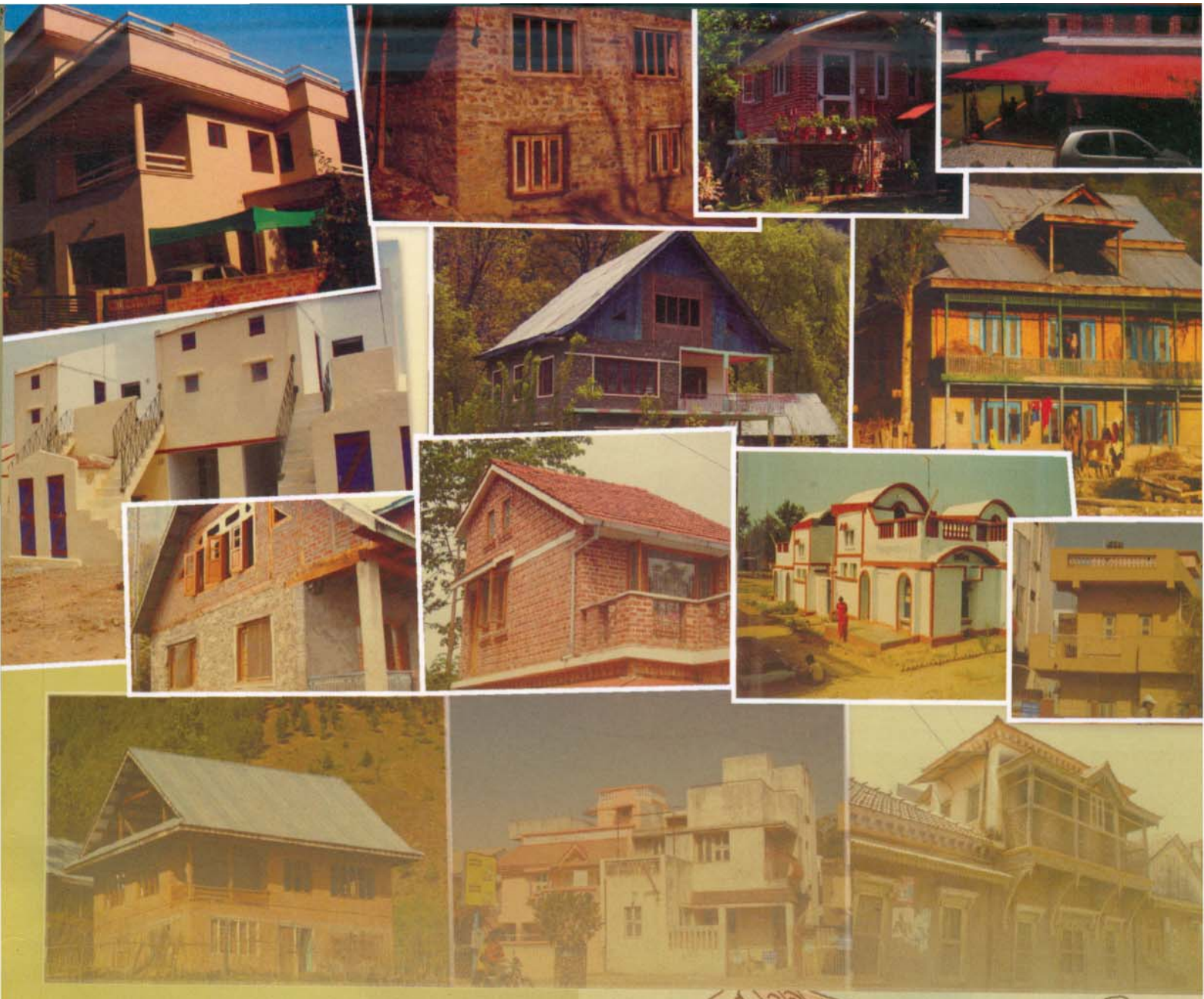
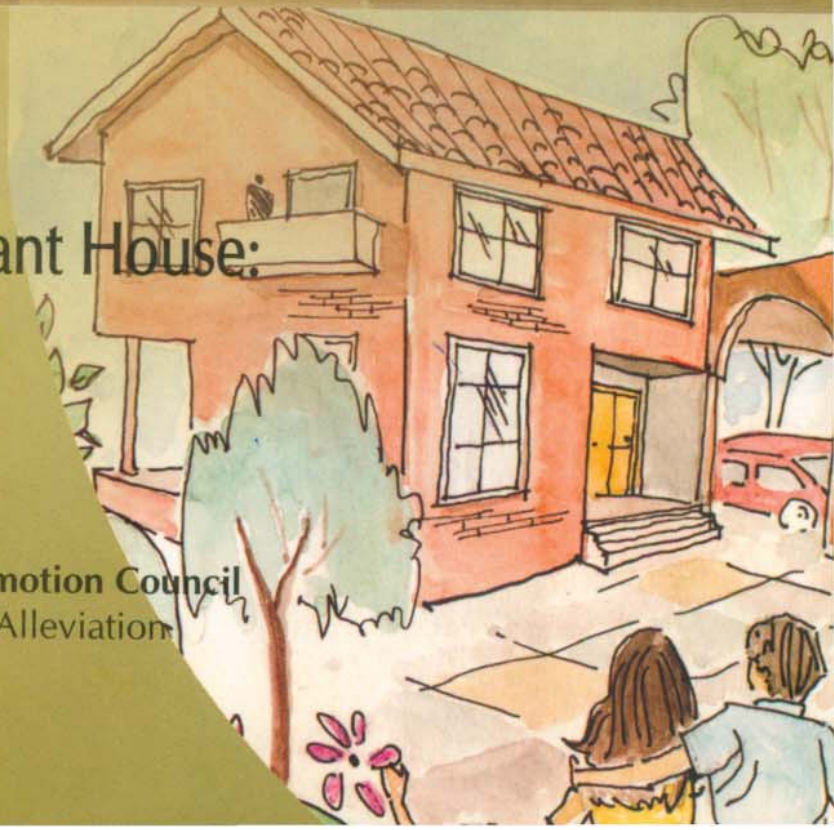


Building a Hazard-Resistant House: A Common Man's Guide



Building Materials and Technology Promotion Council
Ministry of Housing and Urban Poverty Alleviation
Government of India.

Common Man's Guide to Build a Hazard-Resistant House

Dedicated to those who want to ensure the safety of their families against future disasters by building a hazard-resistant house.

A publication of

Building Materials and Technology Promotion Council
Ministry of Housing and Urban Poverty Alleviation, Government of India.
Core-5A , 1st Floor, India Habitat Centre, Lodhi Road, New Delhi 110 003 (India).

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May, 2009

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Preface

The Indian subcontinent frequently witnesses disasters caused by the natural phenomena such as earthquake, cyclones and floods. These result in widespread injury and death and hardships to people that could be prevented. The people suffer huge losses due to damage in or destruction of their houses and other buildings they own. This happens because people in general are unaware or 'uninformed' about the critical aspects of construction incorporating disaster resisting features. The local contractors and artisans are also equally ignorant in this matter. Unfortunately people are generally unaware of the care that they can and should exercise in such construction to ensure that the construction is made in true sense hazard - resistant and long lasting.

In other words, it is very important that people learn about the basic rules that are important in designing and planning of their houses, and later in ensuring good quality of construction, so that within the limits of budgetary constraints they are able to build a house that has much higher resistance to disasters than the commonly built houses.

This Guide covers only the load-bearing masonry structures, since in our country the houses are mostly constructed with this type of construction. The Guide does not cover the RC frame structure. The main reason for this is that it is perfectly acceptable, even from the technical angle, to build a load-bearing masonry structure with the help of the local artisans, whereas it is not advisable to build a RC structure without appointing an experienced engineer for design and construction.

The book is primarily meant to help the house owner get constructed a safer house to live in, and to ensure the safety of his family in case of a likely future disaster. This Guide will be useful especially where the house-owner does not seek the guidance of an architect or an engineer, and depends fully on the technical services of a local contractor or artisan, starting from preparation of the house design, selection of the technology to be used, and execution of the construction without supervision by a third party. No doubt the guide gives tips on the non-technical aspects such as material procurement, appointment of a contractor and the like: but the major portion of the book focuses on various technical aspects that have a direct bearing on the performance of the structure in case a disaster strikes.

In short, in true sense of the word, this Guide is prepared with view to help the "house owners of tomorrow" in ensuring that the houses that they are going to get built are going to be hazard-resistant and long lasting. The guide follows the relevant Bureau of Indian Standards (BIS) codes, thus eliminating the need to procure them. The information provided in the first part of the book is useful in planning and designing of the house as well as in the material procurement and appointment of the building agency, be it a contractor or an artisan. The information provided in the later part is useful during and after the construction.

It would be appropriate to mention here that the authors' experience of over three decades in this field, including six major disasters in the country, and close association with the building artisans in those regions provides a strong foundation for this Guide. It is hoped that the Guide reaches the small towns and villages, where it is difficult to finds engineers and architects who can make a real and meaningful contribution in bringing a long-term safety to the people.

Rupal Desai Rajendra Desai

The information given in this Guide is in conformance with the relevant Bureau of Indian Standards (BIS) Codes. The practical tips and cautions are based on the firsthand experience of the authors.

Acknowledgment

First and foremost we must acknowledge that the idea of making a book for a common man originated from Shri Shailesh Kumar Agarwal, Executive Director or BMTPC. This was indeed a logical thing to do since, as he indicated, in recent years there have been training programs and publications for the engineers as well as for the building artisans. But very little technical work is done to strengthen the owner-driven process of house construction.

Just as the work was under way, a personal crisis brought the work to a near standstill. In this situation it was only the patience and words of encouragement from Shri J.K.Prasad, Chief of Building Materials in BMTPC that helped us continue with the task and complete it.

While putting together our disaster related past lessons in making this book, we can not forget to acknowledge the invaluable lessons learnt from Dr. A.S.Arya, ex professor IIT-Roorkee, and Dr. K.S. Jagadish, ex professor IISC, Banglore.

As in all our recent publications, the special input by Shri B.J.Karani, as a non-technical outsider, in the form of reviewing of all the written matter and ensuring a logical flow of information is most valuable, but not so visible.

Finally, we must acknowledge the support of Brinda Pancholi for attractive illustrations, the NCPDP team, especially Harshad Talpada, our engineer, Ajay Kankrecha, computer expert and Minal Graphics for designing the layout without which putting together this whole book would have been difficult and time consuming.

Last but not the least we must not forget to thank the community members and the artisans without whose co-operation we could not have built up an extensive photo library of the subjects relevant to this guide.

