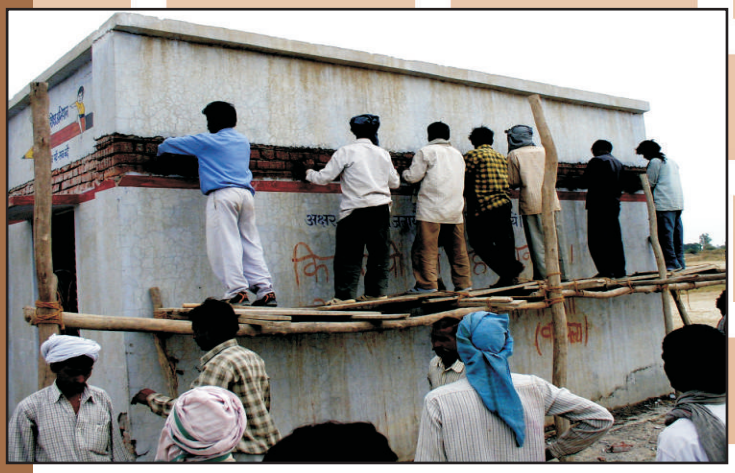
Trainer's Guide for Training in Hazard - Resistant Construction

To ensure effective training of artisans for vulnerability reduction



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Government of India

INDIA

Ministry of Home Affairs
Government of India
New Delhi

United Nations development programme
55 Lodi Estate, P.O.Box 3059
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PREFACE

It is an accepted fact that there is a dearth of appropriately skilled building artisans in our country and a great need to up-grade their skills. The poor quality of construction not only results in reduced life of the buildings, but in the event of earthquakes, cyclones or floods it also leads to significantly greater damage to life and property.

A number of agencies and individuals have been conducting training programs for the artisans. But it has been observed that these training programs vary greatly in regards to their quality, content and duration. In the final analysis, these three factors alone will decide how well the artisan is trained.

The fact remains that there are several hurdles faced by these organizers in properly training the artisans. The most important among them are the lack of resources needed for thorough training, willingness on the part of the artisans to participate fully, non-availability or ignorance of the use of the right training tools and methods, and non-inclusion of the critical topics in the training curriculum.

The experience of various agencies involved in training programs indicates that it is difficult to get the masons to leave their work and spare enough time to attend a training program since most of them lead a hard life of hand-to-mouth survival. More often than not, the trainee-masons demand to be compensated for the time they put in for training. This places greater strain on the resources of the program. It is important, therefore, that the training is so planned that in a short duration of three to five days, maximum number of topics get covered in training so as to achieve the desired up-gradation of skills.

Keeping all these hurdles in mind, this Trainer's Guide has been prepared to assist those who will undertake the training of building artisans. It provides a ready, standardized curriculum of three- and five-day duration that will cater to most conceivable situations in the country. These curricula are fully based on the technical information provided in the **"Manual for Hazard-Resistant Construction in India"** (**MHRC**) published by the UNDP, India, which is a comprehensive source of information based on the relevant Bureau of Indian Standard Codes on non-engineered construction and retrofitting of masonry buildings.

To ensure that the artisans get hands-on training even in absence of an actual construction site, the alternative of "mock-ups" has been suggested. These are found to be very convenient and economical. The Guide provides necessary details of such "mock-ups" and links them to training at different stages. Another important factor to ensure effectiveness of the training is the use of right type of training tools. This guide provides details on how such tools can be made. Inclusion of these tools in the training program also helps in strengthening the confidence of the trainer in the effectiveness of the disaster-resisting features that form the mainstay of the curriculum. Organizing of the training program demands a great deal of preparations prior to starting the program. The Guide also focuses on the type of preparations required at the community level.

The past experiences clearly indicate a fact, that the trainers must have strong convictions about what they teach in order to be able to train effectively. This is especially true in case of the load-bearing masonry and the retrofitting of the existing masonry buildings. With this objective in mind, the Guide provides some additional reading material in appendices at the end which must be read before giving training.

It is our sincere and earnest hope that this Guide will help in making the building artisan training program more effective in the country, bringing uniformity and a quality standard in it, and thus help reduce the impact of future disasters like earthquakes, cyclones and floods on the people.

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NCPDP, Ahmedabad,
August, 2008

ACKNOWLEDGEMENT

First and foremost we, the authors acknowledge the initiative taken by the UNDP team under the guidance of Shri Sushil Kumar without which this collaboration would never have become a reality. Throughout the production phase the support and cooperation from every one at UNDP was a constant sources of encouragement for us. As always the technical guidance and constructive comments from Prof. A.S. Arya have been crucial in ensuring completeness in the manual and in bringing credibility and value to this manual.

Relevant Building Codes & Guidelines of Bureau of Indian Standards as well as the Government Technical Guidelines for disaster resistant building construction prepared in the aftermath of various disasters form the basis for this manual. On the other hand two decades of our work in the field of building technologies through field demonstrations and onsite training of masons and engineers, coupled with community awareness programs form the backbone of this manual. In addition it is backed by a large number of manuals and public awareness materials that we have produced in five different languages of India for as many regions.

In much of our disaster mitigation related field work we have had good fortune of associating with a few pioneers in this field including Retd. Prof.A.S.Arya of IIT Roorkee and Retd. Prof. K.S. Jagadish of IISC Bangalore. Their input always brought in sound engineering to our work dictated by the practical considerations of field.

Through out these years of working with the building artisans, the artisans themselves have been the principal source of learning, especially from the immense pool of vernacular knowledge . It has been only these artisans that have kept our hopes of vulnerability reduction through bringing improvements in the non-engineered building scenario alive. The culmination of these feelings was experienced in our work with 28 master masons in the Uri Region of Kashmir in the summer of year 2006.

Among those that we have been closely working with we must acknowledge the valuable support that we got from Ajay Madhwani, Harshad Talpada and Ajay Kankrecha of the NCPDP team in putting together this document, Shri B.J. Karani in doing meticulous proof reading as well as review as a non-technical person.

All our work with building technology has been accompanied by extensive photographic documentation with a sole objective of sharing the experience with the others. A variety of training tools also have been developed for more effective training. All the photographs and the training tools used in this manual have been selected out of our own collection.

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1 Introduction

Present Scenario

Natural phenomena like earthquake, cyclone and floods occur frequently in a big country like India, in one region or another. Unlike in the developed countries like Japan or USA, these occurrences turn into disasters that take thousands of lives and destroy hundreds of thousands of buildings. This brings much hardship to the people. The principal reason for all this is that 80% of houses and many infrastructure buildings are simply not built to withstand the forces of nature's fury. As a result, in the **earthquakes** the walls get cracked or even collapse, the roof made of timber with tile or slate roofing simply disintegrate, RC slab gets detached from the walls it is resting on and slides. And in **cyclone,** the tin roofs get lifted up and sometimes get completely blown off.

Why?

The studies of the damage of the past disasters have shown that a lot of this is on account of ignorance on the part of the building artisans. This results in violation of the basic rules of good construction and also non-observance of the special disaster resisting features that must be included in the construction in disaster prone areas.

What needs to be done?

One sure way of reducing the damage in future disasters is to increase the know-how that the building artisans, including masons and carpenters, have about all these aspects. The best way to do this is through a **training program** for them that would include **lectures** and **hands-on training**. Such a training program could be conducted by a trained civil engineer having experience in disaster resistant construction and having understanding of popular building systems and commonly used building materials.

Objective of Trainer's Guide

This guide is prepared with the objective of guiding the person who is going to conduct the training program of the building artisans in Disaster Resisting Building Technologies. The Guide will not only provide the training schedule and training details but also provide guidance on how to conduct this training.

Approach

The structure of the training program is based on a logical sequence of information transfer to building artisans that has been found to be effective by the authors in the past one and half decades. It begins with focusing on creating a felt need in the masons through making them aware of the possibility of disasters in their area and the possible outcomes, namely damage and destruction. Next it goes over the possible reasons of this outcome followed by the basic principles which are routinely not followed and, which if adopted could cut down the possible damage. This is followed by special features that the artisans need to learn about making the construction disaster resistant. Beyond this, the focus shifts to the aspect of material consumption in various features that the artisan should be familiar with followed by the reiteration of the critical rules that the artisan must remember to follow.

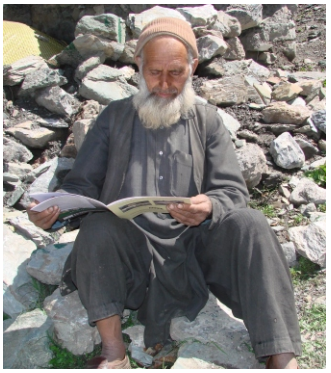
Scope

The Training Guide covers the popular building technologies that the people are likely to continue using in the disaster prone areas. This includes masonry walls made of stone, concrete blocks or bricks, commonly used pitched roof with tiles, AC/CGI sheeting or slate, and RC slab roof. It covers the new construction as well as the restoration of damaged buildings and retrofitting of the existing buildings as the **principal means of vulnerability reduction**. The training program proposed by this guide book covers all these three aspects of vulnerability reduction since the authors believe that with just one of them the artisans would not be adequately prepared to work towards vulnerability reduction. The information provided here is applicable for Seismic Zones III, IV and V, Wind Speed Zones IV and V, and for the areas frequently affected by floods. But the training procedure can be adopted for other areas as well.

The Guide gives a detailed (a) five day training program that covers new construction, restoration and retrofitting, (b) three day training program that covers only new construction, and (c) three day training program that covers only restoration and retrofitting, each with activities to be carried out in various sessions, how to conduct training, what to say and what to ask, how to handle the trainees, the points that need a special emphasis etc. It also covers the advance preparation that needs to be carried out in the field, planning of each session including the management of the trainee manpower, equipment required, where to conduct training including that on the mock up for most of new construction and that on the existing houses for some of the new construction features and for the restoration & retrofitting. Finally it also instructs the trainer on how to assess the performance of the trainees.

Outcome

It is important that the trainer fully familiarizes with the content of the Trainer's Guide, and understands how to use the information given in it to conduct an effective training program. the Guide essentially serves as a tool. The outcome of training depends as much on the tool and as much on the person using it. The convictions of the trainer about the need for the training and in the technologies covered in the Guide, however, is really a prerequisite for the success of the program. It is important that the trainer is in position to appreciate the appropriateness of the masonry building systems for constructing buildings up to two to three storeys high, and the option of retrofitting as economically the most viable option on hand to bring safety against future disasters for a majority of the people living in the disaster prone areas.



How to use this Guide?

2

Understanding and digesting the contents :

It is important that the person who is going to use this Guide as a tool to conduct training, not only understands the contents of it, but digests some of it well enough to turn it in to a conviction about what he is going to teach. This could be done in the following sequence.

Familiarize with the structure of each chapter of the "Trainers' Guide" with a general idea of its content.
Read the contents of the Appendix 'A' containing "Extra Reading" and digest it well.
Study the appropriate Program Schedule
Study the detailed program of each day given in the Guide. Note different colored script.

Use of colors

Different colors are used since a specific color is used for a specific purpose as described below.

- **The notes in blue are instructions about:**
  - What is to be done
  - How to communicate more effectively
  - How to prompt the trainees to participate in discussion
  - Planning for the session
  - Managing of the "trainee manpower"

- **The notes in black are what the trainer is supposed to say.**

- **The notes in brown are about what is to be done on the mock-ups as a part of the hands-on training.**

  - Understand the need for advance planning and the details of what planning is required prior to conducting the training for community level preparation, as given in **Chapter 03** titled "Advance Preparation", including:

- **The notes in red are the points with extraordinary importance that should be conveyed to the trainees**

Community level preparation

Identification and **selection of the existing buildings** for training
Identification, sensitization and **registration of building artisans** as potential trainees
Understand what type of Mock-up needs to be made and how it will be used for training given in **Chapter 04 titled "Mock-up Preparation for Training".**

- **Familiarize fully with the "Mason Manual".** It is referred to as **"MM"** throughout this manual. A specific section of "Mason Manual" is referred to by adding a suffix to **"MM-"**.
- **Relate the details with the locally popular building system** from the view point of conducting the training.
- **Study the material requirements** for various items. Using this information and the local cost of various materials work out the cost of materials for every item.

Training Program Schedules

5 Day Program for New Construction, Restoration & Retrofitting

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
1	1	1	1) **Introduction to disasters of the past and their impact (Statistics);** 2) **Disaster prone areas & expected damage levels** (MM- 01); 3) **Popular building systems** (MM- 2):		
	2	3	1) **How the forces are caused in disasters;** 2) **Damage types** (MM- 3) **How buildings get damaged in disaster;** 3) **Vulnerabilities in a building** (MM- 4); 4) **Disaster Resistant Load Bearing Construction - Basic Rules of Design & Planning** (MM- 5)		
	Lunch				
	3		.	3	**Good Quality Construction** (MM- 6, 7) – 1) Mixing of mortars; 2) Use of cement, 3) Installation and encasement of vertical steel in masonry construction, 4) Cutting and bending of bars for band, 5) Stone masonry foundation, 6) Brick masonry wall, 7) Window encasement, 8) RC Lintle installation.
	4			0.5	Recapitulation of day's learning & grading assessment while the masonry construction continues
2	5	1	**How a building behaves & Disaster resistant features** (MM- 7); 1) Special rules for masonry walls, 2) Disaster Resistant Features		
	6			3	**Disaster Resistant features** (MM- 7) - 1) Installation of Plinth level band rebars, 2) Connection of vertical rebars and band rebars, 3) Eave level band, 4) Connection of Eave band and Gable band rebars ,5) Connection with lintle rebars and Eave band rebars
	Lunch				
	7			2.5	**Disaster Resisting Features** (MM- 7) - 1)Casting of Plinth Band concrete, 2) Gable Wall construction, 3) Placing Gable Band reinforcement
	8	1	Recap of two day's work; Cover any points missed from (MM- 7 & 8); **Commonly Committed Mistakes in Construction**		

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
3	9			2.5	**Disaster Resistant Features** (MM-7) - 1) Roof to wall connection; 2) Roofing to under-structue connection; 3) Diaphragms; 4) Special features for flood and cyclone (MM- 7 & 8). Note: Only 1 & 2 can be done on mock-up. Rest will be done on existing building.
	10	1	**Material Quantities for Disaster Resisting Features** (MM- 9)		
	11	0.5	**Do's & Don't's of new construction** (MM- 10)		
	Lunch				
	12	1	**Restoration** (MM-11) - 1) What and why?; 2) Damage categorization; 3) Damage Restoration Procedures		
	13			2.5	**Restoration** (MM-11) - 1) Different Categories of Damage
4	14	1	**Retrofitting** (MM-12) - 1) What is Retrofitting & Advantages; 2) Introduction of a few retrofitting measures		
	15			3	**Retrofitting Installation of Retrofitting Features** - 1) Cast in-situ Bond Elements, 2) Seismic Belt with Tie Rod, 3) Vertical Reinforcement including connection with RC slab roof, 4) Opening Encasement (MM-12)
	Lunch				
	16			3	Completion of work started in previous session; **Installation of Retro Features (cont.)** - 1) Diaphragm bracings & struts; 2) Collar Beams; 3) Knee Braces, 4) Column Jacketing; (MM-12)
	17	0.5	Recap of Retrofitting Training		
5	18			1	Completion of retrofitting work
	19	0.5	**Material quantities for retrofitting features** (MM-13)		
	20	0.5	**1) Do's & Don'ts of retrofitting; 2) Tools & equipment; 3) Good Quality Non-engineered RC Structure**		
	21	2	**Basics of Good Quality RC Construction**		
	Lunch				
	22	3	**Evaluation of participants**		
Ttl. Hrs.		**16**		**21**	

3 Day Program for Restoration & Retrofitting

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
1	1	1.0	1) Introduction to disasters of the past and their impact (Statistics); 2) Disaster prone areas & expected damage levels (MM- 01); 3) Popular building systems (MM- 2):		
	2	3.0	1) How the forces are caused in disasters; 2) Damage types (MM- 3) - How buildings get damaged in disaster; 3) Vulnerabilities in a building (MM- 4);		The damage/vulnerability can be explained on actual buildings nearby.
	Lunch				
	3	1.0	Restoration (MM-11) - 1) What and why?; 2) Damage categorization; 3) Damage Restoration Procedures		
	4			3.0	**Restoration (MM-11). 1) Diffferent Cateogeries of Damage, crack sealing, grouting, crack stitching, restoration og damaged walls etc.**
2	5	1.0	**How a building behaves & Retrofitting measures(MM-12) - 1) What is Retrofitting & Advantages; 2) Introduction of a few retrofitting measures**		
	6			3.0	**Retrofitting Installation of Retrofitting Features** - 1) Cast in-situ Bond Elements, 2) Seismic Belt with Tie Rod, 3) Vertical Reinforcement including connection with RC slab roof, 4) Opening Encasement (MM-12)
	Lunch				
	7			3.0	Continue and finish retrofittinf features. 1) Concreting of seismic belt.2) Concreting vertical reinforcement 3) More bond elements
	8	1.0	Recap of two day's work; Cover any points missed from (MM- 11 & 12); 1) Material quantities for retrofitting features (MM-13)		
3	9	1.0	**1) Special attention to principals of good practice (MM-14). 3) Tools & equipment; (MM-15)**		

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
	10			3.0	**Installation of Retro Features (cont.) -** 1) Diaphragm bracings & struts; 2) Collar Beams; 3) Knee Braces, 4) Column Jacketting; 5) Vertical reinforcement and RCC slab connection (MM-12)
	Lunch				
	11	1.0	**Evalution of participants through writen or oral exam.**		
	12			2.0	Participants can describe what has been done on the actual work done. More explanation/stress on retrofitting
	13	0.5	**Grading and certificate distribution**		
Ttl. Hrs.		**9.5**		**14.0**	

3 Day Program for New Construction

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
1	1	1	1) **Introduction to disasters of the past and their impact (Statistics);** 2) **Disaster prone areas & expected damage levels** (MM- 01); 3) **Popular building systems** (MM- 2):		
	2	3	**1) How the forces are caused in disasters; 2) Damage types** (MM- 3) - **How buildings get damaged in disaster; 3) Vulnerabilities in a building** (MM- 4); 4) **Disaster Resistant Load Bearing Construction - Basic Rules of Design & Planning (**MM- 5)		
	Lunch				
	3			3.5	**Good Quality Construction** (MM- 6, 7) – 1) Mixing of mortars; 2) Use of cement, 3) Installation and encasement of vertical steel in masonry construction, 4) Cutting and bending of bars for band, 5) Stone masonry foundation, 6) Brick masonry wall, 7) Window encasement, 8) RC Lintle installation.
	4			0.5	Recapitulation of day's learning & grading assessment while the masonry construction continues
2	5	1.0	How a building behaves & Disaster resistant features (MM- 7); 1) Special rules for masonry walls, 2) Disaster Resistant Features		
	6			3.0	**Disaster Resistant features** (MM- 7) - 1) Installation of Plinth level band rebars, 2) Connection of vertical rebars and band rebars, 3) Eave level band, 4) Connection of Eave band and Gable band rebars ,5) Connection with lintle rebars and Eave band rebars
	Lunch				
	7			3.0	**Disaster Resisting Features** (MM- 7) - 1)Casting of Plinth Band concrete, 2) Gable Wall construction, 3) Placing Gable Band reinforcement
	8	1.0	**Recap of two day's work; Cover any points missed from (MM- 7 & 8); Commonly Committed Mistakes in Construction**		
3	9			3.0	**Disaster Resistant Features** (MM-7) - 1) Roof to wall connection; 2) Roofing to understructue connection; 3) Diaphragms; 4) Special features for flood and cyclone (MM- 7 & 8). Note: Only 1 & 2 can be done on mock-up. Rest will be done on existing building.

Day	Session	Theory Hrs.	Class Room Details	Pract. Hrs.	Practical Details
	10	0.5	Material Quantities for Disaster Resisting Features (MM- 9)		
	11	0.5	Do's & Don't's of new construction (MM- 10)		
	Lunch				
	12	1.0	Evaluation of participants. Simple test papers can be handed over for evaluation. Masons who can not read, an oral exam can be conducted with the same test paper.		
	13			2.0	Ask students to demonstrate what they have learnt. Eg. Masonry work, mortar and concrete mixing, roof connection etc.
Ttl. Hrs.	14	0.5 **8.5**	Grading and certificate distribution	**15.0**	

Advance Preparation for Training 4

It would be reasonable to assume that the training program will take place in a community, be it a village or a small town where load bearing masonry construction is common. Secondly, it will be necessary to identify a couple of buildings to impart training in, since some of the activities will best be undertaken in existing buildings. All this will require the following preparations.

- Finalizing the training site
- In case the training is to be done on the mock-ups, then prepare the mock-ups
- Identification of existing houses/buildings for certain portions of training, and communication with the respective house owners for making the necessary arrangements for this purpose
- Identification of masons followed by a meeting with masons for confidence building, and registration

a. Community Meeting

Conduct village level meetings with the following objectives.

