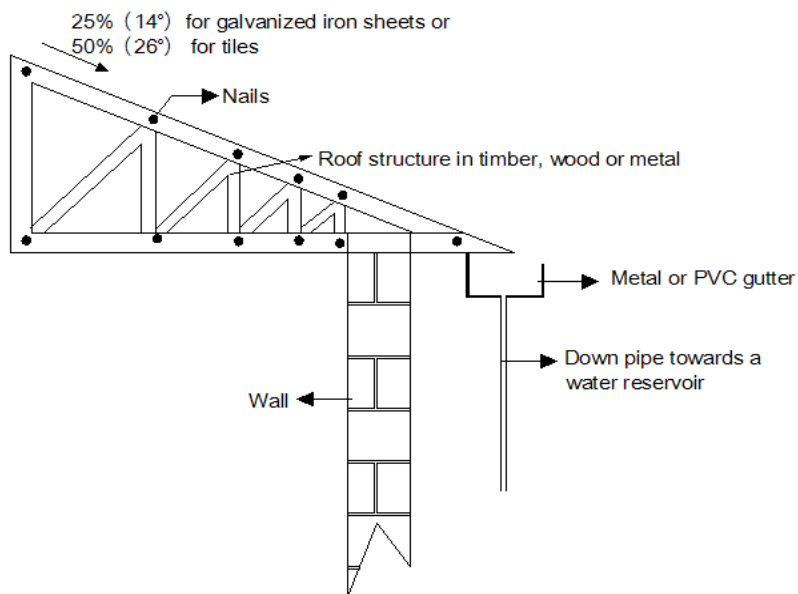
- A strong roof should provide lasting weather protection.
- Roof truss ties: Flexible but strong roof trusses enhance safety
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility so as to prevent collapse under the force of nature.

- The roof structure can be in timber, wood logs coated with anti-termites product and metal painted with rust proofing.
- The recommended roof covering materials is Iron Sheet.
- A hipped roof is recommended to protect walls from rain water penetration and for wind resistance(Fig.D3)
- A Roof Eave of a minimum 35cm is recommended.

Fig.D3

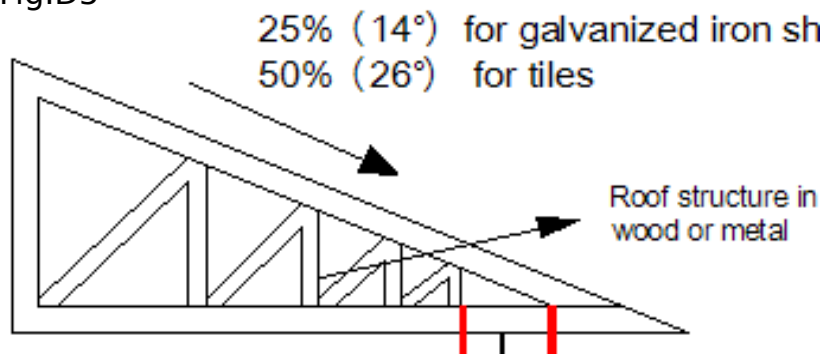


Fig.D4

**Minimum roof slope(Fig.D5):**

- Galvanized iron sheets : 25% or 14°
- Tiles: 50% or 26°

Fig.D5



## Orientation:

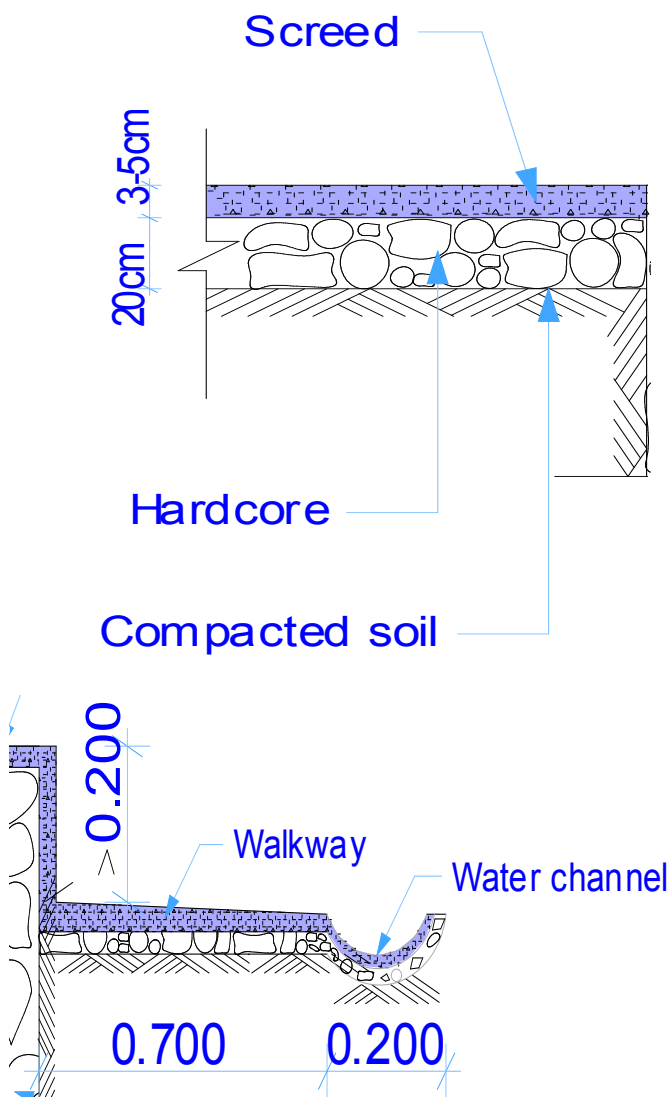
- Roof structure should be placed such that it faces the opposite direction of the wind.
- The joints of wooden roof trusses must be nailed together and tied with metal straps to provide flexibility and strength to enhance the safety of the building.
- Gutters should be used to collect rain water from the roof to the reservoir to provide a source of good household /gardening water.