Rupal Desai - Rajendra Desai
Ahmedabad, India.

Abbreviations

WORDS	ABBREVIATIONS	WORDS	ABBREVIATIONS
AC	Asbestos Cement	Max.	Maximum
BB	Burnt Brick	Min.	Minimum
Bldg.	Building	mm	Millimeter
CB	Concrete Block	No.	Number
CGI	Corrugated Galvanized Iron	OPC	Ordinary Portland Cement
cm.	Centimeter	PAN	Permanent Account Number
Cmt./Cu.m.	Cubic meter	PC	Pre-cast Concrete
Cont.	Continuous	PCRC	Pre-cast Reinforced Concrete
CR	Coursed	PPC	Pozzolomic Portland Cement
Cu.ft./c.ft.	Cubic foot	RC	Reinforced Concrete
Fndtn.	Foundation	RCC	Reinforced Cement Concrete
g	Gauge	RR	Random Rubble
GI	Galvanized	s	Second
Gr	Ground	Sm.	Seismic
HSD	High Strength Deformed bars	smt./Sq.mt./Sq.m.	Square meter
Ht.	Height	St.	Storey
kg./kgs.	Kilogram	Sq.ft./Sft.	Square foot
Lvl.	Level	UCR	Uncoursed rubble
m	Meter	Wnd.sp.	Wind Speed

BIS	Bureau of Indian Standards
BMTPC	Building Materials and Technology Promotion Council
NCPDP	National Centre for Peoples' Action in Disaster Preparedness

Table of contents

Understanding
The Guide And The Local Hazards

1 Introduction

This Guide is made to assist you, a non-technical future house-owner, since you intend to get your house designed and constructed by local building contractor or a building artisan. It is aimed at helping you take decisions right from the conceptual stage of designing your dream house, through hiring a competent contractor or an artisan, and intervene in a meaningful manner at various stages of construction through the completion of the structural part of construction such that it becomes a hazard-resistant house that will ensure the long-term safety of your family and you.

The higher cost should not become a cause of concern to bring this dream in to a reality. To make the house disaster-resistant is not going to cost you much more than building an ordinary house. The cost becomes excessive only when without understanding the real cause of damage and the remedy to prevent that damage, you start using non-local materials which you will have to bring from far and which may be costly.

Generally after a disaster like an earthquake or a cyclone or a flood, people start thinking that there is no future in their traditional building materials and technologies. With their confidence in the local materials and techniques shaken, they begin to think of materials that are not local, that are different from what they have been using all along. They begin to think of cement, steel and RCC construction as the only option for the safety against a future disaster. In the region where the stone is available in plenty they long to make use of bricks. With such a psyche, people reject the materials from the damaged or collapsed houses. Instead, they buy fresh, non-local materials, and pay a much higher price for new purchases and incur further spending to get these transported to the site of construction, adopt new technologies, and get building artisans from far who are totally ignorant about the local area and conditions. This is why the intending house-owners find the new disaster- resistant construction beyond their reach. And at the end there is no certainty about what is being built.

In reality, if only they try to understand the root cause of the house collapse, and how the weaknesses that caused the collapse can be countered through affecting simple and affordable changes in their own building technologies, then new disaster-resistant houses can be built by the local artisans with little use of the non-local materials. In this case they can certainly use the materials salvaged from the collapsed house along with addition of necessary new and some special materials. The additional cost of constructing a hazard-resistant house may not come to more than 10% of the total cost of an ordinary building.

So in case you are planning to get a house built with the help of a local contractor or local building artisans, you should read this Guide, and thoroughly understand the contents. It will help you take the right decisions in every aspect of this activity e.g. planning and designing the house, selecting the site, appointing the contractor, procuring the right materials, continuous dialogue with the contractor/artisans to ensure that they follow all the important rules, and adhere to principles of quality construction, without incurring unduly high cost.

It is very important and crucial that before its use, you fully read this Guide and understand how information of each stage is to be used and where exactly in this Guide it is available. This will help to ensure effective and timely application of the relevant information.

Do not ever forget that:

Natural hazards can strike at any place, at any time and be of any intensity. An earthquake is the most dangerous and destructive among hazards, because it does not give an advance warning. So whatever the likely local hazards, the house you build must be able to resist them in order to give your family a protection against damage or collapse.

How to use this guide?

This Guide is broadly divided in five main parts as follows:

- Understanding the Guide and the Local Hazards - Chapters 1 & 2
- Before Starting Construction - Chapters 3 to 9
- During Construction - Chapters 10 & 11
- After the Construction is Complete - Chapters 12 to 15
- Appendices - A, B

With these chapters the Guide takes the "future house owner" through all the important steps starting from knowing and understanding local hazards to ensuring of good quality construction and creation of safer living spaces.

Understanding The Guide And The Local Hazards

Chapter 1-

Introduction:

Defines three basic premises which are the fundamental assumptions of this Guide: One, that a house must be safe to live in, and therefore disaster-resistant. Two, the house must be long-lasting. Three, the reader of this Guide being a non-technical person should know that the additional cost for ensuring adequate hazard-resistance is no more than 10%, and hence, affordable for most households.

Chapter 2 -

Know natural hazards in your area:

Gives information about the three natural hazards that need to be looked into in order to decide the level of hazards the future house may have to withstand.

Before Starting Construction

Chapter 3 -

Basic rules for planning a hazard-resistant house:

Covers the important issue of the selection of site, the shape of the house and its plan, the roof type, the construction technology, and finally the implications of these selections on the hazard-resistance.

Chapter 4 -

Constructing your house with load-bearing masonry walls:

Helps in choosing the main materials of construction for walls and roof, and finalise the building technology selection.

Chapters 5 and 6 -

Building masonry with Cement Mortar in different Seismic & Wind Speed Zones:

Covers rules prescribed in BIS codes for hazard-resistant construction of masonry walls including wall thickness, height and lengths, opening sizes and spacings, disaster resisting features such as RC bands and vertical rods etc.

Chapter 7-

Building masonry with Mud Mortar in different Seismic & Wind Speed Zones:

Covers rules prescribed in BIS codes for hazard-resistant construction of random rubble masonry walls in mud mortar including wall thickness, height and lengths, opening sizes and spacings, disaster resisting features such as RC bands and vertical rods etc.

Chapter 8 -

Understanding and purchase of the basic materials of construction:

Provides important tips about the selection of materials, method of purchasing, cautions to be exercised in purchasing, and material requirements for various items.

Chapter 9 -

Appointing a contractor for construction:

Provides tips for appointing the building agency, be it a big contractor or a building artisan-cum-contractor, what should be expected of him and what the house-owner should do as a part of a two-way relationship.

During Construction

Chapter 10 -

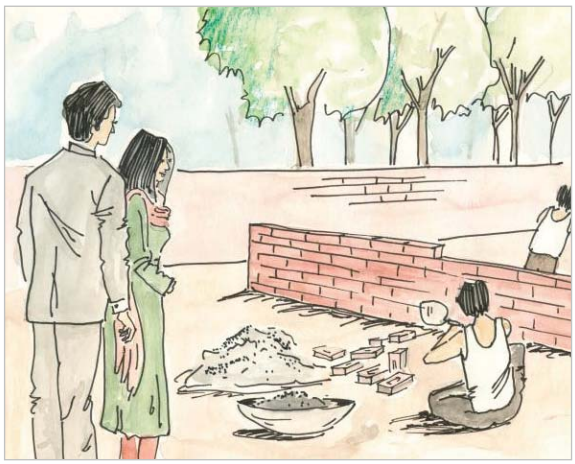
Important rules for masonry construction:

Covers basic but important rules for all important materials such as bricks, concrete blocks, rubble, cement and steel that must be adhered to.

Chapter 11 -

Special care to be taken during construction:

Covers in brief the very important care and cautions that need to be followed in the construction as it progresses from foundation to the roof. This chapter refers to IMPLEMENTATION of all that is described in this guide, and leads the house-owner to do's and don'ts of construction at every stage. It should be referred to frequently, if possible daily, while chekcing progress in construction.



After the Construction is Complete:

Making a house hazard-resistant is not enough. Some further precautions are needed for the safety of the family members.

Chapter 12 -

How do you make the interior of your house safer?:

Provides tips on how to make the house interior safe from loose items lying around the house.

Chapter 13 -

What other preparations you and your family need to make?:

Gives tips on what actions the family members can take at home as well as at work.

Chapter 14 -

What should you do during and after a disaster?:

Gives tips on ensuring safety of the family members during and after a disaster, and the preparation required for this.

Chapter 15 -

Affordable alternatives which are environment-friendly:

In this chapter the house-owner's concern about environmental degradation and global degradation are answered through the building technologies that are less damaging.

Appendices

Provides additional information that can be useful for construction.

Know Natural Hazards in Your Area

2

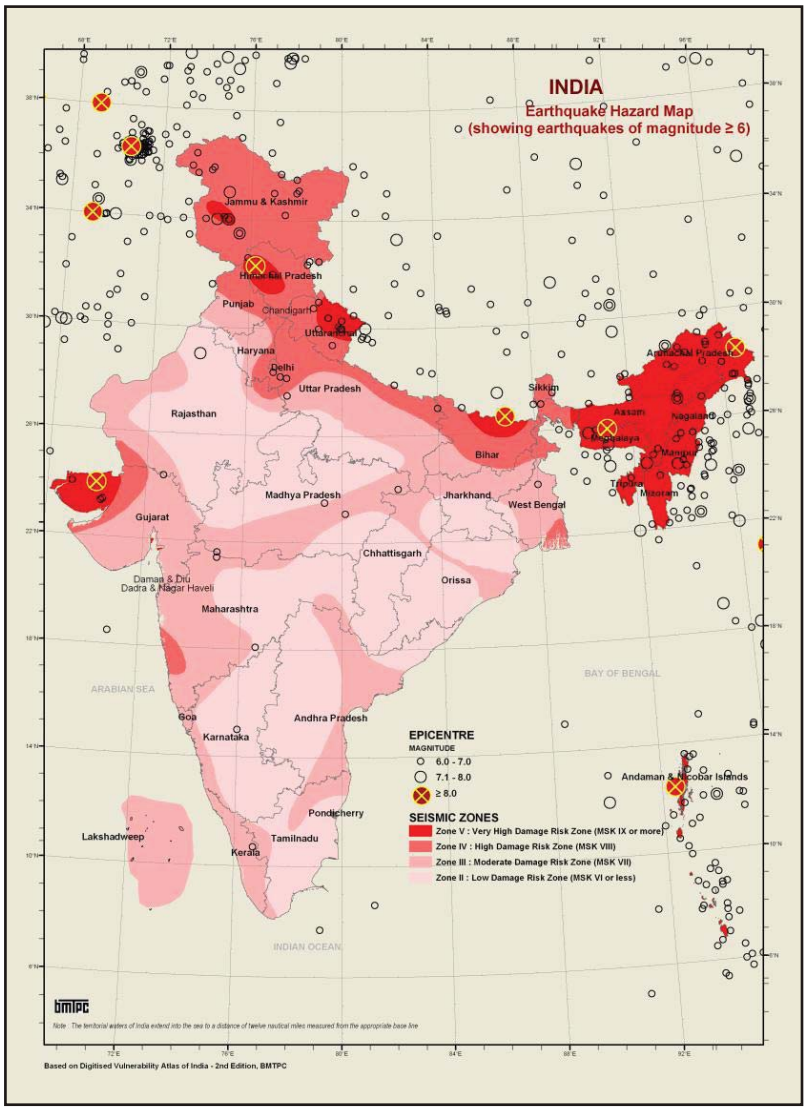
Now get ready to start planning the dream house you want to build. First of all you must know which natural hazards can strike in the area where you want to build your house.