- In order to have a maximum possible impact on the community it is important that the **people know in advance what the objectives are** of the training program and how the community will benefit from it.
- Once the community is convinced, have them **finalize the training site.**
- It will also be necessary to take the help of the people to **identify the building artisans** so that meetings can be arranged with them. Since part of the training will be conducted on existing buildings, once again the **cooperation of the people is a pre-requisite.**
- Thirdly, **Select more than one existing building** for the training to be worked upon. For this too, peoples' cooperation will be required.
- Finally, **identify few contact persons cum resource persons**

b. Selection of two or more buildings/houses

The requirement of buildings will be for the following

- **New construction** for items related to pitched/flat roof (and timber floor in the areas where such floor are common)
- **Restoration of damages**
- **Retrofitting of existing houses** (damaged or not damaged)

All these activities could be done in the same buildings or in different one depending upon the buildings and their conditions. In order to prevent the last minute problems of different kinds, some of the critical considerations will be:

- Select two houses, if available, for each of the above mentioned requirements, with one of them as a backup
- Make sure that the houses selected take care of all different requirements in terms of the features that have to be included in the training, and the major regional variations in the generic building systems that are most popular and that the people are most likely to continue using.
- House owners must be reassured to win their confidence for obtaining permission to work on their house.
- If a house of a lower cast person or of a poor person is selected then it is unlikely to be visited by the upper cast individuals. This could destroy the demonstration value of the work that would be done during training.

- If a house of a higher cast person is selected, he may not allow the masons to enter some parts of the house. So this must be made clear right at te onset with the house owner or else the training simply stops.
- If a poor persons' house is retrofitted then the rich in the town are unlikely to visit it and learn about it. It is also likely that the rich may treat the retrofitting option as a poor person's choice.
- People will allow any kind of work on their house and be willing to invest their own funds only if a few days of effective ground work is done.
- In the absence of this ground work one may not get a right kind of structure to work on.
  If people do not understand what you are going to do then they tend to offer houses which are badly damaged. At times because of this very reason the building may have been abandoned.
- Take the structure that is typical of structures found in the area.
- It is extremely important to create a clear picture about what is retrofitting and what kind of houses are needed to work on for training. Although, one can retrofit a badly damaged house
- after it is repaired which may included partial reconstruction, it would be a time consuming and more expensive process which may be difficult to be fitted in the training programme. Hence, a house to be taken in the programme must be only lightly damaged or not damaged at all. This would also convey that every house in the area needs to be retrofitted, damaged or not damaged.
- If a house owner is even little shaky do not pursue him/her, since those interested in participating will never say no in the first place.
- Work on a house should not be taken up in the absence of adequate confidence building of the house owner. This is to prevent problems during or after the training.
- The house owner could be a spokes person as desired by the programme only if right type of house owner is chosen, if that person is properly informed before the work is initiated and if adequate interaction takes place with him/her during the training programme.
- Government building also forms an excellent demonstration piece and can inspire confidence.
- If it is a public building then there should be no local political hurdles
- Ideally it should be the same house as the one on which the new construction features would be demonstrated, or should be in a very close vicinity of that building to keep the training logistics simpler.
- It should be of an average size, and not too big
- Two story structure, if possible
- House should be occupied/in use. Abandoned building does not inspire much confidence, and sends a wrong message.

c. Selection of masons

The ground work must also involve **communication with the masons i**n the form of awareness building, confidence building and creating a felt need for the training. If the ground work is not enough only a few masons may participate in the training.

i Masons were of little help in reaching other masons. For that too, the **ground work has to be done by the team.**

ii **Masons of different skills joining the training** is preferred. So at least a few can do the cement work well, few can do the roof timber work well, a few can work on stone and a few can work on bricks walling. Wrong selection of masons tends to mess up the work, eg. Masons with the experience only in tile laying or plastering or bar bending.

iii In the absence of a trained mason during the training, all the **leg-work has to be done by the team.** This affects the supervision and quality control. But it may be difficult to take the mason for too many days from one place to another away from their homes

iv **Do not undertake too much work** with the hope of finishing certain items, it may put too much load on the masons which results in to less time for communication and interaction.

v Masons are not likely to bring their tools/ equipment unless specifically told to. This is partly because of their earlier experience which involved simply sitting through workshops and not doing any physical work. Hence, an **explicit communication is desirable**. Punitive measures also need to be announced

vi Do not depend on masons or any one outside the team to get the names of masons.

vii **Get names of good masons** from the village and try to contact them.

viii **Masons must be instructed** beforehand that

1. what tools they should bring,
2. they should come on time,
3. they will be doing work with their hands,
4. a redetermined and uniform wage would be paid,
5. they would be paid in the end of training,
6. the cost of equipment lost in training would be recovered from all masons,
7. they would receive a certificate, manual etc.
8. A minimum of 8 masons will be required in the morning of training at 7.30 a.m. for the training to take place.

ix **Pre-register the mason with Rs.15** advance deposit to ensure that they would attend training as promised. The deposit will be fully refunded when they show up in training.

x **Assign tasks to the masons** that match their skills so that things move smoothly and good quality work is produced.

d. Advance Preparation for Retrofitting Sessions for Walls

- For hands-on training it is necessary that one or more buildings with different types of locally popular building systems are available to work on.
- It also would require getting permission from the house owners of these buildings so that the trainees can enter these houses and work on retrofitting it.
- Since the available training time is limited it will be best if some preparatory work is done ahead of time on the selected building. This will involve ...
  - (i) Removal of plaster from the length of Horizontal Belt and the vertical bar that is expected to be installed in training,
  - (ii) Raking of joints from half of it,
  - (iii) In case of UCR wall making of a few holes for the Bond Elements,
  - (iv) In case of UCR wall making of a few holes for the shear connectors for the Belt,
  - (v) Making of a few holes for shear connectors for the vertical rod,
  - (vi) Exposing of slab reinforcement for connection with the vertical rod, and
  - (vii) Installation of a few shear connectors for vertical reinforcement and Belt.
- This will permit the participants to work adequately on most of the items.
- All this could be done in the first three days of training by hired help.
- The rooms that the trainees will be working on also must be cleared ahead of time.

e. Advance Preparation for Retrofitting Sessions for Floor & Roofs

The preparation mentioned in the previous retrofitting session applies to this session as well. This part of training will require carpenter skilled in building roofs with all the necessary tools. In many areas, especially the mountainous north, the building artisans have skills of masonry as well as carpentry.

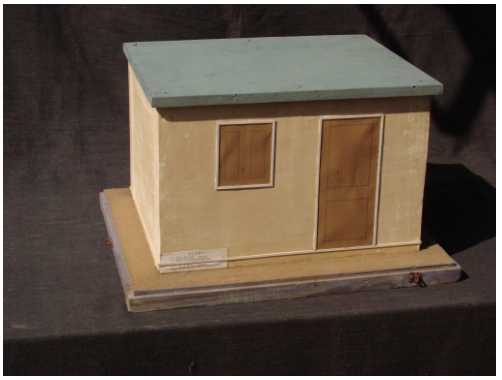
- In case Knee Braces are to be applied, they must be designed and fabricated in advance for keeping them ready at the time of training. Field conditions should be checked to determine the size of the braces.
- If timber floor is to be anchored then Brackets made of MS angle. Thsese will have to be fabricated in advance. Field conditions should be checked to determine the size of the brackets.

Making of Working Models

5

1. Working Model of House

This model is used to demonstrate the behavior of a building in earthquake and cyclone. Hence, the basic requirements are as follows.

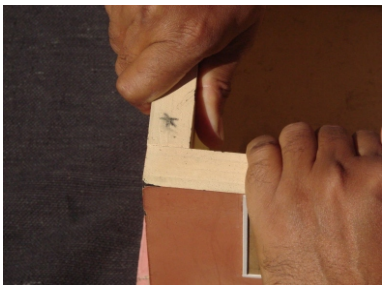


A. Walls

- Use a material for walls that is stiff but is amenable to some bending
- Ensure very strong wall to wall joint using suitable adhesive and screws so that pushing and pulling of walls do not break the joint
- Securely fix the four sided box made from this material to a wooden base.
- Finish the walls showing doors and windows that do not violate the basic rules of disaster resistant construction pertaining to total width and spacing between them and with the wall corner.

Walls to be flexible so that they can deform under the forces perpendicular to their respective surface.

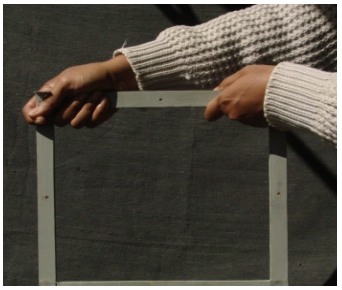
Wall to wall connections to be strong to withstand bending of walls for demonstration



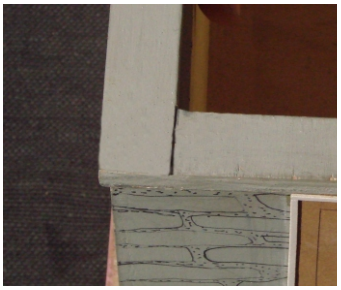
B. Eave level Band

- Use timber strips and make a four sided frame for band with the proportions to match that of a band
- The connections between all four sides of the frame must be strong to withstand pulling and bending
- The frame should have some holes so that permanently installed pins in the top surface of the walls, one or two in each wall, fit in to them in order to securely attach it to the walls.
- Put some kind of marking at one point on the frame/band and also at a point on the wall exactly opposite that mark to ensure trouble free installation of the band
- Paint the wooden frame with appropriate color to look like a band

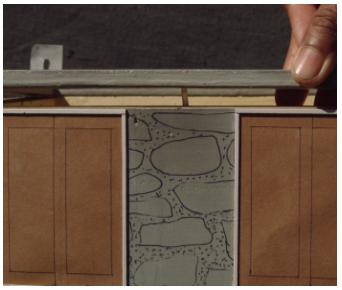
Wooden frame to be placed at the eave level, which can represent a **band** of any type



This band to have stiffness much higher than that of the walls



This band to have strong corner connections



The band to be securely attached at the top of the walls through permanently installed pins

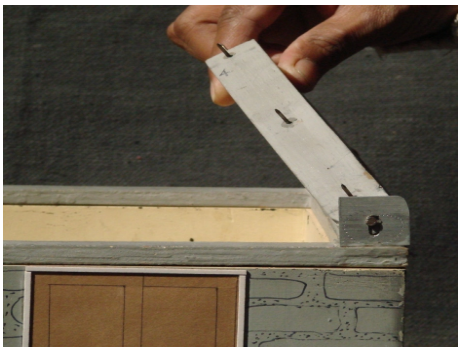
C. Slab

- The proportions of the plate must match that of a slab
- The plate should have some holes so that permanently installed pins in the top surface of the walls, one or two in each wall, fit in to them in order to securely attach it to the walls.
- Put some kind of marking at one point on the side of the slab and also at a point on the wall exactly opposite that mark to ensure trouble free installation of the plate/slab.
- Paint the wooden frame with appropriate color to look like RC slab.

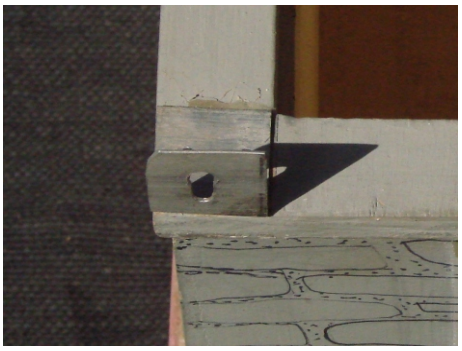
A **flat plate** of timber or any other stiff material that represents an **RC slab** roof that can be securely attached at the top of the walls (in place of timber band) through permanently installed pins.

D. Gable Walls

- These are to be made of the same material as that of the walls and painted appropriately
- Pivot arrangement may be made on a wooden frame (the one being used as eave band or another identical one) and gable walls should be attached to the frame such that it can swivel back and forth. Since they are installed on a timber frame that can be secured on the top of the walls, the whole assembly can be removed when the wall deformations are being demonstrated, and when the flat RC slab is being demonstrated.



Gable walls that can swivel back and forth about the base.



Pivot arrangement may be made on a wooden frame/band.

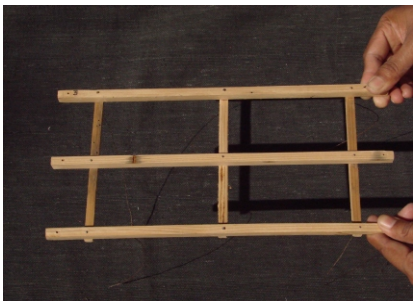
E. Pitched Roof Frame

Pitched roof frame to be of rectangular shape that can (a) be detached from gable walls as well as can be anchored to them, (b) deform into parallelogram shape under the effect of in-plane tension, and (c) resist deformation with the installation of diagonal ties.

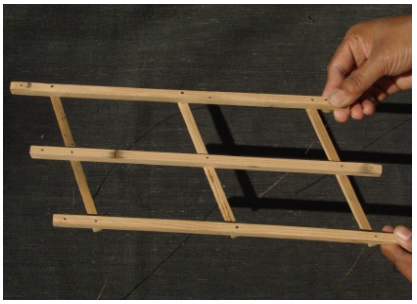
The frame to be made of round/square sticks, of appropriate diameter/size, and to be placed on gable walls using permanent pins in the apex of gable walls, such that it can be removed.

Roof understructure arrangement: Ridge beam and rafters

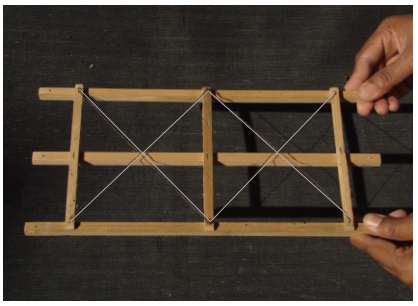
Roof understructure arrangement: Purlins and truss



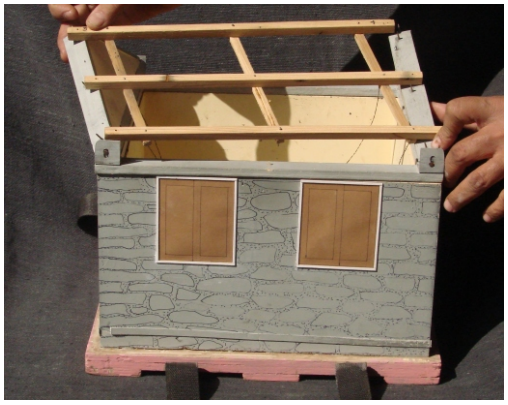
The roof frame to consist of purlins connected to truss or struts with simple pins that allow rotation of purlins with respect to the rafters



It must be possible to deform (in-plane) the rectangular frame in to parallelogram when the diagonal ties are detached from one end.



Install diagonal ties made of thin wires such that at one of their ends they can be detached



Anchor roof frame to the eave wall and ridge beam using permanent pins such that the frame can be easily detached.

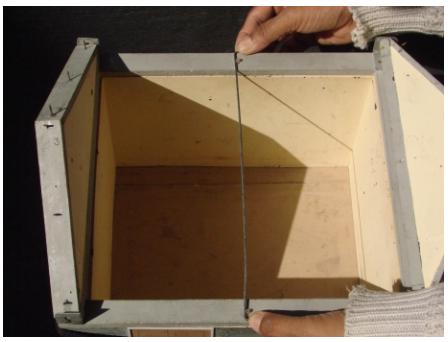
- When frame is installed on the ridge beam and eave wall with diagonal ties removed it must be possible to rock the gable walls back & forth accompanied by the in-plane deformation of roof frame.

Special instructions for making working model to meet above requirements

- **Consult a model maker who is well versed in various materials**
- **Use 1:10 scale for the model to make a model that is not too large to carry around and at the same is not too small for effective communication**

F. Miscellaneous Items

An "L" shaped 3mm stiff wire of appropriate length to represent the vertical rod to be installed in a corner of the working model for retrofitting

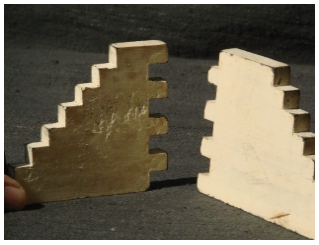
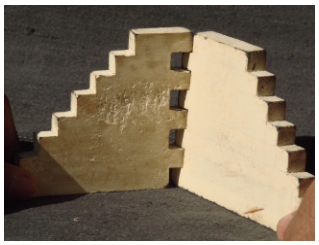


A "C" shaped 3mm stiff wire of appropriate length to represent the tie rod to be installed from one wall to the opposite wall in the working model

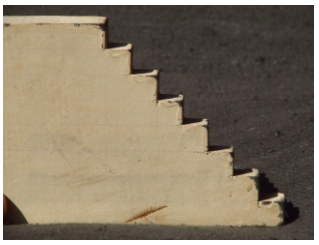
A 25mm wide belt of appropriate width and color to represent a seismic belt made from fabric with Velcro at its end to be installed on the working model at eave level on all walls

2. Model Demonstrating Wall to Wall Joint

Two pairs of walls that can be detached from each other to represent an effective way to explain the good and bad wall-to-wall joint in a classroom.

A) Wall to wall connection using toothing,

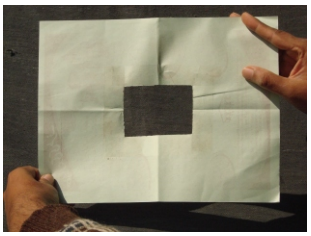



((B) Wall to wall connection done with walls built in stepped manner.

3. Paper Simulating Racking Shear Action

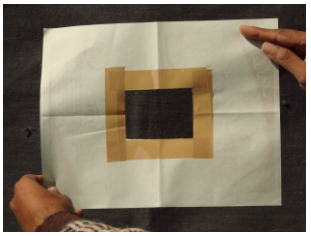
Use A4 size paper of commonly used thickness to make the following.


I. Do not take very thick paper. In this case the corners will tear off when the paper is pulled in the diagonal direction. Otherwise take a paper with a light diagonal cut mark 75mm long that can facilitate the diagonal tearing when the paper is pulled in the diagonal direction. In reality in case of a wall the whole top edge moves in one direction in relation to the bottom edge. This can be achieved in the paper model if the top and bottom edges are sandwiched between two pieces of wood.



II. paper with a very light diagonal cut mark

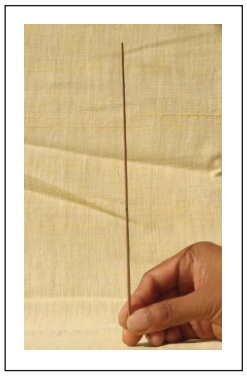
III. Paper with 100mmX75mm opening in the center



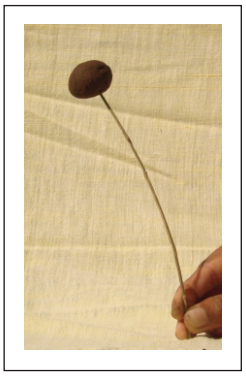
IV. Paper with 100mmX75mm opening in the centre with a colored adhesive tape along all four sides of the opening, and going 25mm beyond either corner of the opening.

4. Twig with Clay Lump Simulating Inertia Force

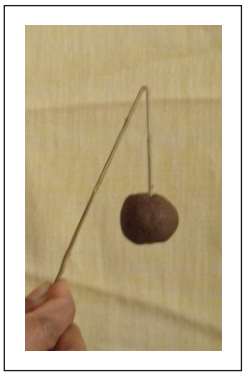
This model shows how the force on a twig created by shaking its base depends upon the quantity of mass attached at its top end, and by increasing this mass the force increases such that ultimately it breaks the twig.



Take flexible, thin (that can break easily when bent much) twigs approximately 350mm (14") long from broom used for cleaning bathroom



Make balls of clay with diameter ranging from 10mm to 20mm and keep them moist so that they remain soft such that the twig can be inserted.



Make sure that when the clay ball is attached to the top of the twig, the twig does not simply bend and break because the ball is too heavy or twig too flexible.

It should be possible to hold the twig almost vertical from the bottom end and shake it.

Equipment, Training Tools, & Manpower

6

A. Lecture

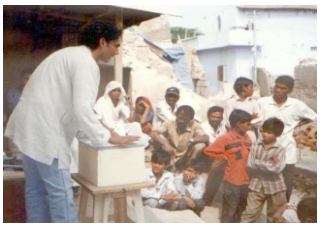
Location to be conducted in:
(i) Classroom or a small hall, or
(ii) A semi covered space in fair weather

Facility: A rug for trainees to sit on, a table and a chair

Manpower
(i) A Senior Trainer (Engineer) with field experience of 5 to 6 years in construction
(ii) A Junior Trainer (Engineer) with field experience of 1 to 2 years to operate various equipments, to carry out the administrative chores etc

Training tools-
(i) A working model of a building with other relevant paraphernalia to explain behaviors of the building and disaster resisting features,
(ii) Samples of special materials like WWM, GI wires, Chicken wire mesh, Bolts, Nails, Washers, U & V Bolts of different sizes etc.
(iii) Charts/Posters,
(iv) Blackboard,
(v) Power supply e.g. 500VA generator with fuel/Inverter,
(vi) TV, DVD/VCD player.

Handouts: Manual, Booklets, Pamplets



B. Hands-on Training

To be conducted at:
New construction at:
(i) full scale building such as a house or a small toilet block,
OR
(ii) mock-up,
coupled with installation of earthquake resisting features for pitched roof and timber floor in an existing building;

Restoration and retrofitting: in existing buildings

Manpower-
(i) A Senior trainer (Engineer)
(ii) A Junior trainer
(iii) 2 master masons.
(iv) 2 labourers provided for miscellaneous support for efficient use of time.