They prevent creation of furrows around plinth by rain falling down from roof eaves and rainwater splashing on walls (Fig. D4).

## PAVEMENT

- The following layers should be respected (Fig.D6).
  - i. Ground beneath should be well compacted
  - ii. 20cm thick hardcore made of broken stones or burnt bricks
  - iii. 3-5cm thick cement screed
  - iv. Floor finish which can be tiles, cement, timber, etc



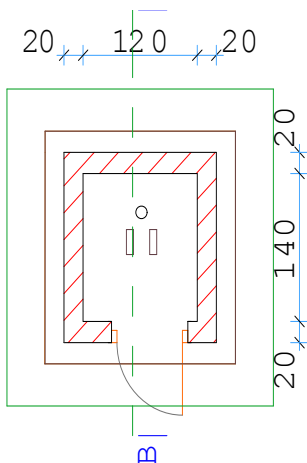


## DRAINAGE

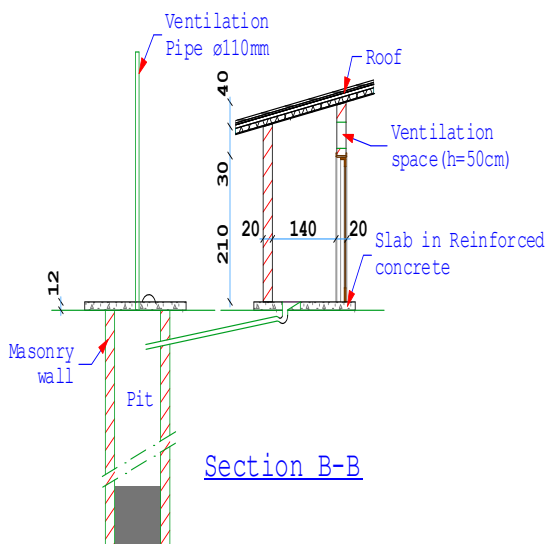
- A drainage system must be part of each house design; this must include drainage for rain water not collected and household water;
- All drains must be connected to a common drainage system;

Drains must be covered or have bridges for access across them, where needed. The cover can be reinforced concrete slabs, metal tubes or bars welded together or timber.

## TOILETS MODEL TO BE USED FOR ALL CATEGORY OF HOUSES



FLOOR PLAN



Section B-B

### 3.5. GOVERNMENT INSTITUTIONS AND OTHER PARTNERS' RESPONSIBILITIES

- The use of funds from Government institutions and partners to support the vulnerable groups in terms of building houses must be supervised by a competent authority/civil engineer at sector level to avoid technical and financial mismanagement,
- At the sector level, a technical specialist in construction (civil engineers at least) must be recruited to supervise and monitor all construction activities,
- There must be a close collaboration between Government institutions including REMA, MINIRENA, MINEDUC, MININFRA, MIDIMAR and MINALOC in terms of decision making regarding environment , infrastructures development and disaster risk reduction,
- Construction of rural settlements must follow all instructions given in this document,
- Local masons should be trained on the construction of houses development with disaster resilience considerations.

### 3.6. EXPECTED RESULTS

1. Reduced number of death, injuries and other damages caused by the destruction/collapse of houses and infrastructures built with no regulations and standards,
2. A basic housing construction instruction document as a user guide available helping against consequences of natural and manmade disaster to protect the people and properties.

### 3.7. USERS OF THIS DOCUMENT

- This document should be used by any person who wants to build a house in the rural area of Rwanda.

## REFERENCE/END NOTE

1. Economic Development and Poverty Reduction Strategy 2007-2012 (EDPRS), Kigali, Rwanda.
2. MIDIMAR, Annual Report, Kigali, 2011
3. MININFRA, Compilation of Policies concerning human settlement, urban housing and construction in Rwanda, Kigali, January 2011
4. MININFRA, Rwanda Building Control Regulations, Kigali, December 2010.
5. MININFRA, the National Human Settlement Policy in Rwanda, Kigali, 2004.
6. Ministerial order no 001/07.5 of May 19th, 2009 relating to the implementation of the national program on regrouped settlement in 'IMIDUGUDU'.
7. [www.utwente.nl/School](http://www.utwente.nl/School) of disaster management, The Netherlands, 2011.
8. La Maison





## **APPENDIX**







## ILLUSTRATION OF DESTROYED HOUSES

### I. Houses Located in Swampy areas.

NYABIHU



NGORORERO

## **II. Class rooms in Huye District with non wind breakers.**



### III. Houses Located near the non protected embankment with no retaining walls

GAKENKE



BURERA

## IV. Constructions in need of rehabilitation