Remember that a house which has fewer weaknesses against the earthquake, cyclone or flood is likely to occur in the area will be safer and will have greater chances of withstanding them when they occur.

So, find out which of these natural hazards can occur in your area, and their intensity.

a. Earthquake Hazard

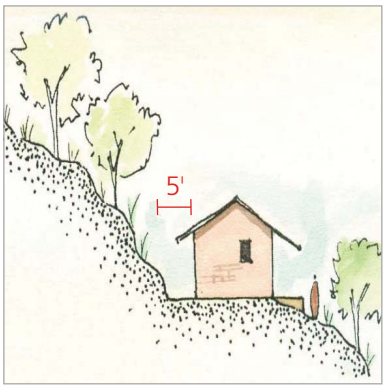
- To assess this hazard, locate approximately on the Seismic Zone Map of India the place where you want to build your house, and determine which Zone it is situated in. This map also shows the magnitude of the past earthquakes in the area.
- The entire country is divided in four Earthquake Zones. Zone II is where the lowest magnitude earthquakes can occur, the likelihood of their occurrence is low. Zone V is where high magnitude earthquakes can occur, and the likelihood of their occurrence is high.
- If the place of construction is in Zone IV or V, you will have to be very cautious. In Zone III, some caution is a must.



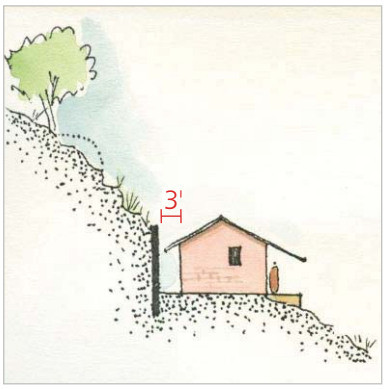
Before Starting Construction

A. Where will you build your house?

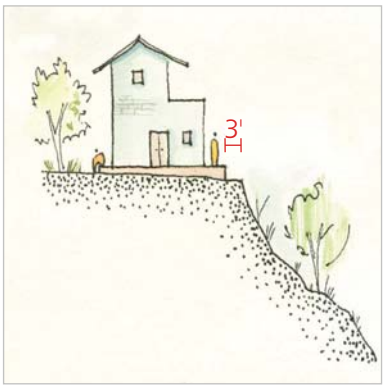
Selecting a site that is safe to construct a house is very important. It is the first step in ensuring your safety.



Maintain min. 5' (1.5m) gap between the house and the bottom foot of a steep hillside slope which may slide down during an earthquake or heavy rain.

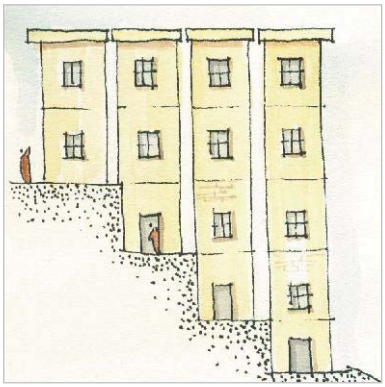


If the slope above is to be cut to make space, then build a retaining wall to prevent the slope from sliding down.

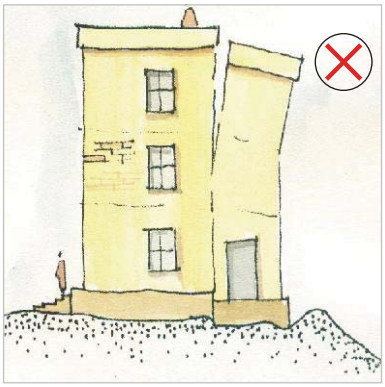


If building on top of a slope, then build at least 3'-0" (1m) away from the edge of the slope.

Avoid a site subjected to the danger of rock fall.

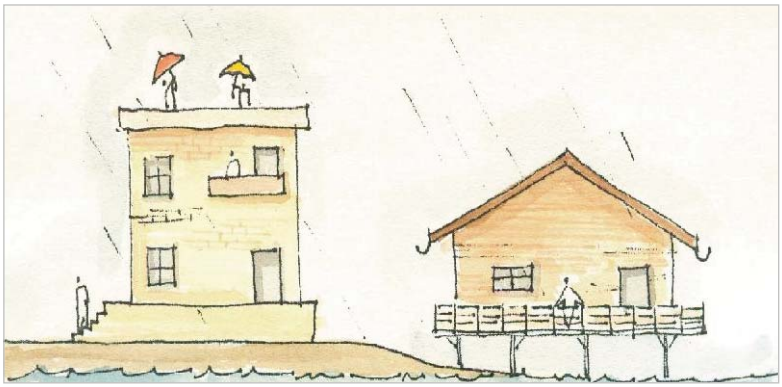


If constructing along a slope, it is best to divide it in several separate blocks, with each at different level.



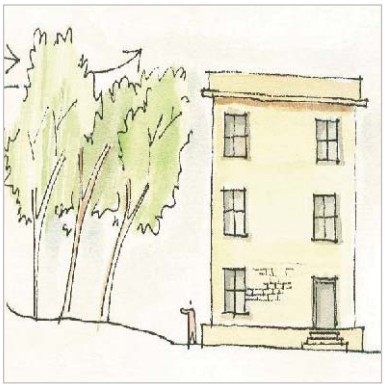
Avoid constructing on very loose sand or soft clays to prevent damage due to settlement.

In flood prone area:



Select a site that is higher than past flood level or raise the site by filling or build high plinth.

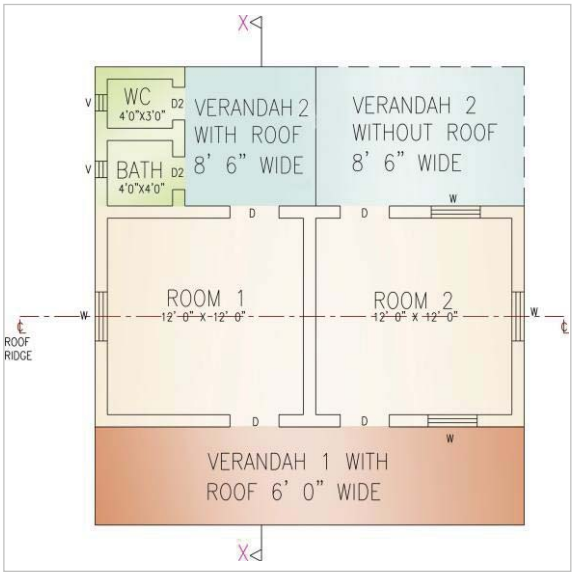
Alternatively, construct on stilts.



To protect from high winds, build on a site sheltered by trees, or else create a barrier by growing trees.

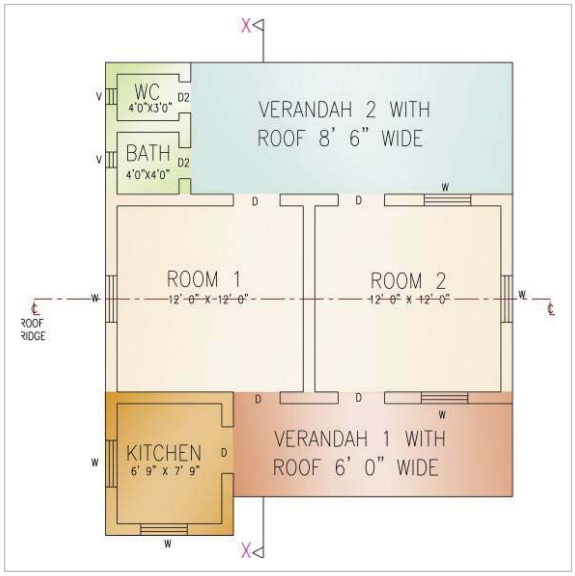
C. What house plan should be selected?

- Several options are given here to help you initiate a process of a house design.
- First decide your requirements and your budget.
- Select any one of the following plans as a starting point for your final design.

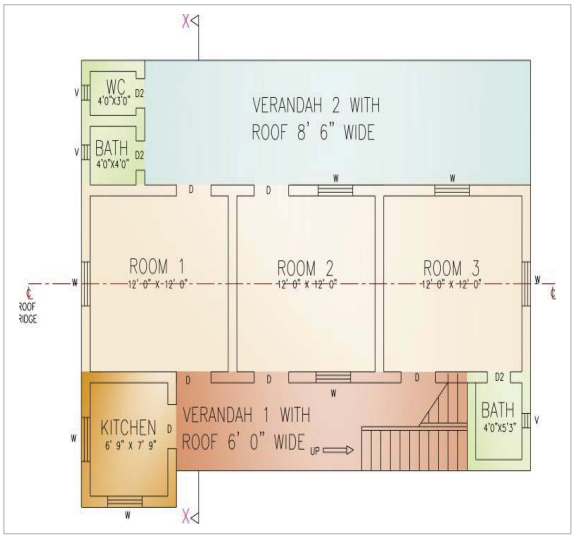


Plan 1.
It can have two rooms with bath and a verandah. Rear verandah can be partly or fully covered.