C. Equipment & Miscellaneous Items needed for hands on training

(1) For New Construction Training

Masonry tools: **to be brought by mason trainees**

Basic Masonry tools (Personal)
Trowel
Plastering tools of different sizes of wood and metal (Personal)
mmX25mm (4"x1") Wood or Aluminum batten minimum 1.8m (6') long
Right angle
Tube Level
Plumb bob (Personal)
Measuring tape
Basic stone masonry tools for UCR work only (Personal)
Cotton string for marking

Bar-bending tools

Binding wire tightening tool.
Bar bending set up steel preferred with rods welded,

Bar bending tools or a 600mm (2') long 25mm (1") dia. Pipe.
5 kg. sledge hammer.
Different size chisels for steel rods.
Bar cutting chisel minimum 1, 2 preferred
Tongs to hold chisel
Wire cutter

Miscellaneous

Sieve for coarse sand
Shovel
4 Pans
Crowbar & Pickaxe for making holes in ground
Scaffolding extending minimum 3m (10') along one wall and 5m (15') along another
Ladder 2.4m (8')
Coir String
Water buckets, drums etc.

Carpentry :

Basic carpentry tools including hand operated auger type r" drill or girmit, wood-saw, Wood hammer with nail-puller end, wood chisel, measure tape (personal)
Heavy hammer.
Pliers
Right angle
Level pipe
Plumb bob
Screw drivers

(2) For restoration Training

In addition to the equipment shown under new construction the following items are necessary

Electric drill with adequately long extension cord only if electric power is available
mm (1¼") diameter GI pipe with slit end to make holes in brick walls
PVC Pipe Grout Hand Pump
Funnel bottom Grout Canister with 25mm (1") diameter hose
Measuring jar for measuring liquid plasticizer
Mixing containers, mud etc. for preparing grout
Ladders (2 to 3 numbers, high enough to reach the upper story lintel level band).
Plastering tools
Hammer
Wire cutter

In case of severely damaged building the restoration involves dismantling and reconstruction of the severely damaged parts of the building. In that situation the items mentioned under "New Construction Training, Miscellaneous" too will be required at the site.

(3) Retrofitting Training (in addition to tools listed under "New Construction Training")

Electric powered Drill and Grinder with adequately long extension cord only if electric power is available.
Wire brush to clean the wall.
Ladders (2 to 3 numbers, high enough to reach the upper story lintel level band).
Pliers with wire cutter.
Sheet metal for form work for corner vertical reinforcement concreting
Wood batten 75mm (3") wide and 35mm (1.25") for forming the lower edge of the F.C. belt plaster minimum 6' long. (Building Artisans should bring along)
Short 900mm (3') max. crow bars (12mm dia. Max.) with one end bent 75mm (3") long with flattened tip, and other end pointed.
Chalk / Marker / Charcoal
Torch
Spanners for tie rods

Training Procedure

7

This Guide provides all the basic information necessary to impart the training of building artisan for skill up-gradation necessary for the disaster resistant construction. It is, however, presumed that the trainer would be a qualified civil engineer. Hence, the trainer is supposed to have the basic knowledge of load bearing masonry construction. Secondly, as mentioned earlier, the training program ought to include all three aspects, namely **new construction, restoration and retrofitting.** As a result the time available for training will have to be divided among these three components.

The training essentially involves transfer of technology through transfer of **information** for **knowledge building** and transfer of **skills** for **skill up-gradation** as well as skill addition. The "Masons Manual" contains the information that should be transferred to the trainees, and the "Trainers Manual" suggests how the skill up-gradation and skill addition is to be done. It is important that the trainer should study the "Masons Manual" To update as well as modify his/her own knowledge and beliefs. This is necessary in order to achieve one of the objectives consisting of leading the trainees to correct their wrong ideas and beliefs, and to get rid of the burden of myths which is achieved through this training. The following procedure is suggested for undertaking the training program.

Stepwise Procedure:

Lecture 1: Bring familiarity of possible dangers of disasters from natural phenomena like earthquake, cyclone and flood, and also of what type of impact they can have on buildings to the trainees. In addition impart the **understanding of building systems** that are most commonly used so that the artisan is able to relate the systems that he is using with them. This would help them relate their systems with others in disaster prone areas and understand how the system works.

Lecture 2: Bring the understanding of different types of damages likely in a disaster, and their causes. Based on this throw light on the vulnerability in buildings against likely disasters .In addition also **impart understanding** of (a) what the **disaster resistant buildings** should be like through simple examples, (b) properly **situating the building** so as to reduce its vulnerability, (c) giving **form and plan** to the building that would not increase its vulnerability against a future disaster, and (d) making **various components** such that they are **less vulnerable** .

Hands-on Training 1: Impart hands-on skills for the basic rules of good quality construction, including the (a) mortar, (b) right ways of using cement and steel, (c) critical issues about foundation, (d) fundamental but most critical rules of different types of masonry construction, all of which would help construct a building without unduly high vulnerability. The hands-on training would be given on a new construction site or a mock-up site.

Lecture 3: Impart knowledge of how a building behaves under the forces of earthquake and cyclone including the damage that they can cause, and **special features** that need to be added in construction to resist these damages.

Hands-on Training 2, 3, 4: Impart hands-on skills for the installation of all **different disaster resisting features** with special attention to the regional peculiarities.

Lecture 4: Create understanding of the material quantity requirements of each disaster resisting item with emphasis on the financial implications once the understanding of the disaster resisting technologies are already imparted, In addition extra emphasis must be made on the cautions against commonly made mistakes in construction.

Lecture 5: Impart understanding of the Damage Categorization System and Restoration required in each category

Hands-on Training 5: Impart hands-on skills for the **restoration measures** for different types of damage.

Lecture 6: Impart understanding of Retrofitting concept and various measures needed to reduce the vulnerability in an existing building.

Hands-on Training 6, 7: Impart hands-on skills for the installation of various Retrofitting Measures to be installed in the existing buildings.

Lecture 7: Create understanding of the material quantity requirements of each disaster resisting retrofitting item with emphasis on the financial implications once the understanding of the disaster resisting technologies are already imparted, In addition extra emphasis must be made on the cautions against commonly made mistakes in construction.

Coordination Between Lectures & Hands-on Training:

One important aspect of conducting the training is the coordination between the lecture and the hands-on session. It is indeed desirable that every topic is first covered in the lecture followed by the hands-on training. This is dictated by where and when the hands on training sessions are conducted. This will also depend on the component of the training under consideration. Let us look at all three components one by one.

A. New Construction

There are two options about where this training would be conducted.

a. New Construction of a Full Scale Building of a Small Size.

In case of full scale new construction there are two ways this can be handled. **(i) Total Construction By Trainees:** In one case the group of 20 trainees construct the building from bottom to top, and their training is done intermittently during the construction. This means that if the building takes 6 days then all the trainees have to be constructing it for six days. The training on restoration and retrofitting is done later. This is the best way to give hands-on training since the masons get to spend most amount of time on working with their hands on the technologies. Since the completion of the building is a must in the given time, the lectures are likely to receive less importance and time. This costs the most, and requires the maximum number of days from the artisans to be present for training. **(ii) Total Construction By Two Masons:** The other possibility is that two masons construct it with the help of laborers under the guidance of the trainer over approximately 10 to 12 days, and the trainees would spend approximately three days at the site at different **stages** of construction. During these three days they will under go the training through lectures as well as through hands-on work. In both the cases it is easy to effectively coordinate between the lectures and practical training. This case will incur less cost than the first case. In this case in between the **stages** the artisans will receive the training on restoration and retrofitting. Thus in this option it would be possible to provide the optimum priority to classroom as well as hands-on training.

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b. Mock-up Construction

This option costs the least and requires least number of days from the masons. Most of the materials can be recycled from one training to the next. They can be carted from one site to the next site. But this option has a limitation. Since total available time is rather limited (5 to 6 days max.), in order to cover maximum number of items in hands-on sessions some of the items will have to be taken up in the hands-on session before they are covered in theory class. The theory classes are conducted based on the content and sequence of topics in MM (Mason's Manual). This will be especially true for some items which come early in the sequence as one starts from the foundation and goes up. In such items their purpose (in brief) and their practical aspects would be covered at the time of the hands-on session, but the technical aspects would be covered later at an appropriate time. In addition extra effort would have to be made so that the trainees are able to connect the "Vulnerabilities" to such features during the Hands-on Session, and also connect different items coming at different construction stages. In the absence of the funds required for full scale construction or a parallel program of constructing buildings, the mock-ups offer the best and the most viable alternative.

B. Restoration

This training has to be given on an existing building having some damage. If such a building is, simply not available then the mock up made for the new construction training could be damaged first and then restored under training. In this case there is no problem in scheduling the lectures before the hands-training.

C. Retrofitting

This training has to be given on an existing building that has inbuilt vulnerability. In this case also there is no problem in scheduling the lectures before the hands-training.

Mock-up Planning & Execution

8

Why Mock-Up?

Training of building artisans has to be hands-on. This requires that construction of some sort is carried out so that all the items of the training curriculum are covered. This can be done in a variety of ways. The three possible ways of doing this are, through:

- Construction of a full scale permanent building with a long term end use that conforms to all the requirements of training. Such a building can have just one or two rooms. It would follow all the rules of good and disaster resistant construction.
- Construction of a very small permanent building with a long term end use such as a toilet or a store or chowkidar's cabin in which many of the training requirements can be met.
- Construction of mock-ups that would be dismantled at the end of training.

In each of the above mentioned cases it will be necessary to design the structure so that the training requirements are met. The budget available to do this will have to be taken into consideration in determining the size as well as the specifications of the building. In case of mock up, the considerations that need to be taken care of will go beyond the budget and the training needs. The size of trainee batch and their possible output will determine the size of the mock-ups.

It should, however, be noted that in all three cases there would be some items from an exhaustive list of training requirements that would have to be carried out on site. In case of the mock-up, depending upon the type of mock up made, the items that will have to be done on the site will be the biggest. In this manual mock-ups of only the walls are recommended. The training requirements of roof will be met with the roofs of one or more existing houses.

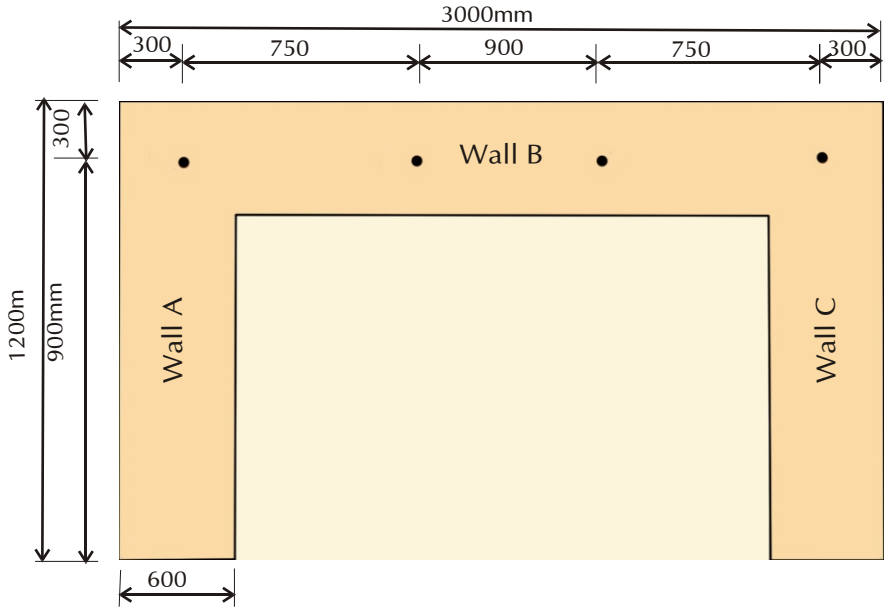
Mock-up Preparation:

A. Important considerations:

- This is to be planned in such a manner that in the given time duration maximum number of important items are covered.
- The height of masonry for various stages of training will be kept at minimum as dictated by the practical considerations.
- All masonry could be done in mud mortar, while concrete would be used only where required for the special disaster resisting features. All of it can be dismantled immediately after the training is completed before it becomes too hard.
- On account of a major time constraint in training, some of the items may have to be included (partly) in the practical training before being covered in lecture. This sequencing is unavoidable since (a) some items go together and separating them would result in to loss of time, and (b) some items can be taken up only after the concrete hardens in items done earlier. In such cases during the hands-on session the practical aspects of "how to" would be covered. The theoretical aspects of such items would be later explained in the lecture, and practical aspects too would be covered in more detail when the appropriate stage is reached.
- Most of the items would be included in the main mock-up. Some of the items would have to be covered separately on the site.

Pre-training - Bring Mock-up to this level before training.

Excavate 2 sets of C shaped foundation for UCR masonry 150mm (6") deep along wall A, B, and c. Mark out locations for vertical bars.



On the day of training following two mock up constructions must be ready.

Note: With a full batch of 20 trainees if a batch with 10 trainees is working on Mock-up "A" then full extent as shown in the sketch above must be constructed to ensure adequate hand-on practice for each trainee. But if the number is substantially smaller, then "L" shaped wall may be constructed. .

Mock-up " A"

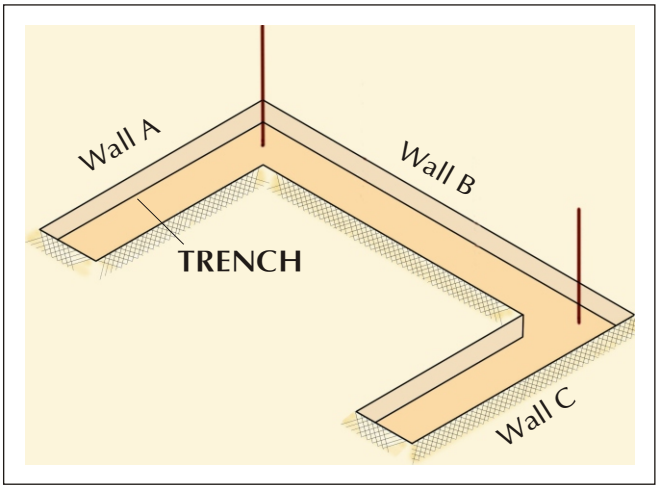
Purpose: This construction will be used for hands on training for the following.

1. vertical reinforcement installation
2. UCR masonry
3. Encasement of vertical reinforcement with concrete in masonry.
4. Placement of plinth band reinforcement.

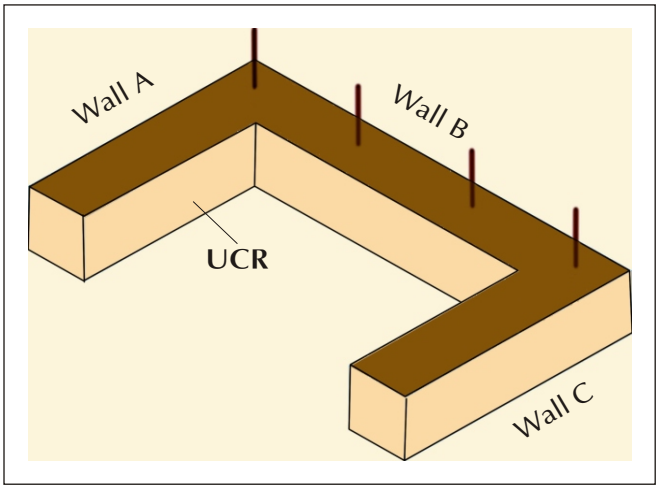
Mock-up "B"

Purpose: This construction will be used for hands on training for the following.

1. Brick masonry with vertical reinforcement embedded in it.
2. opening encasement.
3. RC lintel installation
4. installation of eave band.
5. connection of lintel to eave band.
6. Connection of eave band to gable band
7. roof anchor devices.



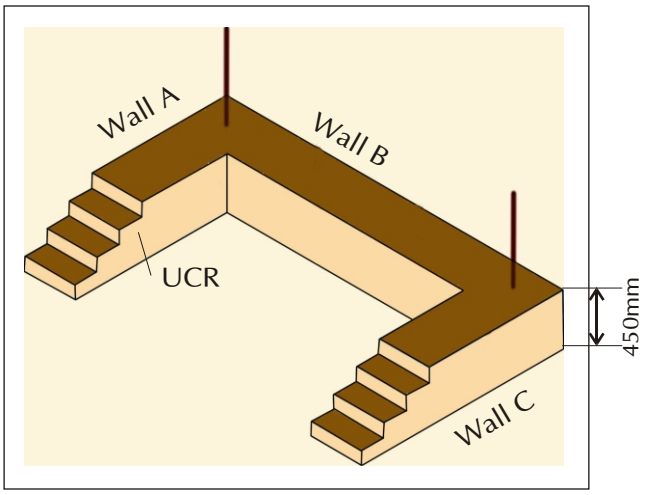
Excavated trench for UCR masonry 150mm (6") deep with three vertical bars where shown with full embedment in concrete at the bottom and laterally supported with some props.



UCR masonry along walls A, B, and c in mud mortar up to 450mm (18") high, with 4 vertical bars projecting out 1050mm (3'6").

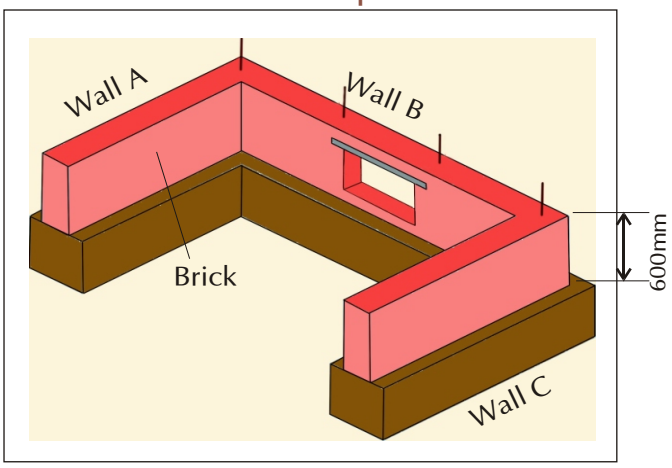
Session 3 - Bring Mock-up to the level shown below during this session.

Mock-up" A"



- Get two vertical reinforcement bars cut and bent.
- Install one vertical bar with full embedment in concrete at base and supported with props.
- Insert PVC pipes on all vertical bars and construct UCR masonry along walls A, B, and C, doing it in stepped manner at both corners up to 450mm (18") height from ground. Encase vertical rods in concrete with proper ramming.
- Get the reinforcement for the plinth level band, cut and bent for walls A, B, and C.

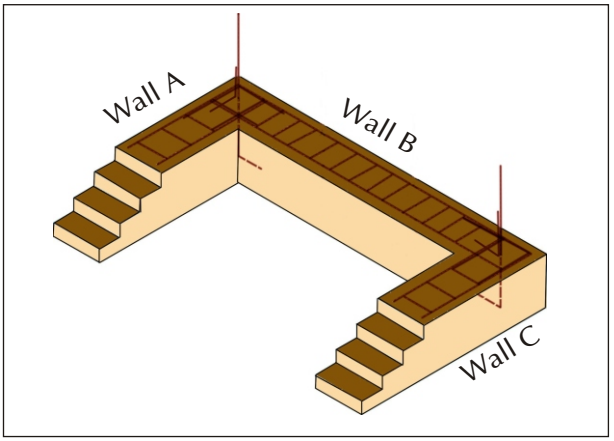
Mock-up"B"



- Consider the top of constructed wall as the sill level. Let all the trainees know that this is a mock-up, so it is not necessary to build full height walls.
- At this level install the sill level "U" shaped rod in concrete to show the bottom of window encasement.
- Build masonry wall 230mm (9") of bricks or 200mm (8") of concrete blocks (if bricks not available) up to 300mm (12") height along all walls encasing all four vertical bars. Both ends must have stepped construction.
- Place a wooden plank as centering for lintle over the window. Install pre-cut bars with its protruding ends bent as necessary to connect with the reinforcement of the eave level band.
- Bring masonry to 600mm (24") height which is to be considered as the eave level.

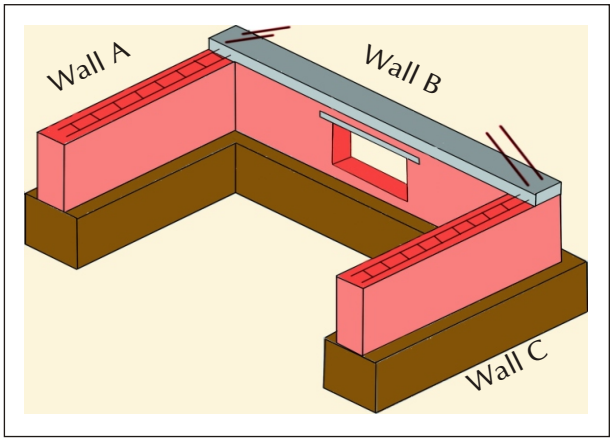
Session 6 - Bring Mock-up to the level shown below during this session.

Mock-up "A"



- Install Plinth band reinforcement on all three walls at plinth level
- Tie all vertical bars to plinth band reinforcement with L shaped reinforcing bars
- Place concrete to encase the portion of vertical bars that is within the masonry .