OR

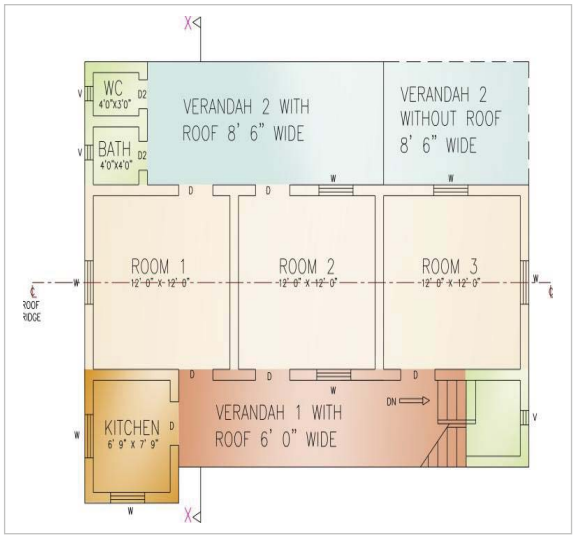


Plan 2.
It can have two rooms plus a kitchen with bath and a verandah. If needed, the rear verandah can be fully covered.



Plan 3.
Ground Storey - One more room with additional bath can be added on the side or in the back. Thus house can have four rooms.

&



Plan 3.
Upper Storey - A storey can be added with the same plan as the bottom storey.

Caution:

In a masonry structure, construction of RC columns in the wall without RC beams placed on them is never done. Such columns (without RC beams) do not give any additional strength but weaken the masonry structure by breaking the joint between the walls at corners.

So remember: It is a dangerous practice and waste of money to build RC columns without RC beams.

A. Selecting the Materials for Wall, Roof and Intermediate Floor

Remember: The strength of your house depends as much on the materials, as on how they are used.

1. **Options for walling materials:**
   Select one or more of the following, which are economically available in the area.

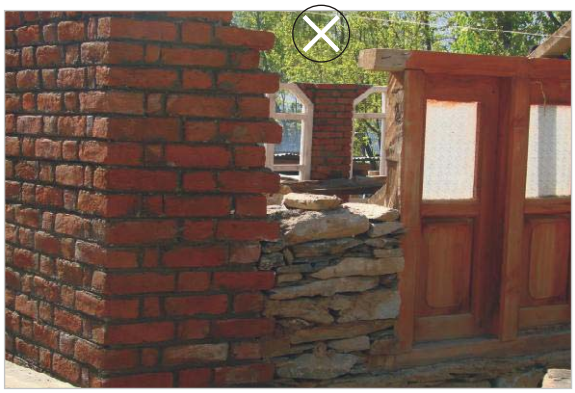
Dressed stone,

Random rubble (RR),

Burnt bricks (BB),

Solid or Hollow concrete blocks (CB)

Starting from foundation, one material may be used all the way up to the top of the building if economical.



Never use different materials side by side at any level

Building masonry with cement mortar : In Seismic Zone III and Wind speed Zone II

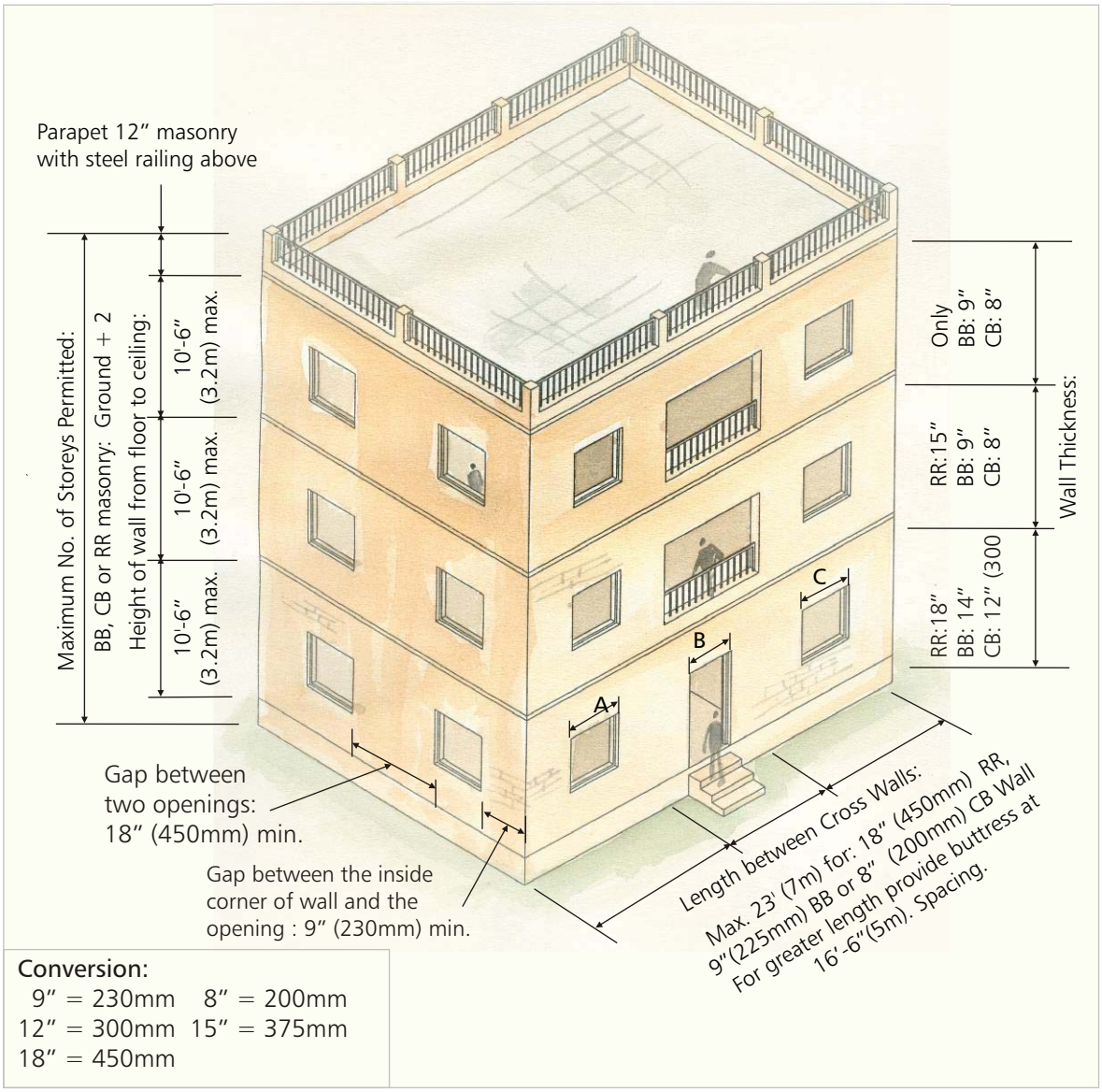
(Wind Speed from 39 to 44 m/s)

For structures built in **Cement mortar or Lime-Cement mortar only.**
Walling materials:
Random rubble (RR),Ashlar or Dressed Stone (DS), Burnt Brick (BB) and Concrete Blocks (CB)
Mortar for walls:
Cement: Sand -1:6 or Cement: Lime: Sand - 1:2:9

A. Rules for Walls, and Openings for Doors & Windows:

The following diagram provides the rules governing the walls and the openings in walls for doors and windows. These rules will assist you in taking the right decisions.

1. In a Structure with Flat Roof:



Conversion:

9" = 230mm	8" = 200mm
12" = 300mm	15" = 375mm
18" = 450mm	

What is the total length of all the openings in one wall (A+B+C) permitted?
This depends on the number of storeys.

- 1-storey structure: 55% max. of total length of that wall
- 2-storey structure: 46% max. of total length of that wall in all storeys
- 3-storey structure: 37% max. of total length of that wall in all storeys

B. Rules for most important Disaster-Resisting Features:

1. Seismic Bands:

- Install seismic band on all walls, including the interior walls, as described below.
- Band must cover full length and full thickness of the wall.
- Band must be uninterrupted.

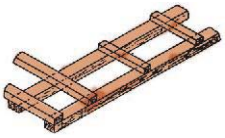
What materials can the band be made of?

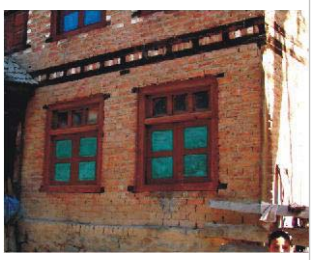
i. Reinforced Concrete

Concrete made with Cement : Sand : Aggregates in 1:2:4 proportion. Thickness = 3" (75mm) min.

Longitudinal Reinforcing bars: 2-8mm HSD.
Links: 8mm HSD with spacing of 12" (300mm)

ii. Timber





Install Timber band following the traditional practice. Ensure strong timber-to-timber connections that do not get pulled open.

Where should the bands be installed?

See the sketches on the next page for details

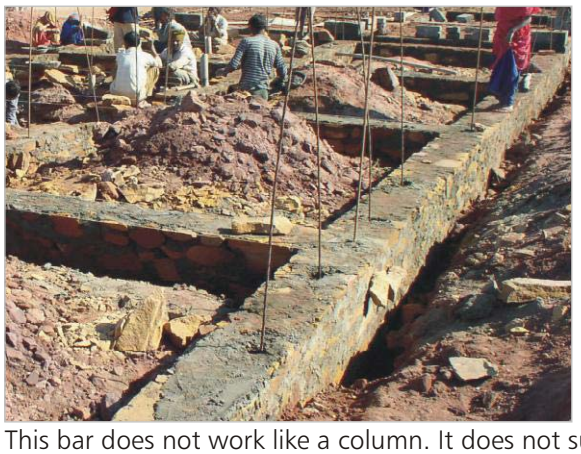
- At Lintel level and Sill level
- Just under the floor, if floor is other than RC
- At Eave level for pitched roof
- On sloping Gable wall top
- At Plinth level - It provides extra safety, especially in flood prone areas, and reduces cracking due to minor settlements in foundation.

2. Vertical Reinforcement:

- Install only one bar inside the wall masonry at each wall-to-wall junction.
- The bar must be started from the bottom of the wall foundation and taken all the way to the top of the walls to anchor down the roof. In between there should be no interruption.
- It must be fully encased within 4" of concrete of 1:1½:3 proportions.
- See the sketch on the next page for details on sizes of the bars.

For single-storey this bar is not required.

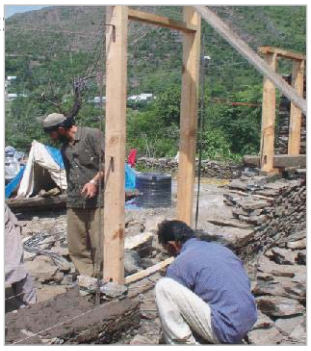
Something you must know about single vertical bar in masonry:



This bar does not work like a column. It does not support the floor or roof above like a column. It makes the walls ductile and, hence, more resistant to earthquake and cyclone forces.

3. **Door and Window Opening Encasement**

- Install only one bar around every opening and ensure that it is encased in concrete of 1:1½:3 proportion.
- The bars on either side of the door opening should start from foundation or plinth level.
- In case of window the bars shall be on either side and on underside of window.

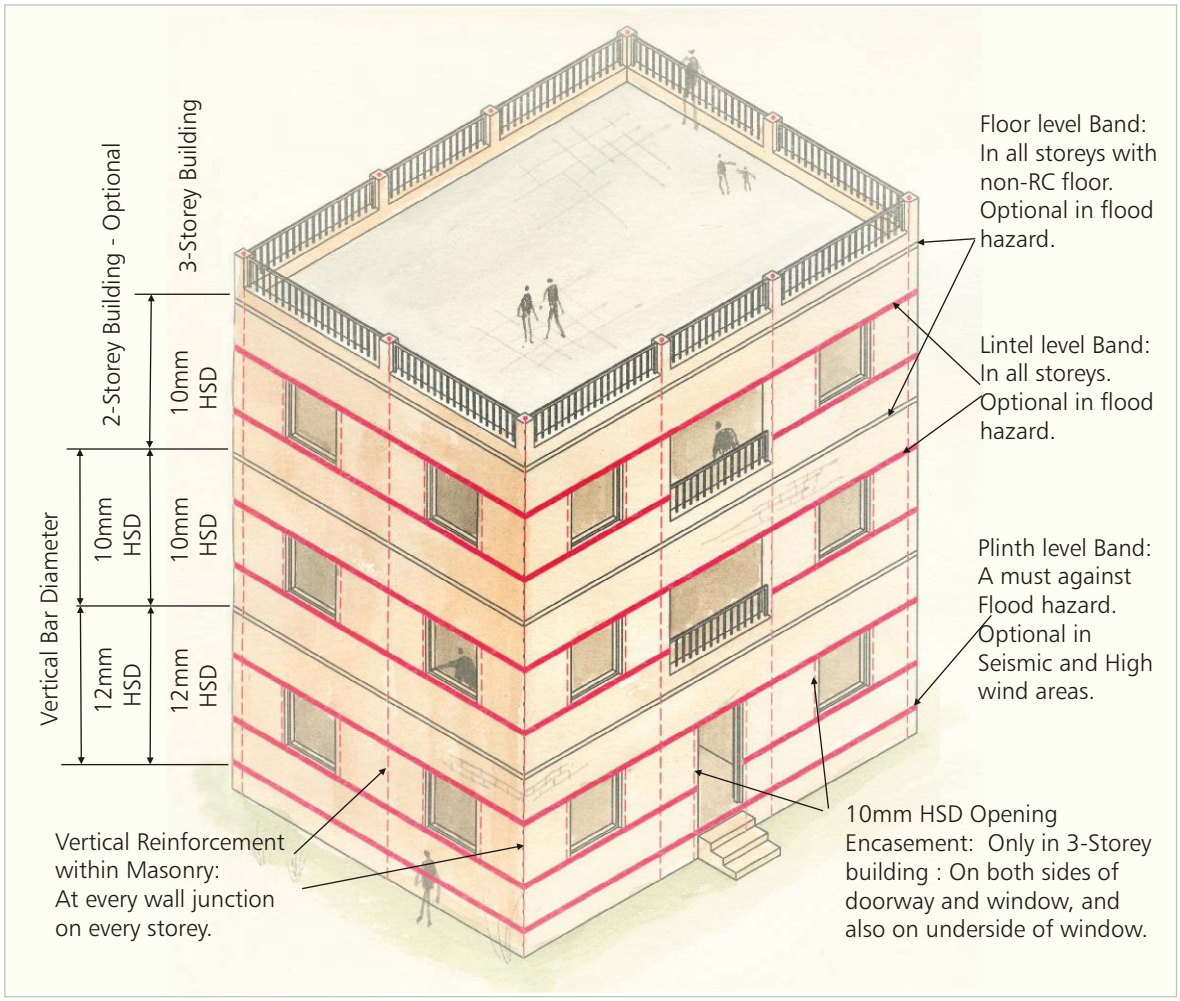



4. **Roof Anchoring and Non-RC floor anchoring:**

- In the eave band and gable band, install various fixtures to anchor all components of roof or floor understructure.
- This could include items like anchor bolts or metal brackets or 'U' clamps or 16 gauge multiple GI wires.


The illustrations here show where these features must be installed.

a. **Disaster-Resisting Features In a Structure with Flat Roof:**



Building masonry with cement mortar : In Seismic Zones IV & V and Wind speed Zones III & IV

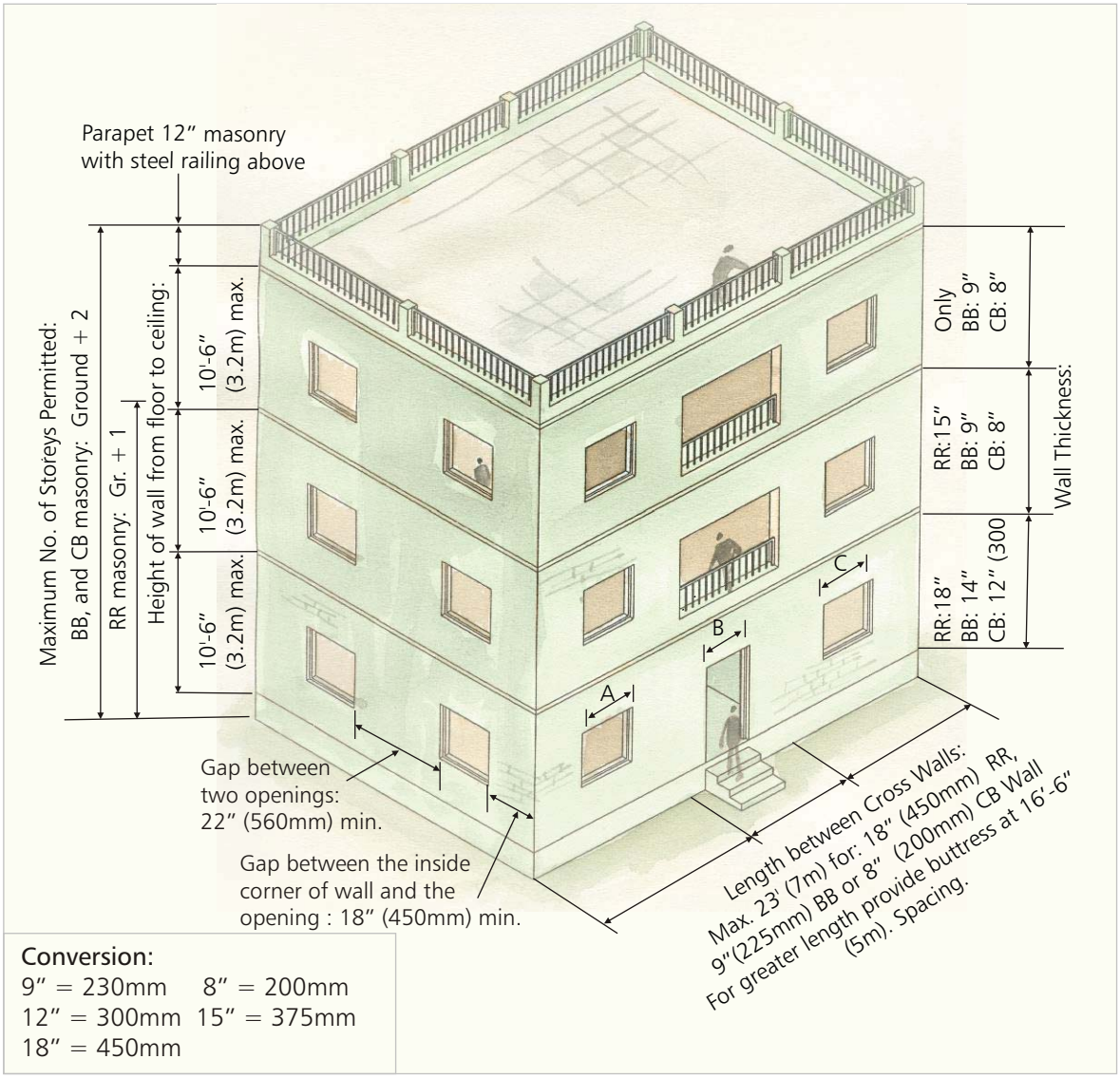
(Wind Speed from 47 to 55 m/s)

For structures built in **Cement mortar or Lime-Cement mortar only.**
Walling materials:
Random rubble (RR),Ashlar or Dressed Stone (DS), Burnt Brick (BB) and Concrete Blocks (CB)
Mortar for walls:
Cement:Sand -1:4 or Cement:Lime:Sand - 1:1:6

A. Rules for Walls, and Openings for Doors & Windows:

The following diagram provides the rules governing the walls and the openings in walls for doors and windows. These rules will assist you in taking the right decisions.

1. In a Structure with Flat Roof:



Conversion:
9" = 230mm 8" = 200mm
12" = 300mm 15" = 375mm
18" = 450mm

What is the total length of all the openings in one wall (A+B+C) permitted?
This depends on the number of storeys.

- 1-storey structure: 50% max. of total length of that wall
- 2-storey structure: 42% max. of total length of that wall in all storeys
- 3-storey structure: 33% max. of total length of that wall in all storeys

Building masonry with mud mortar :
In Seismic Zones III, IV & V and Wind speed Zones II, III & IV

(Wind Speed from 39 to 44 m/s)

For structures built in Mud mortar only.