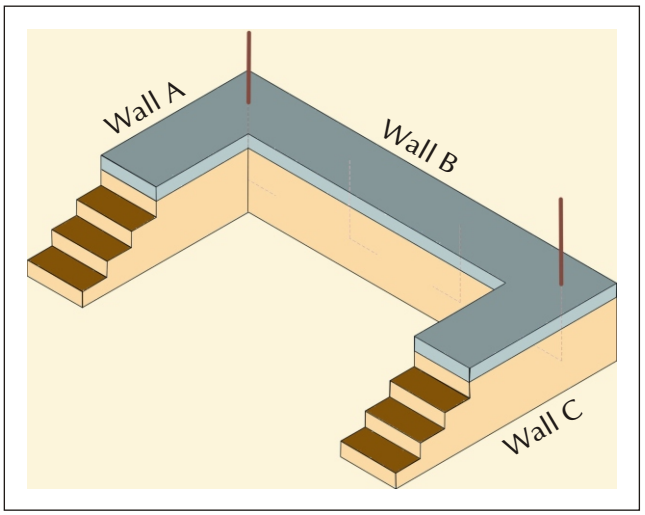
Mock-up "B"



- Install eave band reinforcement on all walls.
- On wall B connect the extended lintle bars to the band reinforcement.
- Cast concrete in wall B portion only.
- Place high priority on band concreting and get it completed first so that it begins to harden when Session 7 begins so that gable wall can be built..

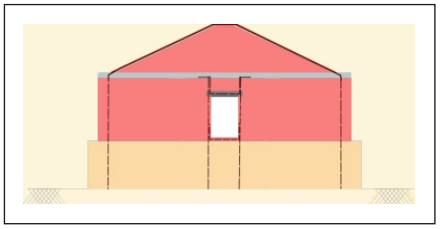
Session 7 - Bring Mock-up to the level shown below during this session.

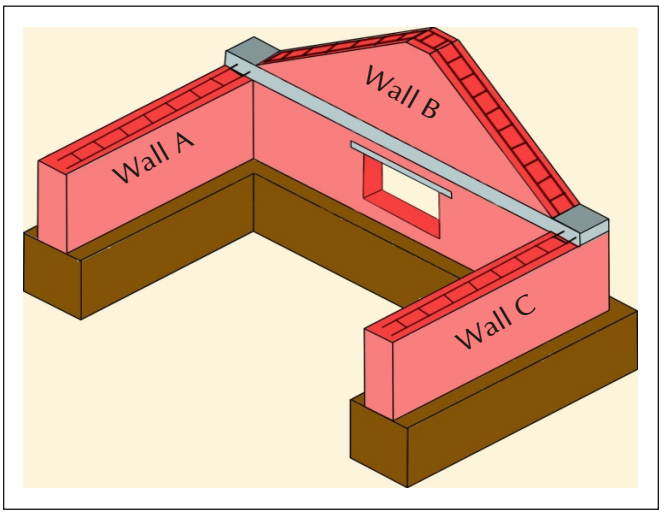
Mock-up "A"



- On all walls, finish concreting of plinth band if time permits.
- Construct Concrete Block masonry with vertical bars embedded in it at two corners.

Mock-up "B"



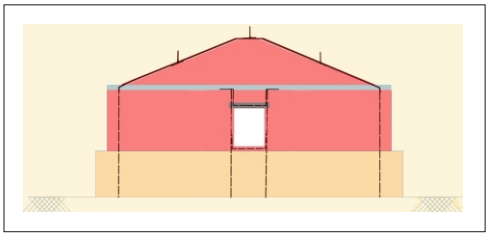


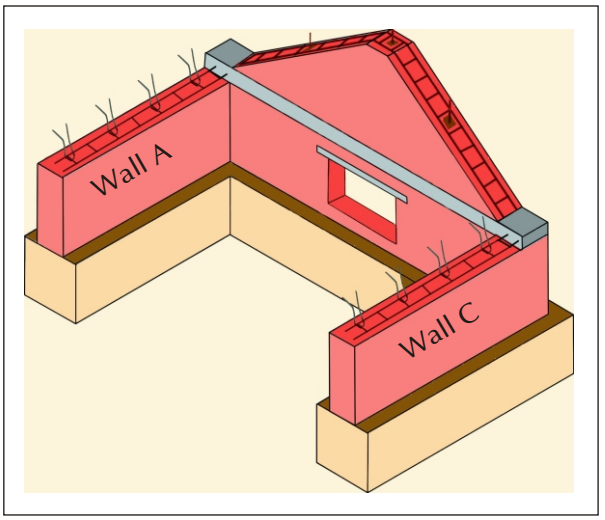
- On wall B construct gable wall.
- Prepare reinforcement for Gable Band.
- Install gable reinforcement connected to the dowels extending out from eave band.

Session 9 - Bring Mock-up to the level shown below during this session.

Mock-up "B"

- On walls A & C where eave band reinforcement is left exposed install various types of anchors for roofing and flooring.
- Install anchor bolts in the Gable Band reinforcement.





Detailed Curriculum Day 1

9

Session 1 Duration 1:00 hr Class-room Lecture

Topics to be covered

1. Past Disasters & Their Impact

Getting to know about the scale of destruction from the past disasters is the first step towards learning the way to prevent such disaster.

Earthquakes

Location	Year	Magnitude	Villages Affected	Cities Affected	Houses severely Damaged	Houses Damaged	No. of Deaths
Latur	1993	6.4	1200	0	35,000	200,000	8000
Jabalpur	1997	6.1	45	1	5,600	57,000	45
Chomoli	1999	6.8	4175	0	19,300	86,000	135
Kutchch	2001	7.7	8,000	6	230,000	850,000	14,000
Kashmir	2005	7.8	100	3	23,799	169,744	978

Cyclones

Location	Date	Deaths	Houses damaged
Andhra	May. 1990	976	14,39,659
Andhra	Nov. 1994	172	79,220
Andhra	Nov. 1996	1,077	6,09,628
Orissa	Oct. 1998	10,000	1,82,853
Guj- Kandla	June.1998	1,308	15,000

Floods

Location	Date	Deaths	Houses damaged
Gujarat	June 2005	202	1,62,000
Bihar	Dec. 2007	419	3,94,900

2. Main Lessons of past disasters

Tip: Ask participants if they have any views on why the structures get damaged in disaster in order to get an idea on their understanding, or the myths that they may be believing in, and even propogating

a. **Materials not responsible, but the manner in which they are used is responsible.**

In other words…

i. It is not important if walls are made of brick or stone or mud

ii. It is not important if roof is made of RCC or Tiles or Timber

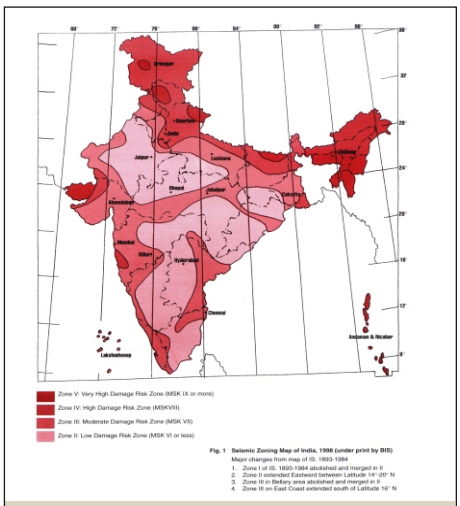
b. **It is the adherence to the basic rules of construction and quality that matters. Lesser the number of mistakes safer is the building.**

c. **It is the use of Disaster Resisting Features that matters. If they are used, safer is the building.**

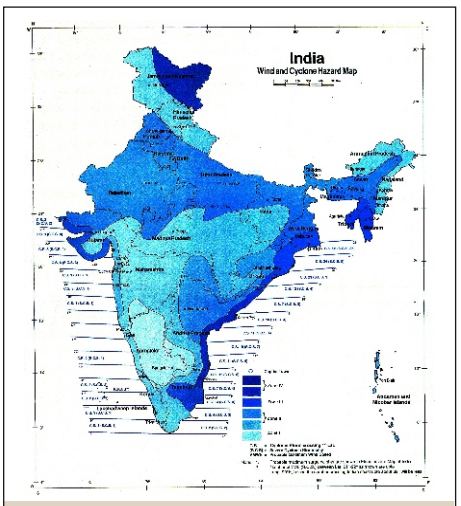
3. Introduction to Disaster Prone Areas (MM-1)

If a person is involved in constructing a building he/she must know what types of disaster can occur and how big.

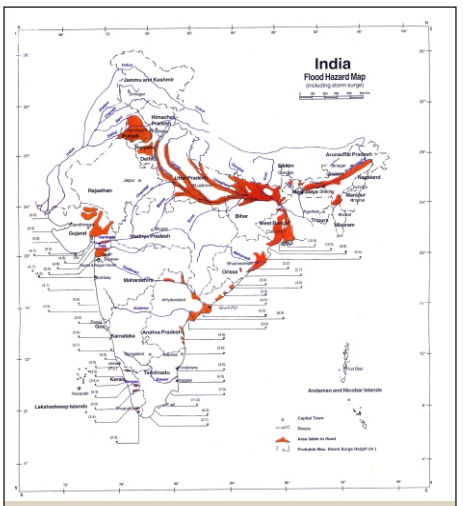
A.What does each map tell?



Seismic Hazard Map: Zones II to V - Higher the Zone Number bigger is the earthquakes that can be expected, and hence, greater is the damage that can be expected.



Wind Speed Map: Zones I to V - Higher the Zone Number faster is the wind speed that can be expected, and hence, greater is the damage that can be expected.



Flood Hazard Map: Areas where major floods can be expected.

B. What type of damage can be expected in the event of a disaster in any area? Different types of buildings would be damaged to different extent as indicated in MM-1. Refer to MM-1.

4. Popular Building Systems (MM-2)

What are the local systems in the area where training is being conducted? Identify them and see how they relate to the systems given in MM-2 before the training program in order to decide what features have to be added for disaster safety.

Tip: Ask participants if they know about the different building systems, and on what systems they have worked on.

★ **Load bearing masonry system:** Explain how this system works. Also explain different systems given in MM-2.

Most commonly used walling materials: Stone, Bricks and Concrete blocks

Most commonly used Roofing:

- Pitched roof with clay tiles, C.G.I. / A.C. Sheets
- Flat roof: (i) RCC slab, (ii) Mud roofing placed on timber deck supported on columns or on masonry walls

★ **Reinforced Concrete Frame system:** Explain how this system works.

- Mostly designed by engineers. But some buildings are built by masons/contractors using their practical experience without the advise of engineer.

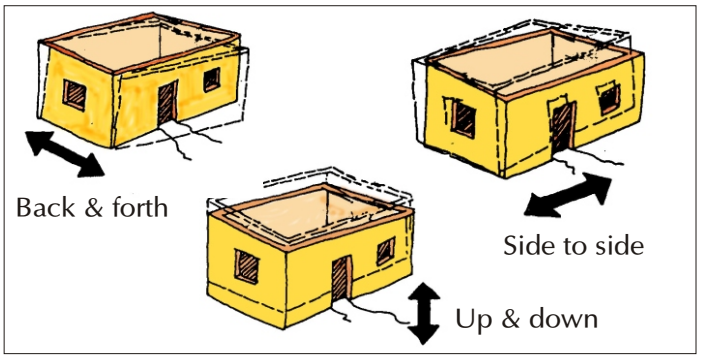
Session 2 **Duration 3:00 hr** **Class-room Training**

Activities to be covered

5. How the forces are caused in disasters?

A. Force caused by Earthquake

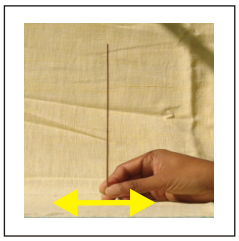
Tip: It is important to understand how structures behave in earthquake to be able to see the relationship between the damage, and the good construction quality and also the special features that may be required to make the building disaster resistant.



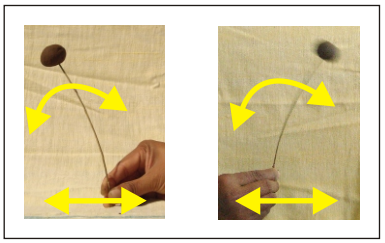
a. What is the relationship between earthquake forces and the weight (mass) of the building?

Earthquake force at any point in a building depends on the weight (mass) at that point. Greater the weight (mass), greater is the force.

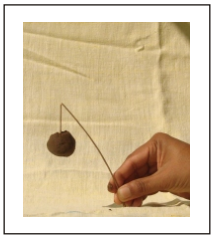
To understand this, demonstrate the following experiment.



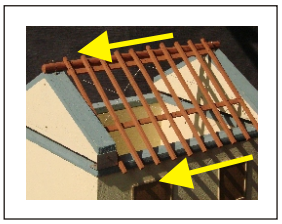
i. Take a twig from a broom and hold it vertical between fingers; move the hand and the whole stick moves.



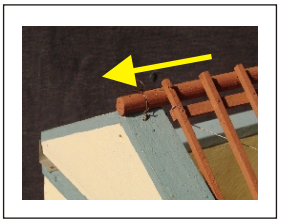
ii. Put a small ball of clay on top of twig and again move it back and forth. The top starts to sway back and forth because the weight at top generates earthquake like forces on the twig that supports that weight.



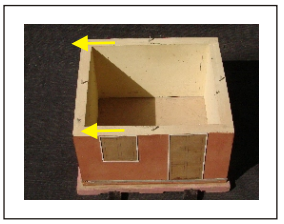
iii. Now increase the weight at the end and move it back and forth; the twig shakes back and forth and finally breaks. Thus with a bigger mass, there is greater force that breaks the twig.



iv. In the same manner a roof that is resting on wall, exerts horizontal force on that wall at the point of support during an earthquake. If the roof is heavier then the force on wall is bigger.



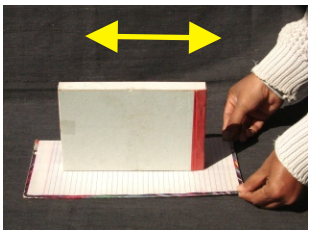
v. Similarly a ridge beam resting on top of gable wall exerts horizontal force on gable wall exactly where it is resting on it. If the roofing is lighter then the force on gable wall is smaller. If the roofing is heavier then the force on gable wall is bigger.



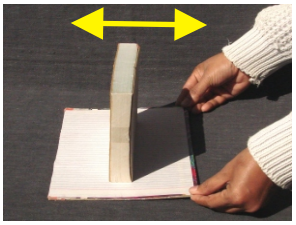
vi. Wall itself also has mass, and hence, it results in to seismic force. If one wall rests against another or is attached to another wall, during the earthquake that wall shakes and as a result exerts horizontal force on the wall that is connected to it.

b. "Out of Plane" forces or forces Perpendicular to the Surface

i. Take a hard cover book 1½" thick that can stand up on its own. Put it on a board .

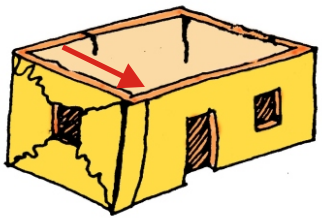


ii. Move the board back and forth in direction parallel to the length of the book. The book remains standing.

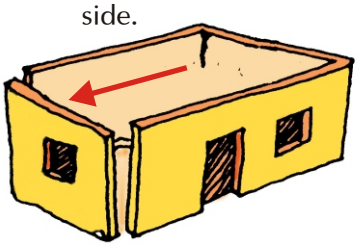


iii. Now move the board back and forth in direction perpendicular to the length of the book.

iv. The book begins to shake back and forth and soon it falls on its side.



v. Now consider a wall of a building and how earthquake force acts on it.



vi. In an earthquake if the ground moves back and forth in the direction of the length of the wall the wall remains standing without shaking.

vii. Now if the ground moves back and forth in the direction perpendicular to the length of the wall then the wall begins to shakes back and forth. If there is more shaking then the wall can collapse.

B. Forces Caused by Wind

a. To understand this take a thin flexible cardboard strip only 75mm (3") long,

b. hold it vertically and blow air at it as hard as you can. The strip will bend under pressure.

c. Now take a strip of equal width but 200mm (8") long and blow air at it real hard. The strip will bend much more.

d. As is evident from this example, the force of wind on the wall due to wind is not dependent upon its mass but upon how wide and tall the wall is.

e. The high speed wind exerts much pressure on the walls.

6. Damage: Types and its Causes : Earthquakes, Cyclones and Floods

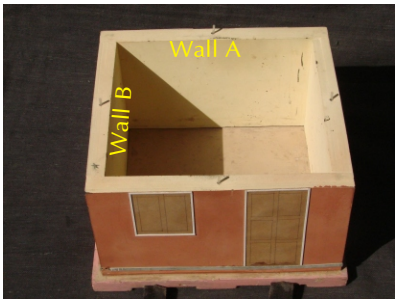
Tip: With some understanding of how the earthquake and cyclone forces exert on a building it will be best to explore if trainees can imagine the type of damage that the earthquake or cyclone can cause.

- Ask them if they can imagine what forces exert on the walls of the building you are sitting in and what would happen to them?
- Based on their answers explain how the building gets damaged?

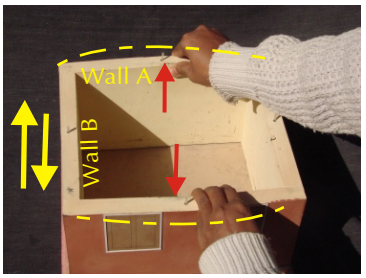
A. Earthquake Damage:

The information provided in **MM-3** can be effectively communicated to the trainees through the use of various models and examples as described here.

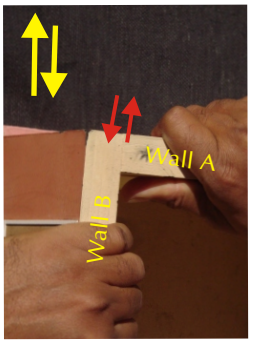
a. For this use a Working Model of a house.



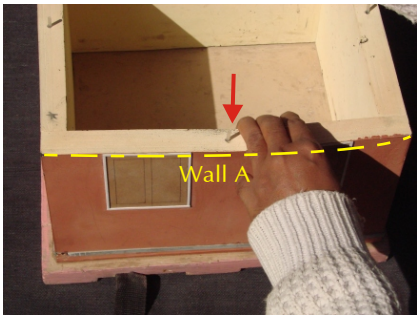
b. Assume that all the walls support the roof. Wall A and B will not move (slide) at their base because of friction and bond between the foundation and walls.



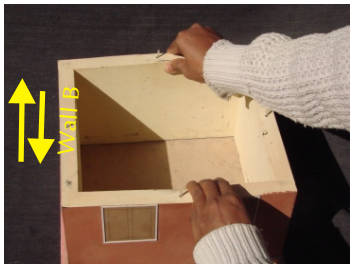
c. Now if earthquake movement is in the direction shown in photograph then the Wall A will bend back and forth due to forces from roof resting on it and under the effect of forces due to its own mass. But Wall B will not move much.



d. As a result where both walls meet Wall A will pull Wall B in the direction of the earthquake movement.
This results in to tension on the corner joint.
So if the corner is weak then corner crack develops.

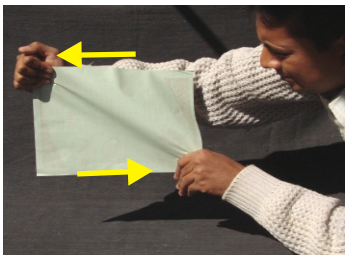


e. If the corners are strong, then the Wall A is held at corners and under the effect of earthquake forces it bends at mid length as visible in the photograph. What will happen if a wall bends much? When the wall bends tension develops on one face of wall. Masonry wall is always weak in tension. So a vertical crack will develop at the point of high bending. Since the back & forth movement is more as you go higher along the wall, the vertical crack begins at the top and is always widest at the top.

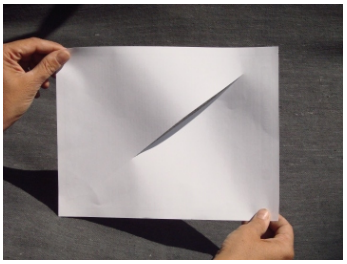


f. What happens in Wall B when the earthquake movement is in direction parallel to it? The wall at its base remains fixed in its position. But as one goes up there are horizontal forces that pull the wall within its own plane..

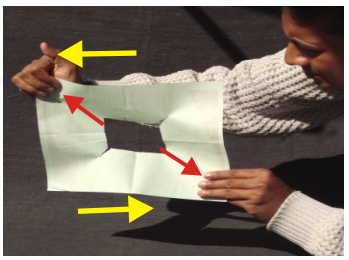
g. To understand this, take a piece of paper.



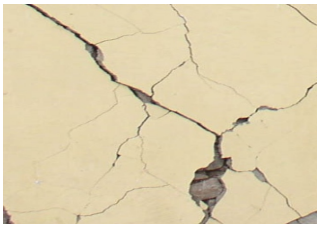
h. Hold it vertically and fixed at its base. Now pull the top front end



i.When the pull is increased the paper tears along its diagonal.