Walling materials:

Random rubble (RR)

Mortar for walls:

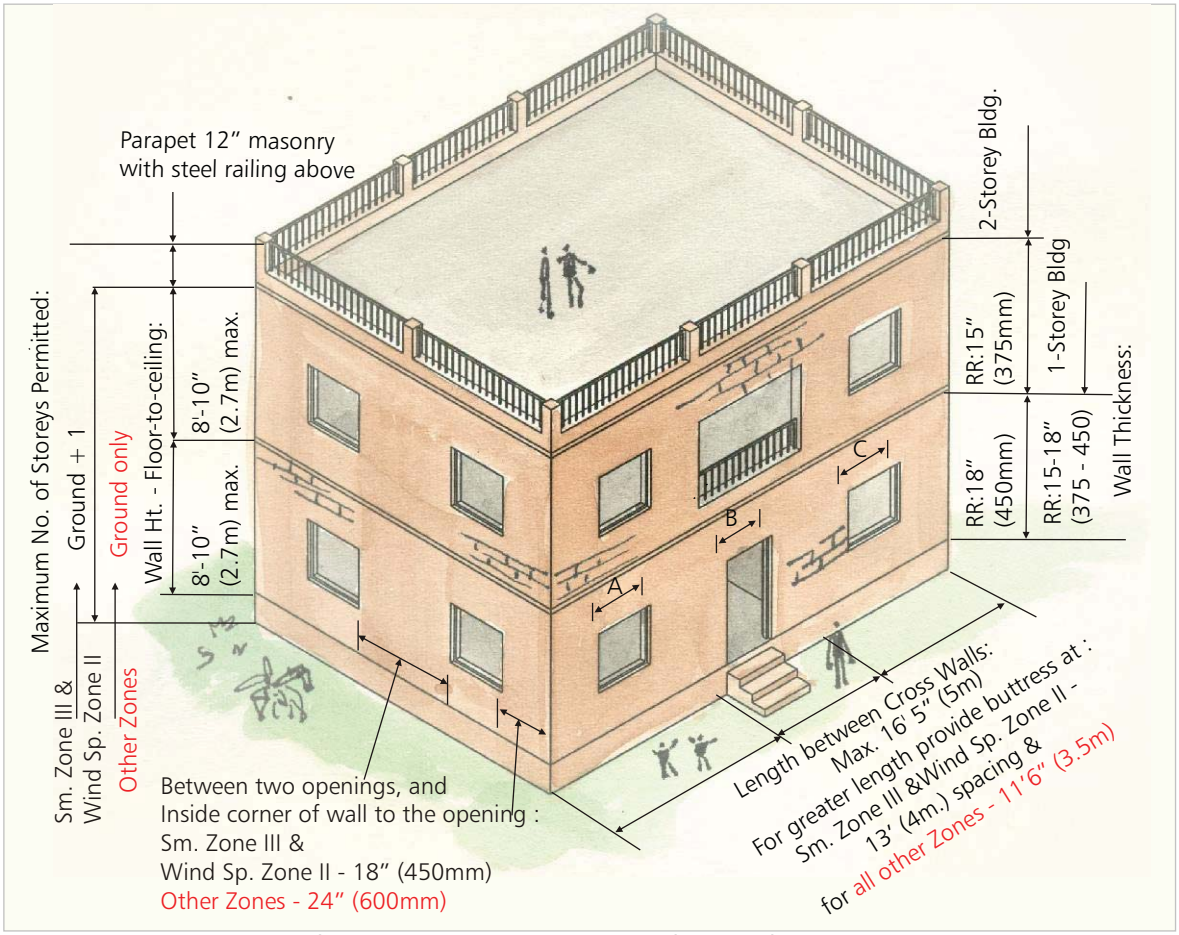
The soil to be used for mortar should contain mainly clayey soil with some sand and silt. It must be soaked in water and thoroughly mixed over a period of two to three days a number of times before using it.

Mud mortar can be used to build house if adequate water for curing of cement mortar is not available or if you as the house-owner cannot afford to use cement mortar.

A. Rules for Walls and Openings for Doors & Windows:

The following diagram provides the rules governing the walls and the openings in walls for doors and windows. These rules will assist you in taking the right decisions.

1. In a Structure with Flat Roof:



What is the total length of all the openings in one wall (A+B+C) permitted?
This depends on the Zone and the number of storeys.

Sm. Zone III and Wind Sp. Zone II:

- 1-storey structure: 46% max. of total length of that wall
- 2-storey structure: 33% max. of total length of that wall in all storeys

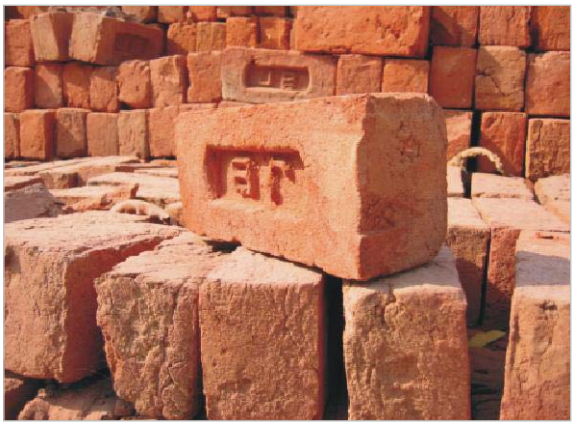
All other Zones:

- 1-storey structure: 33% max. of total length of that wall in all storeys

Understanding and Purchasing Basic Materials of the Construction

The reader must have finalised by now the technology and the materials that are going to be used in the new construction. Now it is important to understand the basic materials of construction that are to be purchased. Quality of what you purchase could have a great influence on the performance of your house in a disaster.

A. Selection criteria and tips for purchasing construction materials.



1. Burnt Bricks

Must be of uniform size, preferably of 9"x4 ½"x 3" (230 X 110 X 75) with a groove on one broad face. Must be uniform reddish brown in colour and give metallic ring when struck.

Must be free from lime particles, which upon wetting expand and crack the bricks.

Must be free from visible cracks, warpage, broken or crumbling edges.

It should not break when dropped on its flat face from a height of 3'3" (1m.) on a hard surface.

Purchase of Bricks:

- Decide the rate for 1000 bricks delivered and unloaded at site.
- Bricks are ordered by the quantity transported to site, generally in a truck or a tractor.
- With the bricks of acceptable quality, the breakage, when delivered, should not be more than 5% .

The labourers must not throw the bricks on the ground. This can cause heavy breakage to the bricks.

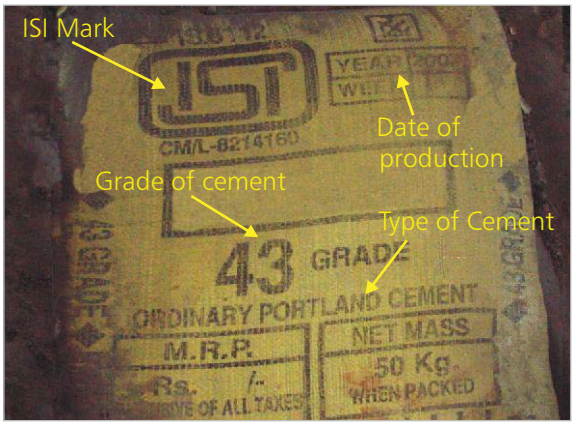
While unloading, the bricks must be neatly stacked at a spot nearest to the construction site.

A. Selection criteria and tips for purchasing construction materials

6. Cement:

For house construction in normal temperature and weather conditions, Portland Cement as well as Pozzolonic Cement can be used. Both are available easily in market.

a. Ordinary Portland Cement (OPC):
Tips for Selection and Use:



- It is available in 43 and 53 grade. For small projects like house construction, use the 43 grade cement. It requires less water for curing than the 53 grade.
- If adequate curing is not done, 53 grade cement can develop fine cracks while setting.
- Always buy fresh cement bags. Good fresh cement will always be in fine powder form.
- It should be purchased in small lots to take care of the immediate needs and must be opened only when the cement is to be used.
- Cement bags stored for more than 6 months should not be used. If stored for more than 3 months, it must be tested before use.
- Store cement bags in a dry, airtight room on a raised wooden platform or on a plastic sheet away from the walls.
- If the cement is found to contain few hard lumps, they should be sieved out. Never crush and use them. If the lumps are found in a large quantity, discard the cement.
- Cement hardens upon coming in contact with water. To achieve the desired strength, concrete must be cured or kept continuously wet for 28 days and cement mortar must be cured for 10 days.
- Once water is added in the cement mix, it must be used within one hour. Any cement-mix left after that period must be discarded.
- Do not add too much water in mortar or concrete. The quantity of water required is one fourth the volume of the dry mortar mix. It must be sufficient to produce a mix that can be worked with .

Appointing a Contractor for Construction

9

Appointing a right contractor and establishing a clear understanding of the arrangement with him is a prerequisite to ensuring good performance of the house in a disaster. It is not just the rates of various items that make up the relationship between the house owner and the contractor. There are other issues that the house-owner should be aware of in dealing with the contractor. These are as follows:

a. What you, as the house-owner, should do?:

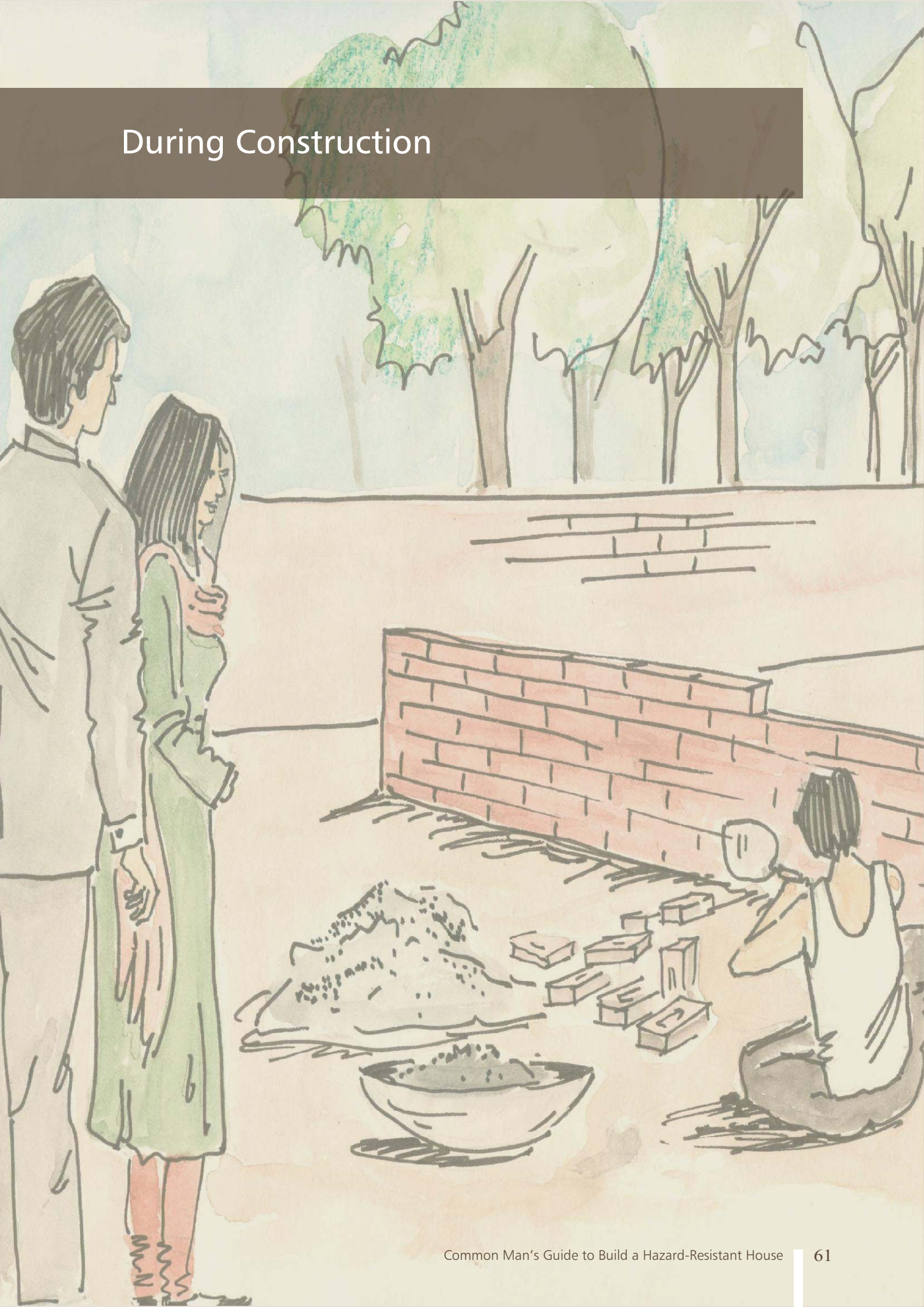
Before selecting a contractor, you must verify his bonafides by meeting another house-owner who has used his services for a similar work or get the list of satisfied customers from him whose houses you may want to see to know his quality of work, attitude, personal dealing with clients , etc.

- You should be looking for a career-contractor and not a new entrepreneur who thinks contracting is a lucrative business.
- You have to see the infrastructure, tools and equipment that he possesses. The selection criteria should be based on those possessing the appropriate equipment such as ladders, pans, spades and pick-axes, water-levels and spirit-levels, straight-edges and right-angles, trowels and plumb-bobs , mixers and vibrators, and not by the outward show of a car, a cell phone and little else.
- If it is a labour contract then, you must learn adequately about the materials to be procured.
- You must ensure that the materials are delivered on time and payments are also made on time.
- You must find out about details of the payment to be made in advance, especially payments which will have to be made at the time of "milestone" activities such as the casting of slab.
- To ensure that the contractor gives good quality work, you must insist on the contractor remove the bad quality work and rebuild it correctly.
- You must be willing to pay appropriately higher rates for work of better quality.
- You must keep a regular check on curing being done by the contractor.

b. Criteria for selecting the contractor

- He must be a local person in order to get good labour rates.
- He should have his own labour force to do major activities, and should not have to sublet them, or depend on casual labour.
- He must have good references from previous clients.
- He must be able to deliver good quality work on time.
- He should have positive attitude towards making modifications, as and when they are required.
- He must have positive attitude towards learning new type of work.

During Construction

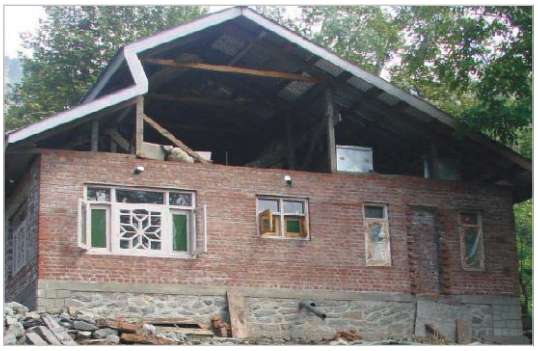


A. General Rules for Masonry Construction

1. Mortars

- Use only one type of mortar in the construction of wall. During construction the masons must use the same mix. And the labourers who are mixing the materials must not make mistakes.
- If constructing in mud mortar, then mud must be of good quality clayey soil. It must be kept wet at least for three days and thoroughly mixed everyday before using it.
- When constructing masonry in cement mortar, the mason must thoroughly wet all masonry pieces like bricks or concrete blocks etc. to ensure the desired strength.

2. General Rules

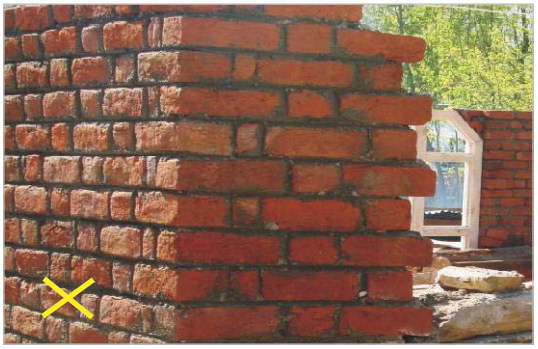


Material can be changed at a particular height, like stone in the plinth, and brick in the walls.

Or with the lower storey in stone, the top storey can be in timber or tin.

Do not use different materials side-by-side or next to each other in a structure.

The joint between the old and the new construction must be done with bars embedded in old wall to ensure disaster safety.



Wall-to-wall connections: Toothings left projecting out at the end of a wall result in weak joint with another wall.

Build all the walls at the same time. Or else, leave the end of a wall in stepped manner to later connect it with another wall.

If the joint between the internal and the external walls is made using toothings, then the internal wall will not hold the external wall well. This will cause more damage to walls in a disaster.

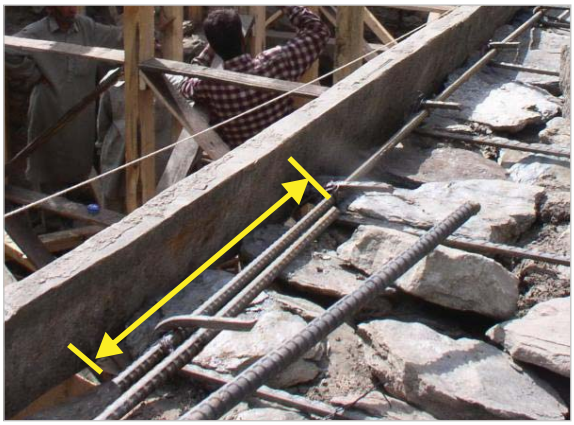
B. Special instructions for cement and steel-based construction (cont.)

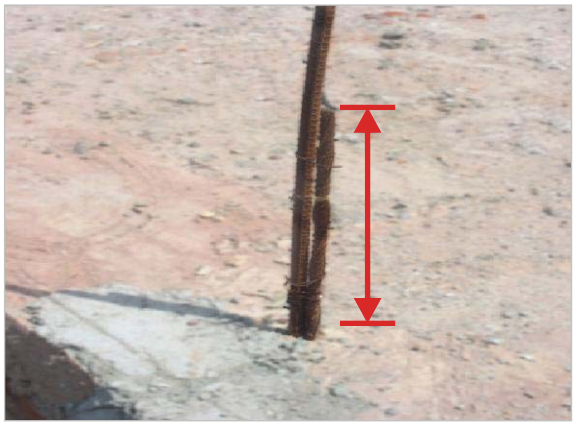
2. Steel-based construction

Safety against hazard demands more strength and ductility. But use of more steel does not necessarily result in a proportionate increase in the strength.

Connection of one bar to other must never be with hooks.

Bar-to-bar connection can be hooked only in cross-links in the RC band.





All bars must have proper overlapping joint of minimum 20" (500mm).

For the concrete to benefit from the strength of the reinforcing bars, the bars must be fully encased in concrete with minimum of ¾"(20mm) concrete all around.

In the RC Band never cut bars at the corner. The main bars must be bent and turned at corners where the new bar can be attached with the proper overlap.

During construction, make sure that the basic principles of good quality construction are followed, the materials are used correctly, and quality is maintained to prevent the weaknesses generally found in the non-engineered masonry construction.

Special Care to be taken During Construction

11

It is important that you as the house-owner make frequent visits to the site when the work is in progress. When you are at the site you should keep an eye on the quality of the work going on. If required you can join in taking some important decisions that may help reduce the cost and ensure good quality. In this chapter, important points at different stages of construction are covered to guide you where your intervention may be necessary.

Foundation Bottom:

For strip foundation, dig down to the required depth. Do not dig deeper if rocky strata is deeper.

Make sure the trench bottom is clean with all loose material and water removed and is compacted.

Install all vertical reinforcing bars right from the foundation bottom.

,Protection against white ants or Anti-Termite Treatment:

In the areas with severe white-ant problem it is better to treat the foundation with the help of a local expert dealing in Anti-Termite Treatment. This must be done before the foundation masonry begins unless advised by the contractor otherwise.

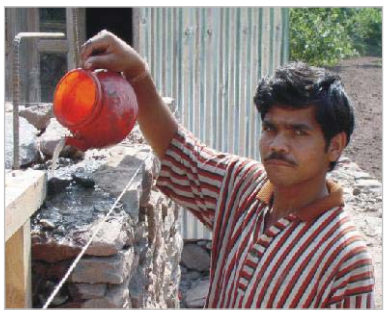
Foundation and Plinth Masonry:

In foundation trench, stones should not be dumped. Proper masonry must be done from the foundation bottom.

Leave holes in masonry during construction for pipe lines for water supply, sanitation etc. so that no breaking is required after it is built.

Make sure that the foundation and plinth for all the walls including the inner walls are constructed at the same time.

Make sure all vertical reinforcing bars are fully embedded in concrete.



Cure the masonry in cement mortar by keeping it wet for 10 days.

Manglore Pattern Clay Tiles

All tiles must be anchored to rafters with GI wire hooks.

Slate tiles to be anchored to roof planks with two minimum two nails.

All ridge tiles must be installed using cement mortar, especially in high wind speed areas.

Install steel rod or GI wires on the bottom-most row of clay tiles.

Keep gable top load wall no higher than 9"((230 mm), and reinforce it with a rebar.

Construct narrow load walls over clay tile roofing at 4' (1.2m) spacing in high wind-speed areas .

After the Construction is Complete

12 How do You Make the Interior of your house Safer?

Constructing a hazard-resistant house is not enough to ensure the safety of the residents. It is important to ensure that the furniture and other household materials in the house do not cause injury to anyone when they fall off or slide from their place during an earthquake or a cyclone. There are a number of precautions that you need to take.

Furniture:

The tall heavy furniture that can topple over must be anchored to the wall adequately.

Overhead Heavy Objects:

Heavy and large articles on the overhead shelves that can fall off and cause injury must be either removed and put lower down, or be strapped to their respective bases.