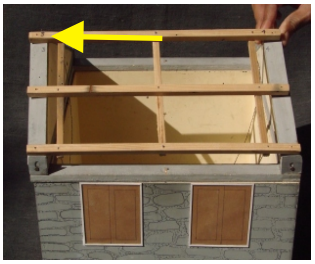
j. Take another piece of thick paper with a square hole in it. When pulled it tears easily from the corner of the opening.

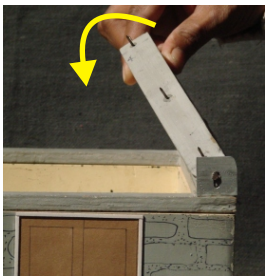


k. Same way Wall B under pull also tears and develops diagonal crack

l. Same way the wall tears and diagonal cracks develop from the corner of openings of window and door.

m. In case of a building with pitched roof there are triangular gable walls which support the roof load. During an earthquake the roof exerts a side way force on these walls.

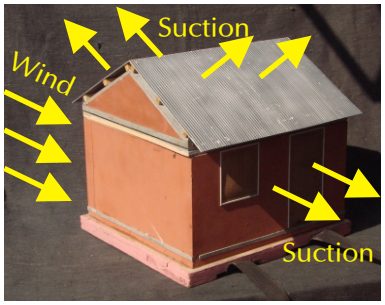




n. Gable walls move back and forth. Since there is nothing holding them. As a result they bend and develop cracks at gable base.

There are more types of damage as shown and explained in MM-3.
Use photographs along with the graphics for better understanding.

B. Cyclone Damages:



a. As shown in the MM-3 Cyclone causes not only pressure on parts of a building, but also suction on some parts.
Ii. This results in to bending and pulling of different parts of a building.

b. As a result in cyclone the walls suffer damage that is very similar to that in Earthquake.

c. Roof, however, suffers different type of damage as is shown in the MM-3 graphics.

C. Flood Damage:

This is explained in MM- 3. This also includes damage caused by heavy sustained rain.

7. Vulnerability Identification (MM-4)

Based on the understanding of how buildings get damaged, and in a typical building which parts suffer most damage, it is important that the trainees should know where the weaknesses are in the buildings that they most commonly build in their area. Since a variety of vulnerable building systems including those with RC slab roof are covered in MM-4, one or more of these systems would be very similar to those used in the area.

Tip: Ask masons what they feel about their buildings after learning about the damages and their causes.

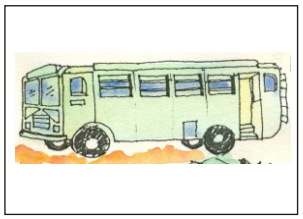
It will be best if the participants are taken to various buildings in the area and are helped in identifying weaknesses in them.

8. Disaster Resistant Building Design: Basic Rules of Design (MM-5)

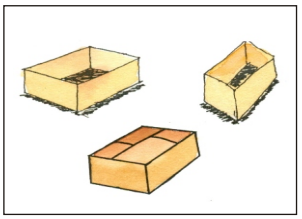
Tip: For the trainees to better understand and remember the most fundamental principles of the disaster resistant construction it is necessary that simple examples of day to day life are used in explanation.
MM-5 gives such examples. Use the explanation given in MM-5.

Tip: While using this information it will be best if items like a small cardboard carton, a table, and a plastic bucket are kept on hand so that the trainer as well as trainees can handle them, and develop their own feelings. It will be best if this portion is conducted in the form of a dialogue between the trainer and trainees through questions and answers that allow the participants to explore the subject.

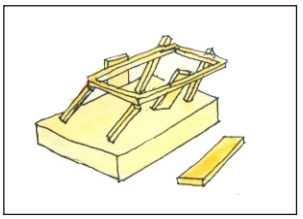
Examples:



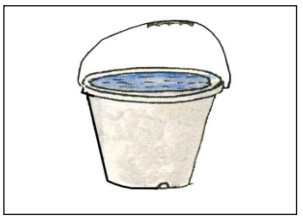
"Why a bus does not fall apart while traveling fast on a rough road?"



How the cardboard box with flaps open deforms and the one with flaps closed remains firm.



How the table can shake back and forth when pushed, and break when joints between the legs and the top are weak



How stiff the top rim of a bucket is compared to the portion below. when filled with water it can totally deform without this rim

The rules given in the MM-5 could be explained simply using the visuals shown in it and the explanation given. Every visual is adequately explained in simple language. Some of the rules are covered here especially because these are routinely violated and that results in to much damage in a disaster.

NEVER DO THE FOLLOWING

- Wrongly situating a building in hilly area.
- Constructing buildings of odd shapes
- Constructing very long buildings
- Not making proper connections between exterior walls and interior walls
- Building high masonry parapets
- Building very thin partition walls
- Building high load walls projecting up above roof
- Making too many or very large openings in walls
- Constructing masonry columns without reinforcement
- Constructing column-like RC elements without beams to support the roof and floor above.
- Making large cantilever elements like sunshades and balconies

It is important that extra emphasis is put on the rules concerning these mistakes.

Lunch Break - Duration - 1 Hr.

Session 3	Duration 3:00 hr	Hands-on Training

Activities to be covered

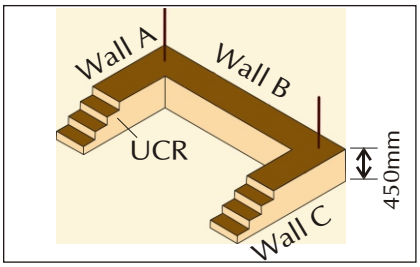
1. Basic Rules of Good Quality Construction (MM-6)

Since good quality of construction is prerequisite to good performance in any disaster, much attention should be given to ensure that the participants understand the rules and also appreciate the need to adhere to them.
This session is also based on the most common violations of the basic rules of good construction practice that result in to major damage during disaster. **Every rule covered under this Chapter should be treated as very important, however simple it may appear.**
Most rules will be covered while doing hands-on work.
Where will the training be conducted?

- **New construction:** Ideally the training for this should be done on a new building under construction where the trainees can come at three different stages for training so that all the important points can be covered. But if construction of a new building is not possible then it may be best to use mock-up.
- **Mock-up:** Alternatively the training can be conducted on a mock up where various parts are constructed as needed during training. Mock-ups will have to be prepared in advance and brought to a particular level before training as describe in Chapter 8 " Mock-up Planning & Execution".

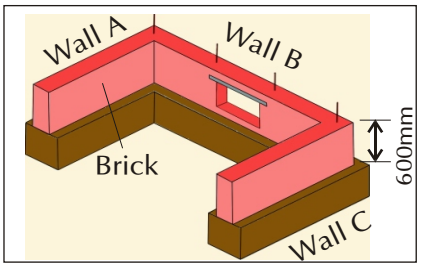
Bring Mock-up to the level described below

Mock-up" A"



- Get two vertical reinforcement bars cut and bent.
- Install one vertical bar with full embedment in concrete at base and supported with props.
- Insert PVC pipes on all vertical bars and construct UCR masonry along walls A, B, and C, doing it in stepped manner at both corners up to 450mm (18") height from ground. Encase vertical rods in concrete with proper ramming.
- Get the reinforcement for the plinth level band, cut and bent for walls A, B, and C.

Mock-up"B"



- Consider the top of constructed wall as the sill level. Let all the trainees know that this is a mock-up, so it is not necessary to build full height walls.
- At this level install the sill level "U" shaped rod in concrete to show the bottom of window encasement.
- Build masonry wall 230mm (9") of bricks or 200mm (8") of concrete blocks (if bricks not available) up to 300mm (12") height along all walls encasing all four vertical bars. Both ends must have stepped construction.
- Place a wooden plank as centering for lintle over the window. Install pre-cut bars with its protruding ends bent as necessary to connect with the reinforcement of the eave level band.
- Bring masonry to 600mm (24") height which is to be considered as the eave level.

Manpower Management:

The trainees will be divided in two groups. Each group will work on one type of masonry for half duration and on the other for the second half. A small group will be made from these two groups to work on cutting and bending of steel for a short time. These persons will be rotated so that others in the group also get to work on steel. Generally it is best to give tasks according to the previous experience of the trainees so that desired quantum of work gets done.

The most important basic rules of good construction and the corresponding recommendations for training are given in a logical sequence as stated below. This should be complemented by the information for each of these items in MM-6.

a. Mortars:

It is very important that the participants understand that mortar makes a major contribution to the strength of masonry and great care should be exercised in making it.

b. Rules for Cement Application:

This is probably the most misunderstood material and, hence, a lot of emphasis in a repeated manner should be placed on the correct method of use of cement so that maximum benefit can be derived from it.

c. Rules for Steel Application:

This is yet another material that is understood very little. To extract the most benefits from steel it is important that the basic rules are understood and followed.

d. Foundation:

Excavation/bottom: This could be demonstrated by simply making an excavation, explaining the firmness of foundation soil, clearing the trench, and refilling it accompanied by compaction. It is very important to convey that back filling has to be done in a systematic manner in small lifts of 150mm (6") followed by compaction

e. General Rules of Masonry:

This covers issues most critical for disaster safety.

- For the rules concerning Wall to Wall Connections it will be best build a "T" or "L" junction with the step like construction.
- The extension of the existing building can be explained by standing adjacent to an existing building since actual construction is not possible during training.
- Small portion of masonry should be constructed by a small groups of participants to work on the rules concerning wetting, use of various tools, vertical joint breaking and filling, and placement of mortar.
- The top of masonry wall at the plinth level and eave level should not to be finished smooth to ensure good bond with the band.

f. Rules specifically for Brick Masonry, Concrete Block Masonry and Stone Masonry.

- For Brick and Concrete Block Masonry the hands on work on the "T" or "L" wall to wall junctions is very important. The rest could be done through simply talking.
- In the stone area a lot of emphasis is required on proper stone masonry since most destruction has been witnessed by wrongly made stone masonry. Every small rule goes to make safer stone masonry. So equal emphasis is needed on each rule.

g. Vertical Reinforcement

To impart ductility to masonry walls and to connect lower storey properly with the upper storey. It is very much important to encase fully and well the bars in concrete. Explain the exact procedure of installation.

h. Lintle Connected to Eave Band

To reduce cracking of walls at the openings. Explain the exact procedure of installation. Make proper connection with the eave band. The rules concerning this will be covered in later session.

i. Opening Encasement

To prevent diagonal cracking starting from corners of door and window openings. Explain the exact procedure of installation from bottom to top. The rules concerning this will be covered in later session.

Session 4 Duration 0:30 hr Hands-on Training cum Discussion

Activities to be covered

This is a very important session since it is beneficial to the participants to help increase the knowledge transfer and its retention. It will also help the trainer assess how much he or she is effective in training. This will help him decide if any refinement needs to be carried out in training. It is not necessary to conduct this session in classroom.

The work on the main mock-up walls will continue so that the desired level is reached. During this the trainers will interact with the trainees recapitulating various points through discussion and actual hands-on work.

Detailed Curriculum Day 2 10

Session 5 **Duration 1:00 hr** **Class-room Lecture**

Topics to be covered

Disaster Resisting Features & Masonry Walls

In order to improve the strength of a structure against a disaster, basic rules of good quality construction have been covered, which dictate how the materials are used. The other aspect which was covered is principals of disaster resistant design which dictate things like house plan, its shape, site selection etc. It is important that both these set of rules are followed. Still the building has several weaknesses that need to be taken care of so that in the event of a disaster the building is able to stand up without much damage.
For this it is necessary to look at the restrictions and rules for masonry walls and the special disaster resisting features that must be installed in the building as described in MM-7

1. Restrictions and Rules for Masonry walls Stone, Bricks, Concrete Block

A. Earthquake Hazard:

For each walling material there are several restrictions on load bearing masonry wall in order to ensure that the inbuilt weaknesses are minimized. These restrictions refer to:

- Thickness of walls for different storeys
- Mortar for different seismic zones
- Wall height and length for different mortar
- Openings sizes for different mortar and different storeys

Cover all rules from MM-7. It is important to make a special mention of mud mortar as described below.

- **Mud Mortar**

Stronger mortar makes stronger masonry and, hence, safer structure. But it does not mean that one can not use mud mortar. If carting cement to the site is a problem or if water for curing is not available then it may be better to use mud mortar for individual house. Since mud mortar is weaker, all rules are more stringent for walls with mud mortar.

B. Cyclone Hazard:

There are a few basic rules that must be followed as given in the MM-7

Important rule concerning the wall openings like doors and window:

- During cyclone it must be possible to keep them tightly shut and even sealed to restrict the high speed wind entering the house and exerting outward pressure on the walls and roofs.
- This pressure along with the suction effect on the roof can blow off the whole roof. So it is best that the wind is not able to enter the house.
- If the wind entering the house is able to get out quickly through similar openings in opposite walls then the wind damage could be reduced significantly.

C. Flood Hazard:

There are only a few principles that need to be followed.

- Plinth height should be kept as high as possible. Ideally its height could be decided on the level of the earlier high flood mark.
- In case of mud mortar it is important that either the wall is fully plastered on both the faces or at least the joints are sealed with cement pointing. Mud mortar loses strength fast upon getting wet, thus weakening the whole structure.

2. Disaster Resisting Features

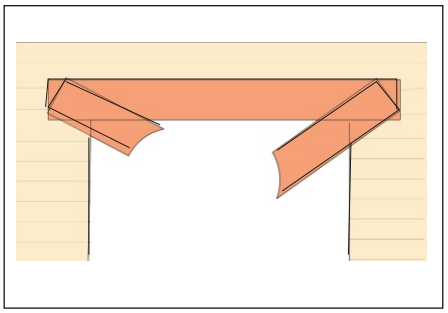
All the basic information is given in MM-7. But additional information and tips are given here to assist trainer in imparting the training.

Tip: It is important that the trainees are able to relate the weaknesses in a building to the remedial measures or the disaster resisting features that should be installed. For this the visuals titled "Disaster Resisting Features at a Glance" in MM-7 should be used against the visual titled "Vulnerability at Glance" in MM-4.

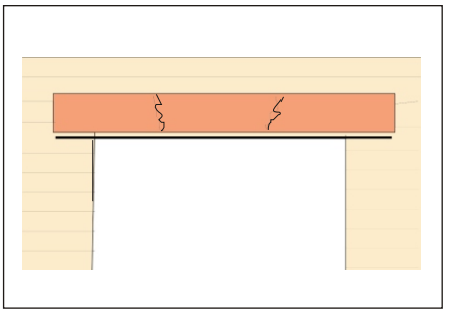
As we know there are weaknesses in every building. We had seen the diagram that shows all the major weaknesses. Now for each of these weaknesses we have to install a special remedy as shown in this diagram. This remedy has a special strength that will get added to the structure and thus help it to get over its weakness.

How do you make sure that this concept will work?

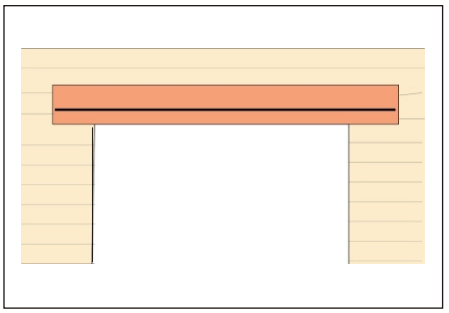
Let us use an example of a lintel that is placed on a doorway.



1. Concrete lintle without any steel bars.
If a wall is constructed on top of it, it will bend, crack and collapse.



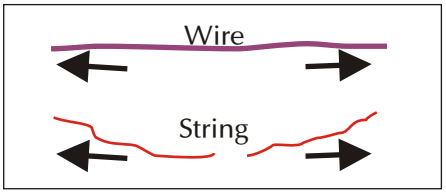
2. Concrete lintel placed on top of steel rods
If a wall is constructed on top rods will bend and lintel will crack.



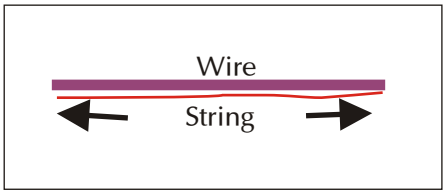
3. Concrete lintel with rods embedded inside concrete
If a wall is constructed on top it will not crack.

Why the third case will not crack? Because steel is totally surrounded by concrete along its full length, and has good bond with the concrete. Hence, it is able to pass on its tensile strength to the concrete that can not take any tension.

Take one more example That of a string and a wire.



Pull the string. It will break when pulled hard. Pull the wire. It will not break because it is strong.



Now take same string along with a wire, hold them tightly together and pull them . String does not break. Because wire being stronger in tension takes up most of the tension

Thus if a strong and a weak material are together with proper bond between them then the weaker material will not fail if subjected to conditions in which it will otherwise fail.

Thus it is very important that good bond is created between the strengthening measure (remedy) and the item that is weak and that needs to be strengthened.

This rule applies to all items that will be installed to strengthen the building or its part.

Now let us see what are the remedies, how they work and how to install them.

We have seen how the building gets damaged under different forces of earthquake and cyclone. The question is:

"How do you prevent this damage?".

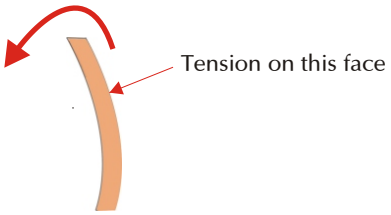
Ask the trainees this question for each damage type and get their response. This is also a chance to see how much they remember about the causes of damage.

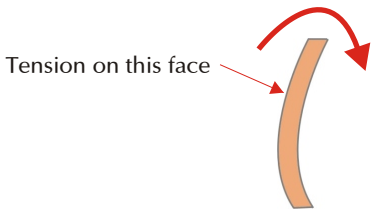
Questions to be asked:

- Why does the corner crack? How will you prevent the corner crack?
- Why does a vertical crack come near middle of the wall? How will you prevent this vertical crack?
- Why do diagonal cracks occur in the wall? How will you prevent these diagonal cracks?
- Why do the door/window openings crack at the corners?

It is possible that some one may talk about a lintel band. If there is such a response then ask the person if he knows how exactly it helps.

A. Vertical Reinforcement Embedded in Masonry: Why is it required? How does it work?

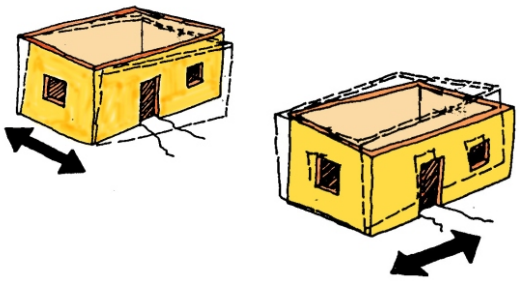




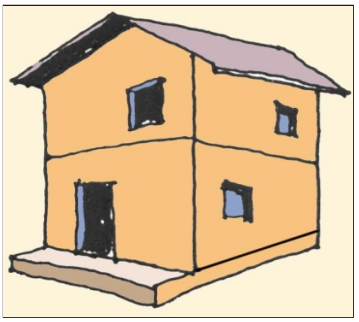
i. Hold this stick vertically and bend it.
ii. What happens in the stick? There is tension created on one face and compression on the other.

iii. Now if you bend the stick in other direction then you get tension on other side.

Similarly with horizontal earthquake force the whole structure bends. This causes tension within the wall which causes damage.



One more point that needs looking in to:
House sits on the plinth. So it exerts horizontal force on plinth in an earthquake or cyclone. If the joint between the walls and the plinth is weak then the wall sitting on the plinth will slide. Similarly the second storey will slide on first storey; or the roof will slide on the wall. Thus the building gets damaged



How do you prevent such damage? Vertical Reinforcement can prevent such a damage.

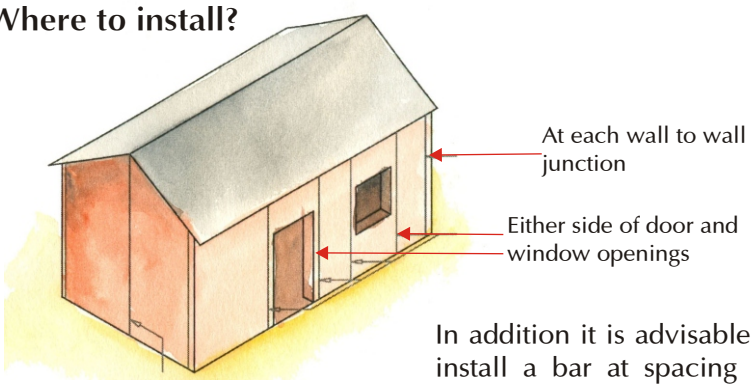
Vertical reinforcement allows the house to bend and return back to its original position without damage. In other words, it brings ductility in the walls.

Vertical reinforcement also strengthens the joints between plinth and wall, first storey and second storey, and, top storey and roof.

It is very important that this reinforcement must be securely connected to the wall in order to make the wall stronger.

Specifications & Procedure are given in MM-7

Where to install?

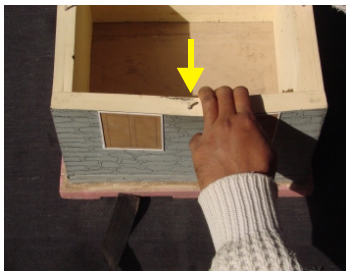


In addition it is advisable to install a bar at spacing no greater than 2m in the walls.

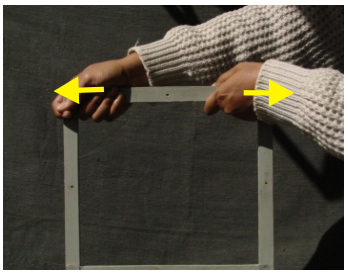
B. RC Band on top of Masonry: Why is it required? How does it work?

To explain how the band works use the Working Model of house.

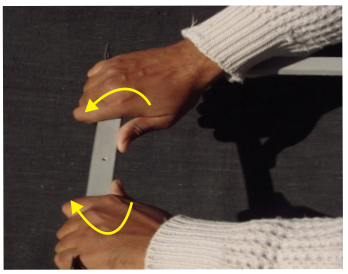
Bending & Corner Separation



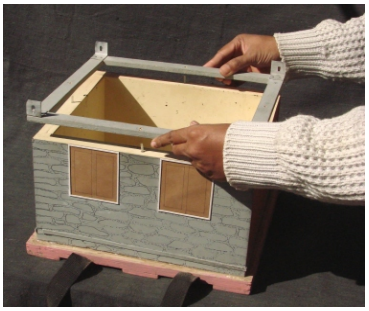
I. Hold the working model and push the wall sideways from middle. This bends the wall sideways.

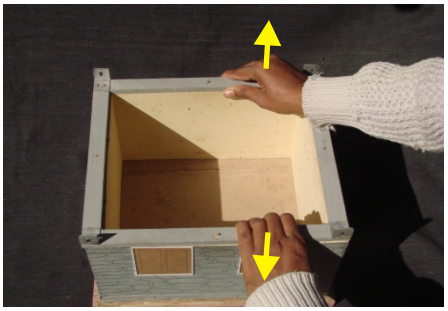


II. Show the band made of a material like wood . Point out that it is very thin but is strong in tension. Pull it.

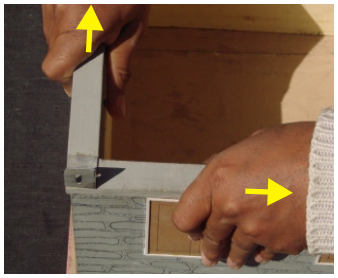


III. It is also strong in bending. Holding it horizontal, bend it to demonstrate the strength.

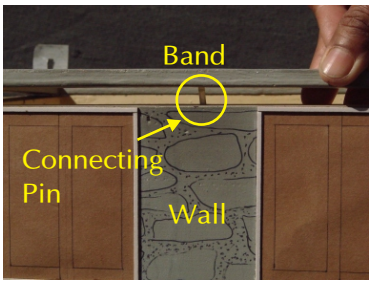




IV Now install the band on top of the model and once again try to push the wall sideways. Show that the bending of wall is almost eliminated by the band. This shows that the band placed at the top of the wall resists the side way forces and thus saves the wall from its effect. So the vertical cracks in the wall will be prevented.



V. Since the band is continuous (without any cuts) at the corner it prevents cracking at corner



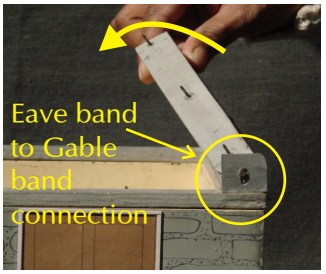
VI. Similarly when band is connected properly to the wall (show the connecting pins), it will resist the tension and save the wall when wall comes under diagonal tension. Thus the diagonal cracks will also be prevented.

IMPORTANT:

- **For the Band to be effective it must be complete without any discontinuity. If it is made of reinforced concrete then the bars must be continuous without any cut.**
- **For a band to strengthen the walls, it must be well connected to walls. The strength of the wall will increase with the installation of additional bands.**

Gable Wall Weakness

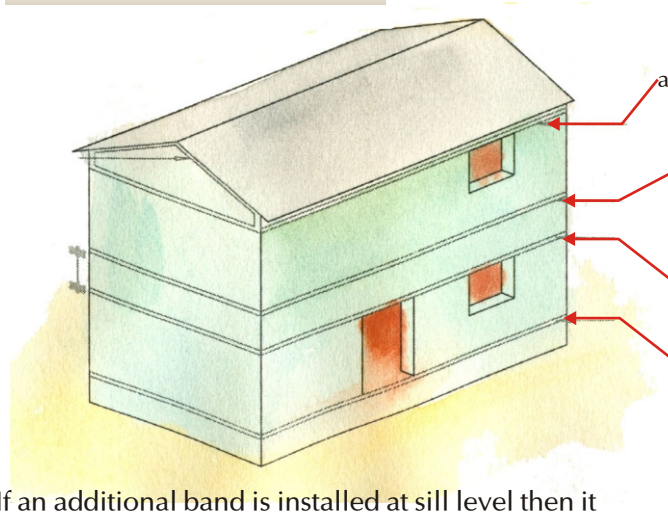
I. Take the model with its gable walls upright



II. With the horizontal force the gable wall tilts to one side, thus getting damaged.

Installation of band along the top of gable wall could greatly strengthen the gable wall. It is important that such a band is well connected to the eave band at the base of gable wall.

Where to install the band?



at eave level in pitched roof.

In case of timber floor a band just below that level must be provided.

In pitched roof or RCC roof buildings, a band at lintel level is needed if the gap between eave and lintel level is 600mm (24") or more.

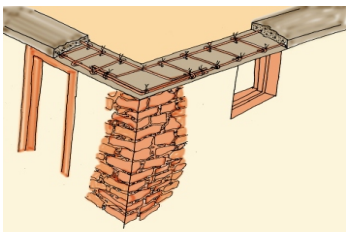
This band, if installed at plinth level, it makes the structure stronger against flood damage such as the cracks due to small settlements in wall.

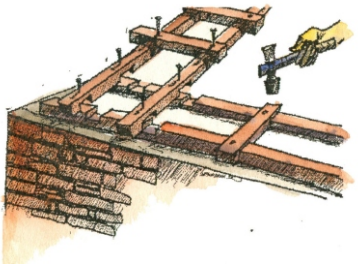
If an additional band is installed at sill level then it will help make the structure even stronger.

What materials could it be made of?

It must be something that is strong in tension.

Reinforced Concrete the specifications are Given in MM-7





Timber, where it is not possible to make RC band or is too expensive.

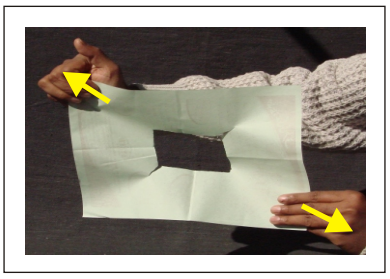
Some kind of wire mesh such as Chicken Wire Mesh or Expanded Metal also can be used if one can not afford RCC..

Special cautions

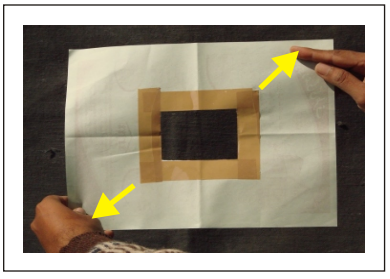
- The reinforcement details at the "T" and "L" junctions must be done strictly in accordance with those shown in MM-7.
- All steel bars must be connected with proper overlap.
- Where ever the vertical reinforcement passes through it, it must be properly connected to the band reinforcement as shown in MM-7.
- All reinforcement bars must be fully encased in concrete.
- Where the gable band is to be installed, the reinforcing rods of the same diameter as those in the band must be taken out projecting from the eave level band in order to connect the gable band rods with eave band with proper overlap.

C. Door/Window Opening Encasement

1. Show paper with square opening The tearing begins at corner of opening when it is pulled Opening creates a major weakness.



2. Take another paper with tapes pasted all around the opening. Pull it and see that the paper does not tear.



This demonstrates that the weakness created in wall by openings can be removed by attaching something all around the opening that will prevent the tearing.

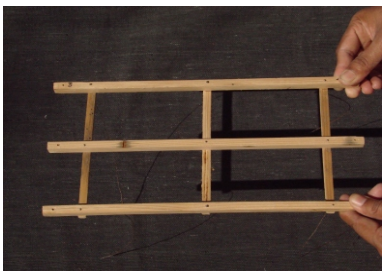
This can be done by reinforcing rods or some types of wire mesh.

It is very important that any of these materials must be securely connected to the wall to be effective.

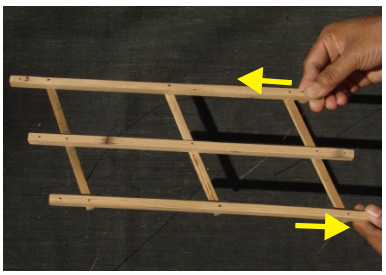
D. Roof Diaphragm Making

Under the effect of earthquake or cyclone forces the roof gets distorted from rectangle to parallelogram shape. This causes much damage in walls.

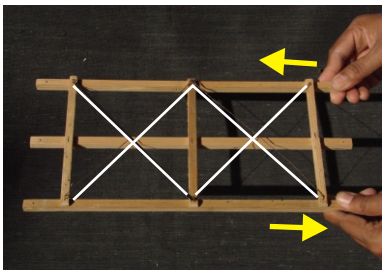
See how this roof frame of the Working Model gets distorted.



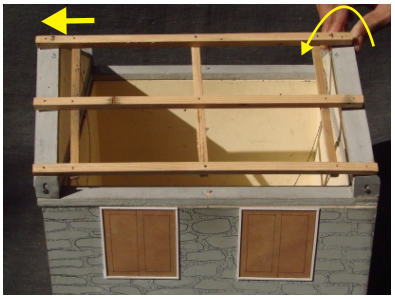
1. Show the undistorted portion of rectangular roof.



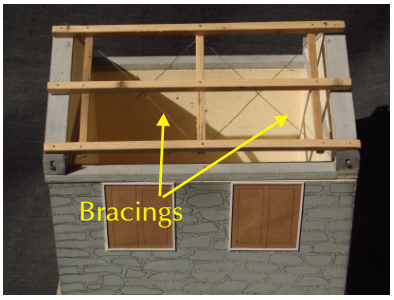
2. Next push one end to change the roof shape to parallelogram



3. Next install the diagonal bracings to show how it is not possible to alter this shape.



4. Install the roof without diagonal bracings, on the gable walls and show how the roof deforms and the gable walls tilt back and forth, resulting in to cracking of gable walls.



5. Now install the bracings and show that since the roof will not deform, it will not allow the gable walls to shake back and forth.

From the photographs in MM-7 show the different arrangements such as "X", "K", "Y" bracing configurations. Also show different materials like GI wire, timber and MS angle and how they can be used as bracings.

Caution:

- **It is very important that "Struts" are installed while installing the bracings. Without the struts, the bracings will not be effective.**
- **If the roof is RC then such bracings and struts are not needed since RC slab does not get deformed.**
- **The roof and the walls will get the benefit of the bracings only when roof is securely connected to walls. This is true in case of RC slab also.**

E. Roof Anchoring to Walls

Explain different options for anchoring of various parts of roof to walls as covered in MM-7.

It is important that the replicability and affordability of the option is considered in training, since it will be possible to replicate these options only if they are viable

F. Floor Diaphragm Making

How the distortions occur and how bracings prevent it can be demonstrated in the same manner as the roof diaphragm.

- The material options are covered in MM-7
- Anchoring of RC slab must be done as shown in MM-7

Caution:

All the cautions described above under roof diaphragm will apply to floor diaphragm

G. Floor Anchoring to Walls

- Explain different options for anchoring of various parts of roof to walls as covered in MM-7.
- It is important that the viability of the option is considered since only the viable option can be used.

H. Making a Stronger Roof

Roofs are generally made very weak with very poor joints between different members of roof. It is important to make it strong to withstand the forces of earthquake and cyclone.
All necessary information is provided in MM-7. Explain in accordance with this.

I. Miscellaneous Issues

Cover following issues as shown in MM-7

- Knee braces at the timber beam to column connection
- Securing of doors and windows against earthquake and cyclone
- Damp Proof Course: Put emphasis on different options on account of varying cost.
- Flood resistant plinth: Put emphasis on different options on account of varying cost.

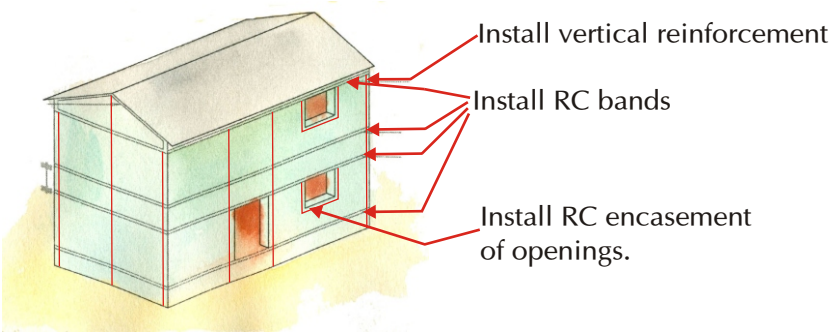
Important points to remember:

- Connect all members of roof framing properly.
- Anchor securely different parts of roof to eave and gable walls
- Install collar beam between opposite pair of rafters.
- Install RC load walls on gable walls to hold down pitched roof structure on gable.
- In cyclone area install RC strips on pitched roof.
- Anchor all clay tiles with wire hooks.
- Tie down bottom most row of tiles with GI wire or steel bar.
- Use "U" and "J" bolts for AC and CGI sheeting.

Session 6 **Duration 3:00 hr** **Hands-on Activity**

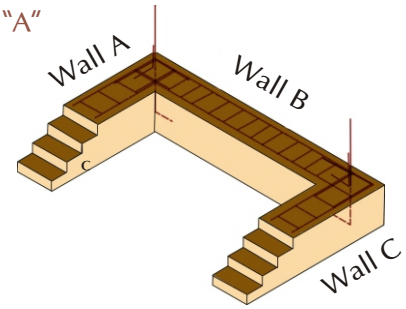
Disaster resisting features (MM-7&8)

How to make strong disaster resistant walls and openings?



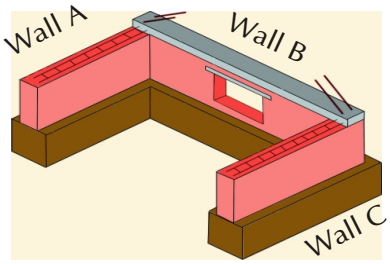
Bring Mock-up to the level described below during this session

Mock-up "A"



- Install Plinth band reinforcement on all three walls at plinth level
- Tie all vertical bars to plinth band reinforcement with L shaped reinforcing bars
- Place concrete to encase the portion of vertical bars that is within the masonry.

Mock-up "B"



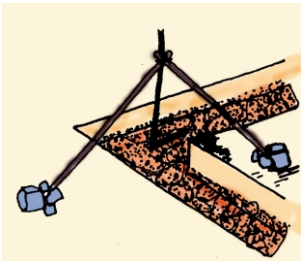
- Install eave band reinforcement on all walls.
- On wall B connect the extended lintle bars to the band reinforcement.
- Cast concrete in wall B portion only.
- Place high priority on band concreting and get it completed first so that it begins to harden when Session 7 begins so that gable wall can be built..

Manpower Management:

The trainees will be divided in two groups. One will work on Mock-up "A" and other will work on Mock-up "B" . After a while they will be switched. Trainer will have to make sure that all trainees get to work on all items. While some are mixing dry ingredients for concrete, the other will work on steel cutting and tying, and later one group will mix the concrete and other will do the concreting.

All items are to be done on the main mock-ups unless it is not possible. In such a case it will done on the side.

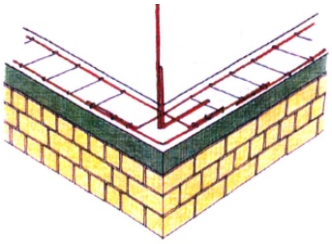
a. Vertical Reinforcement



This item was executed in Hands-on Session 3 during the construction of the UCR wall. So basics of how it is to be encased in concrete withing the masonry has already been covered.

- since this item is already done, some additional explanation about the procedure and the cautions should be covered in this session while standing in front of the mock-up.
- Emphasis must be placed on all the locations where the bar must be installed.

b. Plinth Band installation



- Finish preparing the reinforcement, place it on the wall and tie it all together
- Ensure proper connections of reinforcement at the wall junctions
- Include T & L wall junctions. If T can not be done on the main mock-up then do this on the side.
- Make proper connection with the vertical rods at all locations.
- Follow the procedure described in MM-7 taking all necessary precautions.

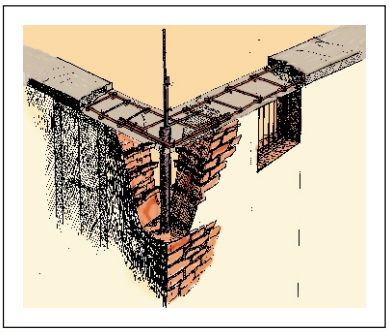
Do not forget to explain the following:

- The bar size requirement as per Seismic Zone.
- Trainees should be made aware that in long walls larger size bars would have to be used.
- In every band the longitudinal bars will always be at mid height of band.
- Band can work as the damp proof course if proper concreting is done.

Extra emphasis must be placed on the following items that affect the strength as well as the longevity of the band:
(a) Adequate concrete cover,
(b) Possibility of bar corrosion
(c) Need for continuous rodding
(d) Proper arrangement of bars at the wall to wall junctions
(e) Proper tying with binding wire
(f) Straightening of the crooked bars before use etc.

c. Eave Band installation

- Follow all the precautions that were followed in Plinth Band in regards to the cutting, positioning and connecting of all the reinforcement.
- Carry out concreting correctly with the right proportions of ingredients in concrete, and ensuring proper encasing of bars.



Do not forget to explain the following:

- Proper connection with the reinforcing bars from the lintel
- Installation of reinforcing bar dowels for the connection of eave band with gable band
- Connection of the top end of the vertical bar with the band reinforcement

D. Opening Encasement

This item was executed in Hands-on Session 3 during the construction of the UCR wall. So basics of how it is to be encased in concrete within the masonry has already been covered.

Remember the rules for spacing and sizes of openings

Opening encasement

Go over how encasing is to be done for window and door.

Important points not be forgotten are:

- Follow all rules and cautions applicable to the vertical reinforcement.
- Vertical leg of the 'U' bar in window encasing must be properly tied to the vertical reinforcement.
- Positioning of the vertical bars must be done keeping in mind the exact position of door/window and minimum possible thickness of masonry and concrete between the bar and the opening.
- For door the vertical rod need to start from the plinth level and for the window it need to start from the sill level. But it would be better and simpler if these rods are started from the foundation just like the rods at the corners.
- If rules of opening sizes and spacing are violated then the encasing of openings is a must.
- Review these rules concerning the openings.

Lunch Break - Duration - 1 Hr.

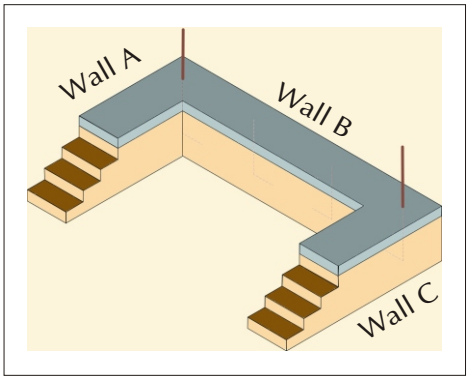
Session 7 | **Duration 2:30 hr** | **Hands-on Activity**

Items to be covered

1. Continue and finish the incomplete items from Session 6
2. Construct Gable wall
3. Gable top RC bands
4. Construct concrete block masonry.

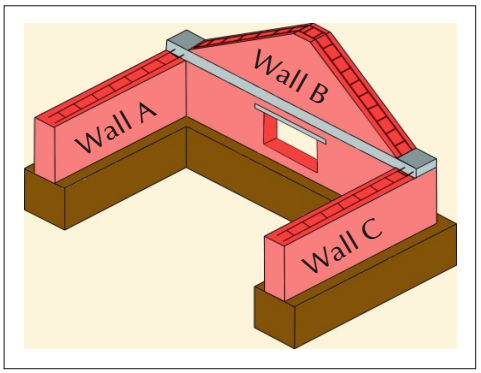
Bring Mock-up to the level described below during this session

Mock-up "A"



- On all walls, finish concreting of plinth band, if time permits.
- Construct Concrete Block masonry with vertical bars embedded in it at two corners.

Mock-up "B"



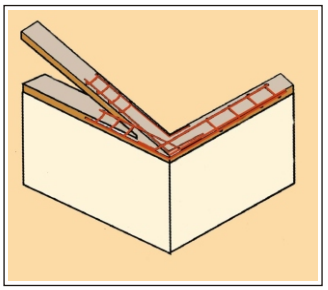
- On wall B construct gable wall.
- Prepare reinforcement for Gable Band.
- Install gable reinforcement connected to the dowels extending out from eave band.