Breakable Items:

Items such as ceramics or glassware that could fall out of the cupboard or shelf must be kept close to the floor or prevented from falling out by placing some type of barricade made of tight wire stretched across or even a wooden batten.

Storage Clay Pots:

Do not pile things one over other making an unstable pile, such as placing clay pots filled with grains one above the other, which may easily topple down with little shaking .

Grain Sacks:

Even stable and heavy items like grain sacks should not be stacked higher than three feet.

Grain Bins:

Grain bins that are likely to topple over must be anchored to walls with a metal strap.

Items with rollers/wheels:

Heavy items like refrigerators, if placed on rollers/wheels, must be anchored to ground to prevent their rolling in the event of an earthquake since they can hit and hurt a person, or get damaged itself.

Flammable Items:

Store containers of flammable material like kerosene in a place from where they cannot fall and break open.

Cooking gas supply:

Turn off the gas regulator every night.

Cabinets:

Put latches on all the cabinet doors to keep them closed during shaking so that the contents do not fall out.

Items/materials that hang:

Secure all hanging things like fan, vegetable baskets, milk pots, flowerpots, picture frames, other equipment which may swing and fall, and cause injury.

Equipment:

All equipment and farming tools must be properly stored all the time so that they do not fall and cause injury, or come in the way and create obstruction in case of emergency evacuation.

15 Affordable alternatives which are environment-friendly

Today, degrading quality of housing is a major hurdle faced by many countries. This is on account of rapidly increasing cost of construction and, at times, also the high cost of land. This is mainly due to steadily increasing costs of construction materials and transportation. For many, to have their own house has remained a distant dream. For those who think of building a house also think of where they can save the cost, and still get a safer, house with low maintenance. There are inherent dangers in considering cost alone while constructing a house. Equally important factors to be kept in mind are technology to be used, including its design and artisan skills available, as also the safety of the occupants. One of the reasons for higher cost is also because people select technology options that are inappropriate for the context on hand, and hence, expensive. If affordable options become known to people, then more people will be able to convert their dream in to reality. Such options are called the Appropriate Options or Appropriate Technologies.

What makes a Technology Appropriate?

In order to decide if a particular technological option is appropriate for the given situation, it is necessary to set criteria which depend on the context, such as Rural-Urban, Rich-Poor, Tropical-Arid-Semiarid, Remote-Easily Accessible, Water-Scarce, Water-Abundant, Forest cover, Soil conditions, Shallow Bedrock etc. This context must not be lost sight of while thinking of constructing a house. While considering resources thereafter, one fundamental factor could be the scarcity of all resources except the human resource. For a system to be efficient and affordable in such a situation, one must make efficient utilisation of available materials and must make maximum possible use of manpower. The other factor to be considered is the high transportation cost. This can be reduced only if the use of local materials is maximized. This is Appropriate Technology.

What makes a Technology Environment Friendly?

Any industrial process creates pollution and that adds to the Global Warming. Transportation of materials over long distance by motorised means creates pollution. Trees help reduce global warming and therefore the use of timber, meaning cutting down trees adds to global warming. Greater use of industrial materials-cement, steel etc. which are themselves pollution creators- further add to global warming. To reduce this one must make maximum use of locally available materials avoiding transportation, efficient use of timber, and technology options that use maximum possible use of manpower. Please remember: the building technologies that are appropriate are also "Greener".

Cost reduction

There are a wide variety of technologies to suit different situations. These can help reduce the cost through a number of different ways without compromising on safety or basic comforts. These are as follows.

- Reduction in the use of the expensive industrial materials such as cement, steel etc.
- Reduction in the transportation cost through increased use of local materials.
- Judicious use of scarce and expensive material like timber.
- Increasing the life of social forestry timber through insect repellent treatment.
- Use of labour -intensive techniques.

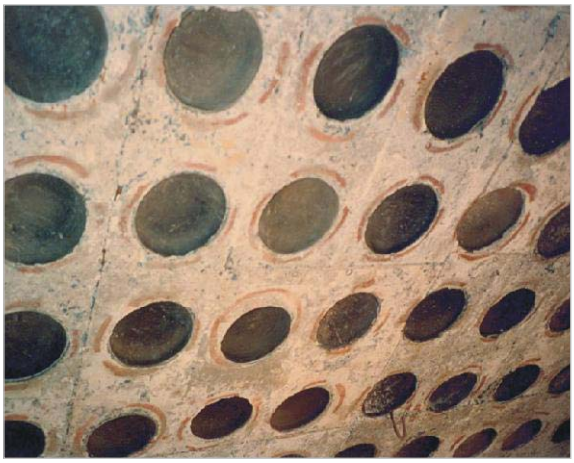
In other words the appropriate technologies are more efficient and, hence, cost-effective compared to their conventional counterparts and in most such cases, they are also environment- friendly.

A few examples of appropriate options and their advantages are as follows:

Roofing: Non Pitched Type

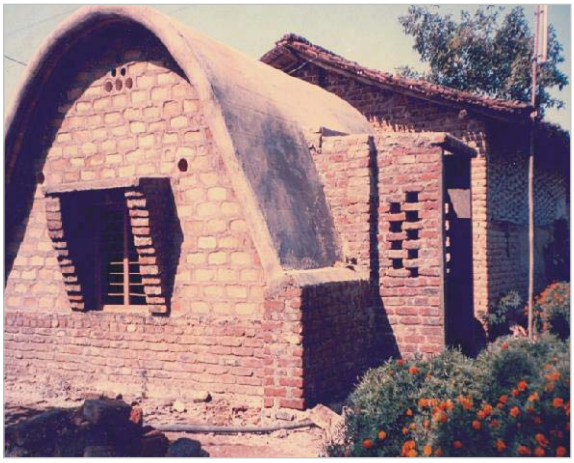
Pre-cast bk. panels supported on pre-cast RC joists

Burnt brick Jack Arch supported on RC joists.



Filler slab using low cost terracotta filler, like shallow bowls or Manglore pattern roofing tiles to replace expensive concrete.

Flat stone or pre-cast doubly curved concrete panels supported on pre-cast RC joists.



Burnt brick vault or dome.

Burnt clay tubes (BCT) vault.

The roof or floor supported on joists is simpler to build and, hence, easy to replicate and economical. These options need very little shuttering. Since all of the casting of panels is done at ground level, quality control is easier and so is curing. All these options use less of cement and steel. All of them have a higher labour cost component as against a RC slab. As a result they provide more employment.

Walling:

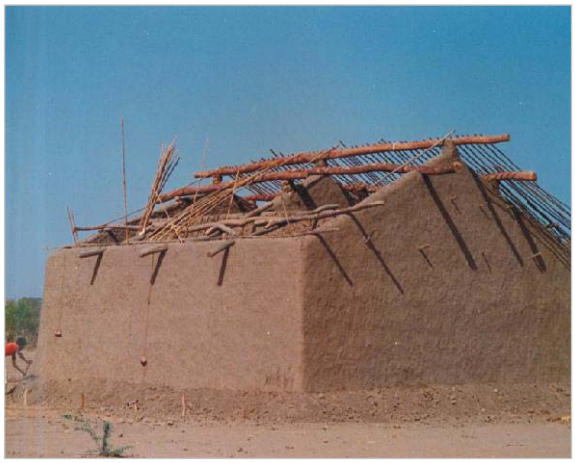
Random rubble masonry in mud mortar

Fly-ash cement blocks for masonry in cement mortar

Rat-Trap bond 9" cavity wall.

Compressed stabilised soil blocks in Soil-Cement mortar or Compressed Soil Blocks in ordinary mud mortar.

Adobe or Hand-moulded Sun-dried Mud Blocks in mud mortar



Hand moulded cast in situ mud wall or Cob wall

Note:

In a majority of cases, cement mortar is not necessary in the masonry walls, load bearing or non-load bearing.

Building Materials & Technology Promotion Council (BMTPC)

BMTPC is an inter-ministerial organization under the Ministry of Housing & Urban Poverty Alleviation striving to bridge the gap between laboratory research and field level application. The Council provides technical support for strengthening the building materials sector through development and promotion of cost-effective, environment-friendly, energy-efficient building materials and disaster resistant construction technologies.

BMTPC has been playing a proactive role in the area of disaster mitigation and management. The note worthy contribution made by BMTPC are publication of Vulnerability Atlas of India and Landslide Hazard Zonation Atlas of India. BMTPC has always been in forefront in educating and creating mass awareness amongst common man and publishes Guidelines, brochures, pamphlets etc. for Improving Earthquake and Cyclone/Wind Resistant Housing. These documents have served as important tool for safety against natural hazards for all stake holders involved in disaster management.The Council is also involved in construction of cost effective disaster resistant model houses and retrofitting of existing buildings besides helping State/UT Govts. in modifications of their Building Byelaws.

In order to sensitize stakeholders regarding retrofitting, BMTPC has been carrying out retrofitting of various life-line structures such as schools, hospitals etc. The widely circulated Earthquake Tips, a joint venture of IIT Kanpur and BMTPC is another milestone towards educating common people of India regarding earthquake aspects in simple easy to comprehend language. The same is being published in vernacular languages.

National Centre for Peoples'-Action in Disaster Preparedness (NCPDP)

NCPDP was established in October, 2000 with a focus on disaster preparedness at the time of Bhavnagar Earthquake in Gujarat state. This was the brain-child of its two honorary directors because of seven years of post earthquake intervention in the regions of Latur (Maharashtra), Jabalpur (Madhya Pradesh) and Chomoli (Uttarakhand) in India. Later, NCPDP played a major role in rehabilitation as well as capacity building for long-term preparedness in Gujarat in the aftermath of Kutchch Earthquake, and also worked on capacity building and technology demonstration in the quake affected Kashmir.

NCPDP is one of a few technology-based organizations in the country with first-hand experience of working at the grass-roots. NCPDP works on a fundamental belief that building capacity of people from within is the only way to mitigate disasters for a safer world, and therefore, intervention by external agencies in the aftermath of a disaster is most needed to work in this direction. Skill upgradation of building artisans should form the backbone of this approach.

NCPDP strives to bring viable, eco-friendly and sustainable technologies to help people reduce their vulnerability against future disasters. It strives to remain prepared for timely intervention wherever a disaster strikes. It is continuing to work on disaster mitigation through (a) training of engineers and building artisans, (b) awareness and confidence-building programs in communities, (c) preparing ready-to-use technical information kits for people, (d) research on structural behavior of masonry structures, and (e) building-vulnerability studies in different parts of India, (f) vulnerability reduction through retrofitting (g) policy interventions.

Building Materials and Technology Promotion Council
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Government of India.

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