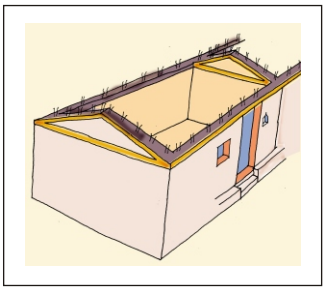
Manpower Management:

The trainees will be divided in two groups. One will work to finish the plinth band on A-C-F-H wall and other will work on the gable of M-N-Q-R wall. After a while they will be switched. Next one group will begin working on preparing the reinforcement for the gable band.
Trainer will have to make sure that all trainees get to work on all items. While some are mixing dry ingredients for concrete, the other will work on concreting.

E. Gable Band Installation

Train as per information given in MM-7



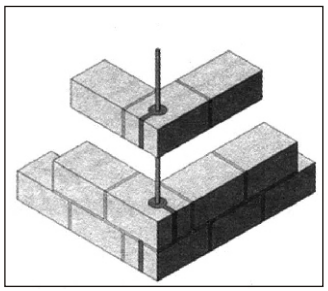


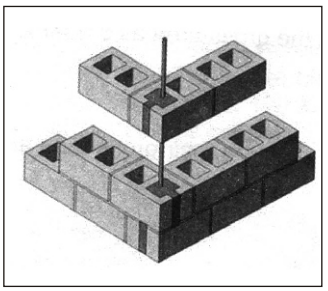
Do not forget to include the following:

- Positioning of gable wall masonry and the RC band without disturbing the interface between the roof understructure and the masonry, and the normal alignment of roof.
- Proper connection with the Eave level band
- Miscellaneous precautions that need to be taken with respect to the reinforcement which is same as those with other bands

F. Concrete Block Masonry

Train as per information given in MM-7





Do not forget to include the following:

- Different types of concrete blocks and their use, especially for accommodating vertical reinforcement
- Basic rules of masonry and rules specific to concrete block
- Bonding at wall junctions
- Installation of vertical bar within concrete block masonry

Infrastructure- steel rods, binding wire, steel rod cutting and bending set up with hammers, chisels and tongs, pliers, binding wire tightening tool. The trainees must be instructed in advance to bring their personal tools relevant to the training.

Manpower- A trainer engineer, a junior engineer, a Master Craftsman for a batch of no more than 20 trainees, an assistant for administrative tasks and for ensuring logistical support. 2 labourers, The trainees must be informed in advance that they will be expected do all the unskilled work that is to be done such as bringing material to the site, mixing concrete or mortar, clearing up the site etc.when required

Handouts Booklets, pamphlets

Session 8	Duration 1:00 hr	Lecture
	Topic to be covered	

I. Recapitulation of the whole days work.
II. Complete discussion on any items left out from MM-7.
III. Commonly Committed Mistakes in Construction of Load Bearing Masonry
IV. Show photographs of mistakes (MM-10)
V. Ask trainees to identify the mistakes.
VI Discuss.
Note: Repeat this viewing of photos and discussion to make sure that the trainees understand and remember them properly.

Detailed Curriculum Day 3

Session 9 **Duration 2:30 hr** **Hands-on Activity**

Topics to be covered

Disaster Resisting Features (Cont.)(Refer to MM-7 for all the information and guidance.) More important points are described here.

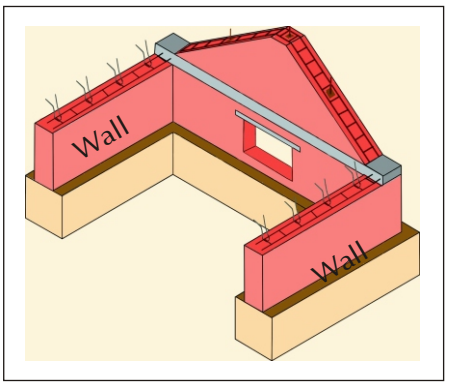
- Continue and finish the unfinished items from the earlier session
- Installation of anchors for roof & floor
- Installation of Collar beams in pitched roof
- Install diagonal bracings and struts for Floor & Roof
- Securing roofing to roof frame and wall
- Secure RC slab to wall
- Stiffening of timber beam to column connection with knee braces

The topics that would be covered will depend upon the type of construction commonly used in a particular area. Barring one item all the items mentioned above will be best covered in one or more existing buildings.

Bring Mock-up to the level described here during this session.

Mock-up "B"

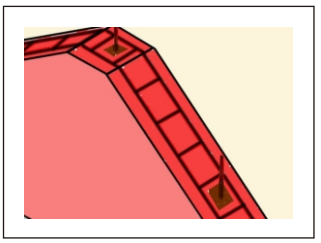
- On walls A & C where eave band reinforcement is left exposed install various types of anchors for roofing and flooring.
- Install anchor bolts in the Gable Band reinforcement.



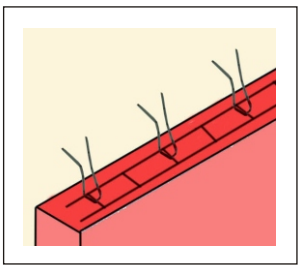
Items to be done on the Mock-up :

1. Anchors in Gable Band.

- 12mm diameter bolt with MS Plate at its base - MS plate gets anchored in concrete while the bolt protrudes out. This could be used for ridge and intermediate beams.
- 2-10 gauge GI wires tied to cross-links and its ends left protruding out - Prior to concreting the band, this is done in such a way that wires of enough length project outt o tie down the roof members . Wires are twisted to anchor down the roof member. In the gable this could be used for purlins and small beams.



2. Anchors in Eave Band.



- MS Angle with 6mm diameter rod to be welded to it - When anchored in concrete the 6mm dia rod prevents the angle from getting pulled out. This is for anchoring the timber floor to walls.
- 6mm or 8mm TOR rod protruding out of band - "L" shaped rod with the short leg anchored in concrete and the long leg projecting out, adequately long to anchor down timber joists or beams . The long leg is bent over the joist with a hammer and attached to it with a couple of nails.
- 2-10 gauge GI wires tied to cross-links and its ends left protruding out - Prior to concreting this is done such that wires of length enough to tie down the roof member project out. Wires are twisted to anchor down the roof member. In the gable this could be used for purlins and small beams.

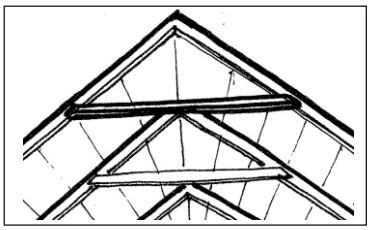
3. Roofing to gable wall connection through RC load wall.

As shown in MM-7 install U shaped 8mm TOR dowel bar with one leg attached to the open reinforcement in the gable band, and the other end attached to a 8mm TOR reinforcement of RC load wall that would go over the roofing tiles and purlins.

Items to be done in Existing Building:

1. Collar Beam in Pitched Roof

- Just take one pair of rafters and install Collar beam: Pre-drilling is a must. Use at least two nails or screws at either end of Collar beam.
- Improve timber to timber connections: Work on each option including 10 to 13 gauge double GI wire twisted around the members, 15 to 20mm wide sheet metal strips nailed to the members, 3mm MS flats screwed or bolted on to large size members

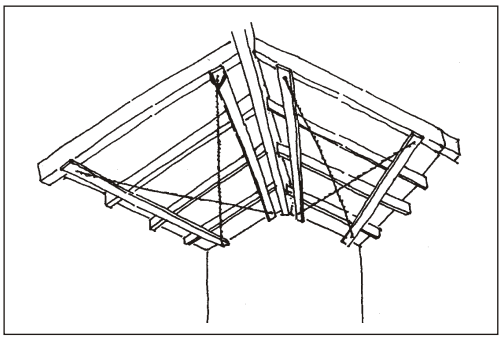


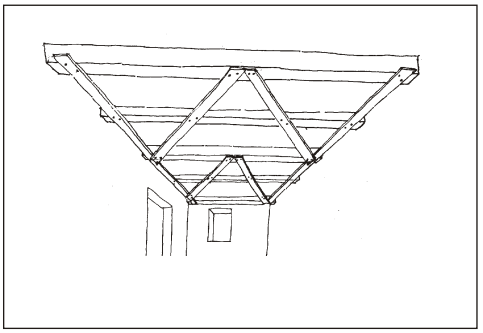
2. Bracing & Strut System for Roof/Floor made with different materials

Show different configurations possible

- "X" Bracings: GI Wire cross ties with timber struts -
- Follow the systematic procedure given in MM-7 to make diagonal ties of 13 gauge wires
- First install timber struts with the help of at least two nails at each end.
- Use 4 to 5 strands of wires, tied one after another
- Twist them all together to pretension the tie.
- It is important that each wire is pulled hard with the carpenter's hammer first so that there is no slack.
- Twisting is done with a piece of 8mm dia rod. It will tighten the tie further. Too much of twisting could result in to breakage of the tie.
- Under a timber joist floor use timber bracings.

  "K" or "Z" Bracings: Timber diagonal bracing with timber struts
- Joints of timber bracings are more difficult
- Use steel gusset plate and bolt is recommended for this
- All bracings should preferably at 45 degrees inclination to struts to be most effective
- All timber components should be pre-drilled to prevent splitting or cracking





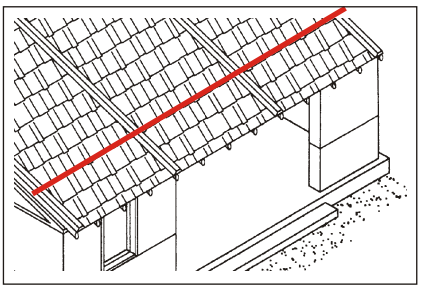
3. Anchoring of Roofing including clay tiles & CGI/AC sheeting to roof

Cover various options included in MM-7 including

- For Clay tiles
- GI wire hooks
- RC strips with positive anchorage with timber understructure in high wind hazzard area (Wind Zone IV & V)
- For AC/CGI sheeting
- J hooks
- U hook in high wind speed area (Wind Zone IV & V)

4. Eave level Roofing Tile Anchor

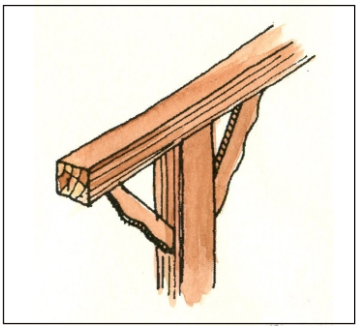
- As shown in MM-7 install minimum 2 strands of 10 gauge wire properly stretched.
- The wires must be anchored at both ends in to the eave board
- Alternatively, 6mm MS rod also can be used for this purpose



Items to be done in Existing Building (cont.):

5. Anchoring of RC Slab to wall

This can be effectively demonstrated by conducting training at a site with RC slab on masonry walls. In the absence of such a site it could be explained at a training site. A sample of an anchor bar similar to that in MM-7 could be shown along with a few bars representing the slab reinforcement. This could be placed next to the mock-up wall for better understanding.



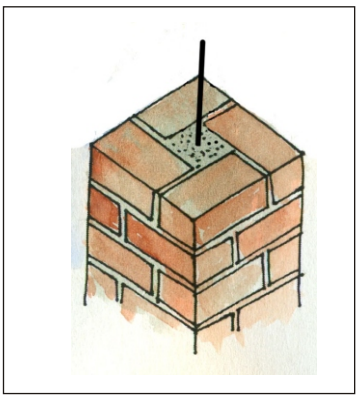
6. Knee-braced Beam-Column Connection

This could be covered only if timber columns are used locally in buildings. Follow instruction in MM-7.

7. Reinforced Masonry Column

This is a very important item that must be included in the training. It is not necessary to construct a full height column. But the trainees must be convinced that unreinforced masonry columns must not be built. For the purpose of training, it is necessary for the trainees to lay a few courses with reinforcement placed in the hollow core of the column to understand how it is built.

Do not masonry column without reinforcing bar.



If time is not adequate then the items being carried out in an existing building may be carried out in the Session on Retrofitting.

Manpower Management:

The trainees will be divided in several groups. One will work on installation of various anchors in the bands; One will do/observe the installation of bracing & strut system in the roof/floor; One will do/observe the making of improved connection among roof components.
Trainer will have to make sure that all trainees get to work on all items. While some are mixing dry ingredients for concrete, the other will work on concreting.

Session 10	Duration 1:00 hr	Lecture

Topic to be covered

Material Quantities for Disaster Resisting Features. (MM-9)

Follow the instructions given in MM-9. It is important that the trainees get some understanding of the material quantity if they are going to promote these options.

Session 11	Duration 0:30 min	Lecture

Topic to be covered

Commonly Committed Mistakes in Construction (MM-10)

This is a short but very important session and much emphasis must be put on it. The trainees must be aware of these mistakes to consciously avoid making them.

Lunch Break - Duration - 1 Hr.

Session 12 **Duration 1:00 hr** **Lecture**

Topic to be covered



a. Restoration - Why?

A structure loses part of its strength upon getting damaged . If earthquake or wind forces strike this structure, it could get damaged further since the damage has increased its vulnerability. In 1956 there was a big earthquake in Anjar, Kutchch. The damaged buildings were simply patched up. Thus the damage was simply hidden under new plaster and paint. In 2001 Kutchch Earthquake these houses were destroyed because their extra high vulnerability. So it is very important to restore the damaged buildings to their pre-dmage state.

b. Damage Categorization: Why and What?

Damage categorization is required to quantify the damage level and standardize the restoration procedure for each level. It also provides a common language of communication about the severity of damage. It instantly gives an indication of how serious the damage is. So it is very important to understand how the category of damage is determined.

Explain damage categories based on the photographs given in MM-11.

There is a tendency of an inexperienced person to over estimate the damage category. Since the definition of the category is very precise it is not left to the interpretation of an individual. It is important for the person assessing the damage to do so based exactly on the definition of each category. The corrective action depends solely upon this assessment. The plaster on the damaged wall tends to exaggerate the visible damage level

c. Damage Restoration Procedures

Explain the restoration procedure for each damage category based on the sequences given in MM-11.

The options included for the corrective action taken in to account the problems availability of special materials and equipment. Hence, simpler alternatives are included.

d. Confidence Building Video Show

Show video titled "See it to Believe It" of shock table test prepared by NCPDP, Ahmedabad in the aftermath of Kutch Earthquake. In this video the trainees will see an artificial earthquake happening in front of their eyes and some ordinary building models collapsing while other models with improved technology not collapsing. This will help demonstrate that the technologies covered in this manual help prevent the collapse of buildings.


Session 13 **Duration 2:30 hr** **Hands-on Activity**

Advance Preparation

For hands-on training it is necessary that one or more buildings with different types of damage are available to work on. This has to be done in advance. It also may require getting permission from the house owners of these buildings so that the trainees can enter these houses and see the damage and even work on restoring it. Even in the absence of a disaster it is generally possible to find some damage in every building. The other alternative is to damage the mock-up using a crowbar, create damage and restore that.

a. Categorization of Damage

- First of all go over the definition of each category
- Next go around the buildings and point out different damages and ask the trainees to categorize them
- Discuss their answers and correct them if necessary.
- Try to reinforce the categorization procedure in their minds.

b. Restoration of Damage

- For each category identify a few points in the building where the restoration can be done.
- Get the measurements of each one of the damages
- To begin with take G2 and G3 damage and let four groups work on their restoration, each mason taking turn.
- Use the option of WWM, C-Clamp and 8mm TOR rod splice so that trainees get the feel for each one of them.
- Grouting must be included in the training since it is a new activity and very few have feel and understanding of it.
- It may be a good idea to even make the PVC pipe grouting hand-pump during the training.
- In case of G4 category it may be difficult to find examples, or, if an example is found, to undertake the restoration since it would require more time than what is available. But it is best that the whole restoration procedure is discussed on site demarcating exactly what has to be done and what cautions are to be exercised.

- In case of G4 category extreme caution has to be exercised during the restoration work since in this category a part of the building is in a state of impending collapse.

(i) **G4 case with the intact RC roof supported on severely damaged walls:** This requires extreme caution and thorough planning.

- The propping up of the slab must be done very systematically.
- As is shown in the photograph and visuals in item D on the last page of the MM-11 the slab has to be propped up from out side and inside very close to the wall.
- It should not be supported at points away from the walls, otherwise it could badly crack at top.

(ii) **The restoration of a partially collapsed RC slab:** **This procedure** also must be explained clearly.

- At first observe the immediate reaction of most every one which most likely will be to recommend the demolition of such a building. This is out of ignorance.
- It is not difficult to restore, if tackled in a systematic manner.
- It is safe to restore the building and save the undamaged portion of the slab.

Detailed Curriculum Day 4

Session 14 **Duration 1:00 hr** **Lecture**

Topics to be covered

Retrofitting of Existing Load Bearing Masonry Structures (MM-12)

So far in this training everything has been about constructing disaster resistant new buildings. But what about the buildings that exist and are not built to withstand a future disaster? There is no need to demolish them and rebuild to ensure safety against future disaster.

To understand this concept, look at this old carton.

Suppose you have to carry a lot of heavy books , and you have this old carton. What would you do? Use this carton or buy a new one? Get answers from trainees. Will the carton tear? If yes, then what can be done?

The best option is to strengthen it before filling it up with heavy books. It is easy, cheap and fast.
How can you strengthen it? Which part is the weakest that needs strengthening? Which is the weakest part of the carton from where it will tear under the weight of all the books? Get answers from trainees.

Apply tape at corners to make sure they do not tear, and to ensure it even more tie a string around it.

Carton is cheap to buy. But a house costs much much more. So if it is not strong enough for a future disaster would you dismantle it and build a new one? Get answers from trainees.

The best option is to strengthen or retrofit the house to face a future disaster because it has many advantages over rebuilding. See MM-12.

Retrofitting means applying remedies to a weak building in order to overcome its weaknesses before it falls sick.

We have already discussed and understood the weaknesses in a building (MM-4). We have also discussed what features need to be installed in a new building to make it disaster resistant (MM-7). What we now have to see is how we bring each of these features in an existing building. This is covered in MM-12.

Show the "Retrofitting Features at Glance" diagram in MM-12 against the "Vulnerability at Glance" diagram in MM-4 to enable the trainees to relate the weaknesses with their remedies and the part of the building that needs that remedy.

1. RC Bond Element:

Ask a question: In thick stone walls, when shaken, the outer and inner faces of wall can separate. Why? Check how much do the trainees remember.

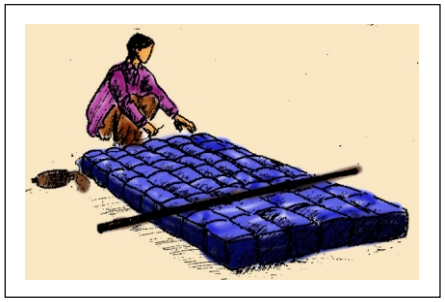
The remedy for this is the **installation of Cast in-situ RC Bond Element or simply "Concrete Header"**. It works just like the "through stone".

i. When do we need to install RC Bond Element?

Answer: It is required under the following two situations. (a) Following the restoration of a building that had delamination or bulging damage. (b) If the building has no damage, but the house owner is of the opinion that in the construction of the UCR wall "through stones" were not used or were used fewer than required.

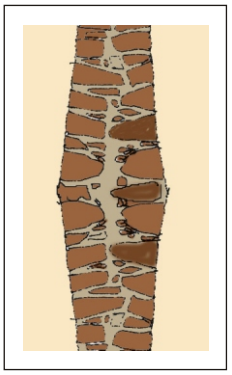
ii. How does a Bond Element work?

Answer: Just like a cotton mattress which has a stitch through its thickness every 6".



Question: If there are no stitches then what happens to the mattress if lifted? Get answers from trainees.

Answer: All the cotton will lump together and cloth on both faces will separate.



Same thing happens to the thick stone wall. All the filler material in the center between two wythes will slump down and one of the outer wythes will collapse.

Bond elements are as important to an UCR wall as the stitches are to the cotton mattress.

iii. Care that should be exercised during the installation of bond elements:

- Extreme care is required while making holes in wall so that that the wall is not weakened.
- The hole must be dumbbell shaped so that by the virtue of its shape both the wall faces are held together.
- In order to make sure that the reinforcing bar contributes its strength to the Bond Element, the bar must be fully encased in concrete.
- All the loose materials from inside the hole must be removed before putting concrete in it.

iv. Where to install a Bond Element?

- Through the thickness of an UCR wall
- One in every 0.8 sq.m. (8sft.)

2. Horizontal Belt:

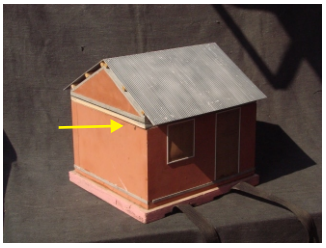
Question: When a wall is shaken vertical and slanting cracks develop. Cracks also occur at at the corners. Why? Check how much do the trainees remember.

The remedy for this weakness in a new building that is to be built is the installation of Band.

i. When do we need to install Horizontal Belt?

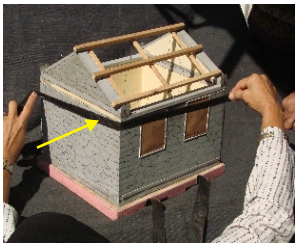
Answer: It is required when a band is not present at different levels as recommended in MM-7.

ii. Why do we need to install Belt?



To install a Band in an existing building, for example, at eave level (show the Working Model), one will have to dismantle the roof and the gable walls

Or to build one at lintle level where one will have to dismantle the slab and part of the wall. That is too expensive. So no house owners will be willing to do that.



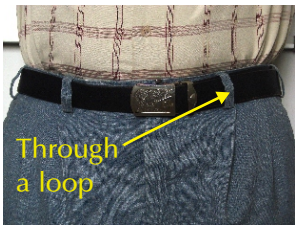
Instead a Horizontal Belt can be installed on the face of the wall without costly dismantling (show the installation of a cloth belt on the Working Model).

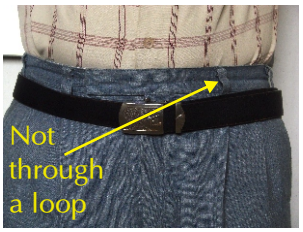
iii. How does a Horizontal Belt work?

Answer: Just like a belt on your pants (point at some one's trousers with a belt) or a string around a carton.

- String helps holding all sides of a carton together
- Belt keeps the pants up.
- Horizontal Belt on a wall will have WWM (show a piece) and bars. So it is strong in tension. This strength can be passed on to the masonry walls.
- If the belt on the pants is not passed through the loops (show loops on trousers) then as the person begins to move, the belt and the pants will separate. In such a case the pants will slide down.
- Similarly the Belt on the wall has to be well anchored to the wall so that when the wall moves due to wind or earthquake, it does not separate.
- Generally the Horizontal Belt is made of WWM with wires of a specific gauge and spacing, plus reinforcing bars, both fully encased in concrete.

Photo of carton with string being tied





iv. Important Points about Horizontal Belt

- Corrosion of the reinforcement, especially the WWM, can be a serious problem. So galvanized mesh is preferred.
- Plaster protects the WWM and bars against corrosion. So proper plastering done with adequate pressure or vibration will remove air from plaster and make it more impervious to water.
- Proper pacers must be placed behind WWM to ensure the gap between the wall and the belt.
- For protection against corrosion the reinforcement must be fully covered with cement mortar and for that there must be a 1/2" gap with the wall.
- Proper bonding with wall is very important for the belt to be beneficial to the wall. This is ensured with use of long nails, shear connectors (explain showing an L shaped reinforcing rod), and the direct bonding with wall which is achieved through raking of joints and cleaning of wall surface.
- The bar must be fully encased.
- Belt alignment must be done properly with the help of tube-level just like in a Band.
- It must be continuous without interruption. Where necessary adequate overlap must be provided in the reinforcement.

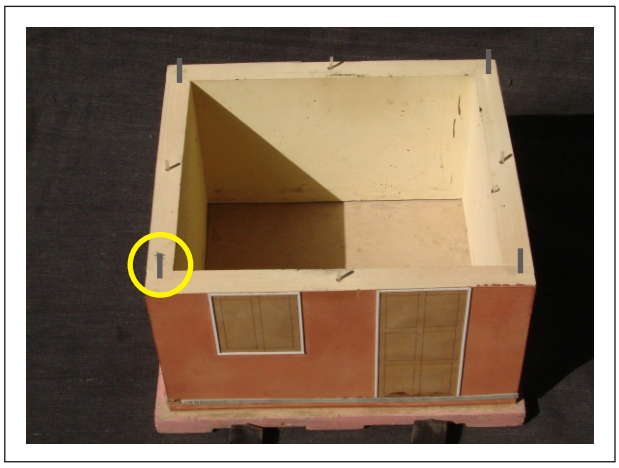
v. Where to install a Horizontal Belt?

- At various levels as recommended in MM-12.

3. Vertical Reinforcement:

When a wall is shaken back and forth, horizontal cracks develop, corners break up and RC slab roof separates from the wall. Why? Check how much do the trainees remember.

The remedy for this weakness in a new building that is to be built is the installation of Vertical Reinforcement inside the masonry walls.



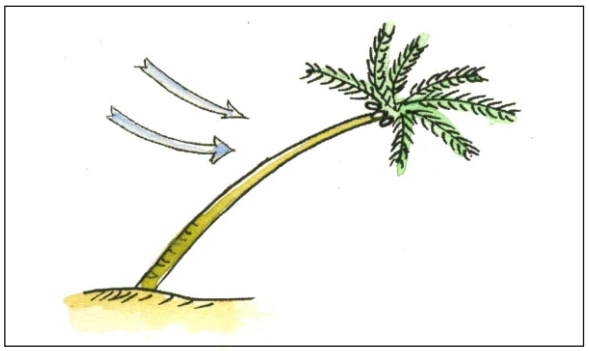
To install such reinforcement in an existing building, one will have to break the corners. That is too expensive and impractical.

Instead a vertical reinforcement can be installed in the corner of the wall (Show stiff "L" shaped GI wire bent at bottom placed in the corner of the Working Model).

i. When do we need to install Vertical Reinforcement?

It is required when such reinforcement as recommended in MM-7 is not installed at the time of construction

ii. How does the Vertical Reinforcement placed on the wall work?



Like a tree which shakes and comes back to its original position, the vertical reinforcement attached to the wall gives ductility to the wall. This helps in bringing back the wall to its original position in an earthquake without damage.

iii. Important points about Vertical Reinforcement

- The size is selected based on the recommendations in MM-7 or MM-12. This depends on Seismic Zone, and number of storeys.
- Continuity from bottom to top must be maintained through adequate overlaps where required.
- Proper bonding with wall is very important for the bar to be beneficial to the wall. This is done through the use of shear connector (explain showing an L shaped reinforcing rod) and the direct bonding with wall which is achieved through raking of joints, cleaning of surface and completely encasing of bar in concrete.
- There are two options A single rod placed on inside corner; or WWM on inside or outside corner.
- The rod must be fully encased in concrete. For this a gap must of at least 40mm must be kept between the rod and the walls and concreting must be done with much care.
- WWM, if used, should be handled just like the horizontal belt.

iv. Where to install the vertical reinforcement?

At various locations as recommended in MM-12

Session 15	Duration 3:00 hr	Hands-on Activity

Topic to be covered

Retrofitting of Load Bearing Masonry Structure (MM-12)

- Bond Element for UCR Masonry,
- Horizontal Belt including an option made of 8mm TOR rods,
- Tie Rod,
- Vertical Reinforcement
- Encasement of Openings

Advance Preparation for All Retrofitting Sessions

- For hands-on training it is necessary that one or more buildings with different types of locally popular building systems are available to work on.
- It also would require getting permission from the house owners of these buildings so that the trainees can enter these houses and work on retrofitting.
- Since the available training time is limited **it will be best if some preparatory work is done ahead of time** on the selected building. This will involve ...
  (a) Removal of plaster from the length of Horizontal Belt and the vertical bar that is expected to be installed in training,
  (b) Raking of joints from half of it,
  (c) In case of UCR wall making of a few holes for the Bond Elements,
  (d) In case of UCR wall making of a few holes for the shear connectors for the Belt,
  (e) Making of a few holes for shear connectors for the vertical rod,
  (f) Exposing of slab reinforcement for connection with the vertical rod, and
  (g) Installation of a few shear connectors for Vertical Reinforcement and Belt.
- This will permit the participants to work adequately on most of the items.
- All this could be done in the first three days of training by hired help.
- The rooms that the trainees will be working on also must be cleared ahead of time.

Planning:

This needs to be done for a batch of 20 trainees. Advance preparation as described above is a must for efficient utilization of time. In addition, it is possible only if (a) the materials are readily available, (b) each group is properly guided and (c) proper sequencing of various items is done.

- The quantity of belt, window encasement, and vertical reinforcement for which the advance preparation is taken up must be such that all of it gets finished during the training session.
- Maximum of 5m (15′) of belt can be installed. In case of the Belt last 300mm (1′ ()) may be left un-plastered if the house owner plans to finish the belt.
- In case of vertical reinforcement it is desirable that one rod (3m) must be installed in a building having RC slab and one (3m) is done in a building with traditional pitched roof.
- One 1m X 1m (3′x3′) window can be encased
- One tie rod should be installed
- 6 Bond elements are installed

Manpower Management:

The trainees will be divided in several groups. Each group must work on every stage of every item. They will be rotated after every half an hour. The activities for the groups could be as follows.

- Work on making a few more holes for Bond Elements and making of Bond Elements
- Work on preparing bars for bond elements and shear connectors, Belt reinforcement and vertical reinforcement, and for alternate Belt made with 8mm TOR bars.
- Work on surface preparation for the belt, make shear connectors, and allow them to harden.
- Work on surface preparation for the vertical reinforcement, makie shear connectors and allowing them to harden.
- Work on installing the encasement belts for a window

Place extra emphasis on the critical points that are mentioned in MM-12.

Manpower Management:(Cont.)

- Work on installation of tie rod
- Once the shear connectors harden, install the belt and followed by plastering and finishing
- Once the shear connectors harden, install the vertical reinforcement followed by its concreting.
- Concreting will be done in stages by different groups
- Installation of a vertical reinforcement and connecting it to RC slab roof (in a different building with RC slab)

Groups will have to controlled, coordinated and supervised closely to make sure that the work is being done correctly. It is also important that none of the items started are left unfinished.

1. Step by step procedure for installation of Bond Elements

Although, MM-12 provides basic and critical information for all the measures, here the step by step detailed information for each measure is given.

- Mark points at horizontally and vertically 1m spacing, with a stagger of 0.5m., thus having one point in every 1.0 sqm. (10 sq.ft) of the wall area.
- Remove the surface plaster of approximately 220mm x 220mm (9"x9") patch at each point and expose the stones. Remove the mortar around the stone to a sufficient depth gently so as to expose the sides of the stone to loosen it.
- Loosen the stone, gently yanking it from side to side, and up and down by means of a small rod with tapered end carefully so that the other stones in vicinity are not disturbed. This rod should be of 12mm. dia. rod, and 750mm length with one end flattened and the other end pointed.
- Pull out the stone slowly, holding it by both hands.
- Remove the material behind the stone gradually to make a 75mm (3") diameter hole through the wall till the stone on the other face is reached.
- Tap that stone to identify it from the far side. Remove this slowly by same gentle process from other side.
- The hole should be bigger in size at both faces and narrower in wall core resembling a dumb-bell. It dose not matter if the hole is inclined instead of level.
- Splash water in the hole to clean off loose materials from surface of stones.
- Place concrete of 1:2:4 mix to fill half the depth of the hole from both sides and place 8mm dia. hooked TOR bar in the hole and fill the hole completely to fully encase the hole. Suitable polymer additive should be used to make non-shrink grout.
- Make sure the entire length of the bar is covered with concrete. The bent length of bar must not be more than wall thickness less 50mm. All bars must be hooked on both ends.
- Cure for minimum 10 days by sprinkling water on the exposed surfaces on both sides. Finish the wall to match the existing wall. Follow the same procedure to make all the bond elements in walls.

Note: Do not make more than 6 holes at a time in a wall, and fill them up with concrete before making new holes at the earliest.
Place extra emphasis on the critical points that are mentioned in MM-12.

2. Step by step procedure for installation of Horizontal belt with Tie Rod

- Study the building and decide the alignment of the belt taking in to consideration the presence of obstructions such as openings, RC elements etc.
- Mark the top & bottom edge of belt on wall using string and tube level.
- Using electric grinder, if available, cut the plaster along the top and bottoms limits of the belt to limit the plaster removal where wall is plastered.
- Remove the plaster from the marked area and expose the walling surface.
- Rake all the mortar joints to the depth of 12mm (1/2") by chisel or by electric grinder. Clean the surface with wire brush and water.
- Prepare the mesh as per required length and attach to it precut 6mm bars with binding wires.
- Install WWM on the prepared surface. In brick or concrete block wall use 100mm (4") to 150mm (6") long wire nails at about 300mm (12") spacing in a staggered fashion in two rows to fix the mesh to the wall. Nails must be driven in to mortar joints. Provide spacers 15mm (5/8") thick of any suitable material between the wall surface and the mesh to ensure full encasement in plaster.
- In case of rubble walls install cast in-situ RC shear connectors with 'L' shaped dowel bar every 1.25m (4') to 1.5m (5'-0"). Once the concrete hardens attach WWM to the bar with binding wire. In addition use 100mm long square headed nails at 150-300mm spacing. Install WWM as described earlier. If a nail bounces back then shift it and reinstall it.

2. Step by step procedure for installation of Horizontal belt with Tie Rod (cont.)

- Ensure continuity of WWM and bars through lap joints minimum 300mm (12") long. If no overlap of WWM is preferred then install 1 additional overlapping bar for splicing with an overlap of 300mm.
- Tie rod shall be 12mm dia MS bar with each end threaded over an adequate length along with two nuts and a 100mmX100mm MS bearing plate. Tie rod shall be installed level from belt on one wall to the belt on the opposite wall going clear through a conduit placed in both walls and the belts. The rod shall be made taut with the help of adequately tightened two nuts at each end.
- Where the belt alignment crosses an opening, change the alignment to go around the opening. In the vertical leg of the belt install additional shear reinforcement as per item number15 under the "Horizontal Belt" in MM-12.
- All tie rods must be in place and made taut, and all holes must be filled with grout before plastering the belt.
- Splash the exposed wall surface with water to remove all dust and also to wet it properly.
- While still wet, apply neat cement slurry followed by first coat of cement : sand (1:3) plaster of 12mm (1/2") thickness. After 1 to 2 hours apply second coat of plaster with same mix and with enough thickness to provide 16mm (5/8") cover over the reinforcement.
- When the thickness of the coat is excessive the plaster tends to fall off shortly after it is applied. Hence, the thickness of a coat should not exceed 16mm.
- Cure the plaster for 15 days.

Place extra emphasis on the critical points that are mentioned in MM-12.

3. Step by Step Procedure for Installation of Vertical Reinforcement

- Identify the inside corner for installation of vertical bar. Select appropriate location to maintain vertical continuity between storeys in case of multi storey structure.
- Mark the area where the bar is to be installed. Using plumb-bob demarcate
- 100mm (4") wide patch at the corner on both walls as the limits of concreting for encasing the rod.
- Using electric grinder, if available, cut the plaster along vertical boundary of both the patches to restrict the plaster removal.
- Remove the plaster from the marked area and expose the walling material. Rake all the mortar joints to the depth of 12mm (1/2"). Clean the surface with wire brush.
- Remove flooring within 300mm x 300mm patch at the corner and excavate to 450mm (18") depth.
- Make holes for installing shear connectors in both walls, starting on one wall at 150mm (6") from the floor, and then at approximately every 600mm (2'0"), but in alternate walls, and finally the last one in the storey height at 150mm below the ceiling level (in more than one storey) or 150mm below eave level. Clean all the holes with wire brush to remove loose material.
- Place appropriate dia bar in the bottom excavation with bottom 150mm (6") bent in 'L' shape. In a structure with CGI roof that is attached to the attic floor the top end could be connected to one of the principal elements of the attic floor. In case of the RC slab roof it will be bent in to 'L' shape for connecting to the slab reinforcement. The rod will pass through each intermediate floor.
- Place appropriately shaped 8mm TOR bar in the holes made for shear connectors and connect them to the vertical bar making sure that the vertical bar is 35 to 50 mm (1/2" to 2") from each wall.
- With vertical bar plumb and at right distance from the walls pour the concrete in 1:2:4 proportion with continuous rodding in the hole in the ground to completely encase the bottom of steel rod in concrete.
- Clean all the shear connector holes by splashing water and wetting thoroughly the surface of the holes. Fill up the holes with non-shrink cement cum polymer grout. Make sure that the grout completely encases the shear connector bar.
- Once all the shear connectors are grouted, clean the exposed surfaces of the wall with wire brush and water.
- Install centering for concreting around the vertical bar. This can be done with GI sheet or timber plank. The concreting must be done in stages with their height not exceeding 900mm (3'- 0") and pour the1:1.5:3 micro concrete in the form work with continuous rodding to prevent honeycombing. Once the concrete is set move the form-work upwards and continue concreting.
- Encase the entire length of the vertical bar in this manner. The bar must have the minimum concrete cover of 15mm.
- Where the roof is of RC slab, in the vicinity of the vertical bar break the bottom concrete cover to expose the slab reinforcing bars. Connect the top bent portion of the vertical bar to the exposed bars of the slab using binding wires providing minimum 300mm (12") overlap. Wet the exposed surface of the slab and then apply neat cement slurry. Finally apply cement mortar in 1:4 proportions and finish the joint to match the surrounding area.
- Cure all the concrete work for 15 days.
- If WWM is not available then prepare the Belt using 8mm TOR rods and 13ga wires and attach it to the wall following the same procedure

4. Step by step procedure for installation of Encasement of openings

- Use WWM (with reinforcing bars if required)
- Install in same manner as seismic belt but using only nails
- Overlap with the lintel or eave level belt
- If on top of the opening there is RC sun shade then the WWM must be connected with the reinforcement of the sun shade.

Lunch Break - Duration - 1 Hr.

Session 16	Duration 3:00 hr	Hands-on Activity
	Topic to be covered	

Retrofitting of Load Bearing Masonry Structure (MM-12)

- Continue and finish retrofitting features already started in the morning
- Anchoring of pitched roof to walls
- Jacketing of masonry column
- Column to Beam Knee Braces
- Anchoring of roofing tiles at eave level
- Anchoring of roofing at various points for tiles/sheeting
- Installation of RC Strip anchored to rafter below
- Installation of bracings & struts under pitched roof
- Installation of bracings & struts under timber floor
- Strengthening of connections among roof members

Note: Since, the hands on training on most of the measures concerning the roof structure are covered in Session - 9 on the New Construction, these items should be covered here in the form of a discussion to refresh the memory of the participants.

Advance Preparation:

The preparation mentioned in the previous retrofitting session applies to this session as well. This part of training will require carpenter skilled in building roofs with all the necessary tools. In many areas, especially the mountainous north, the building artisans have skills of masonry as well as carpentry.

- In case Knee Braces are to be applied, they must be designed and fabricated in advance for keeping it ready at the time of training. Field conditions should be checked to determine the size of the braces.
- If timber floor is to be anchored then Brackets made of MS angle will have to be fabricated in advance. Field conditions should be checked to determine the size of the brackets.

Planning:

Since most of the items mentioned above have been covered once under the training for new construction they may be eliminated. It will be important that the new items be covered first. But, if time permits, different options for the items may be covered, with focus on the regional variations.

Manpower Management:

The trainees will be divided in several groups. Each group must work on every stage of every item. They will be rotated after every half an hour. The activities for the groups could be as follows.

- Work on finishing work started in the previous session
- Work on jacketing of a masonry column if required in local construction
- Work on installation of knee bracing if required in local construction
- Anchoring of roofing if required
- Installation of RC strips if required in local construction
- Installation of bracings and struts under the roof and floor - if required in local construction
- Strengthening of connections of roof members

Groups will have to controlled, coordinated and supervised closely to make sure that the work is being done correctly. It is also important that none of the items started are left unfinished.

Retrofitting of Load Bearing Masonry Structure (MM-12) (cont.)

1. Continue and finish retrofitting features already started in the morning

All items must be finished so that the house owner does not complain, and also in order to prevent corrosion of reinforcement

2. Jacketing of masonry column

- The procedure is well covered in MM-12.
- Extreme caution needs to be exercised not to damage the column
- It is important that the surface preparation is done thoroughly so that the jacketing has good bond with the column

3. Column to Beam Knee Braces

- The procedure is well covered in MM-12.
- Pre-drilling of wood by hand-drill or electric drill is desirable to prevent splitting of timber.
- Every beam resting on top of the column must have a knee brace

4. Anchoring of roofing tiles at eave level

- See MM-12 for procedure.
- Ensure tautness of the wires
- Wires should be as close to the lower edge of the tiles as possible

Retrofitting measures for roof are no different from the measures that are installed in new roof. Hence, these items have been covered in Session 9 on New Construction. In this session the critical points of these items need to be reiterated. But no hands on work is required on these items.

5. Anchoring of roofing at various points for tiles/sheeting

- See MM-12 for procedure
- If the roof does not have enough anchoring then carry this out.
- If the existing anchoring is not properly done then point this out and install better anchoring
- It is very important to follow the method strictly, especially to prevent the leakage of water from roof.
- Give extra emphasis in High Wind Speed Zones Zone III & IV.

6. Installation of RC Strip anchored to rafter below

- See MM-12 for procedure
- Give extra emphasis in High Wind Speed Zones Zone III & IV.
- If the roof does not have enough of these strips then carry this out.
- It is very important to follow the method strictly, especially to prevent the leakage of water from roof.

7. Installation of bracings & struts under pitched roof

Since this was already covered under new construction it will be best if different materials and different configuration are used.

- With GI wires only "X" configuration can be used. This is a cheap option, and also an option for sites not accessible by motorable road.
- Use 4 to 5 strands of 13 gauge GI wires
- Tie one wire at a time using carpenters hammer to pull it as tight as it is possible
- Once all wires of all the bracings are installed, tighten each bracing by twisting using a small piece of steel rod
- With timber or MS "K", and "Z" both can be used. This option can be used in public buildings also.
- Bracings must be installed such that there is continuity from ridge level to eave level, and from one gable to the opposite gable without a break.
- All bracings must be at approximately 45 Degrees

8. Installation of bracings & struts under timber floor

This is relevant only if timber floor is common in the area

Since this was already covered under new construction, if there is time available then use different configuration.

- This can also be done under a floor consisting of MS joist supports. But it will involve on site welding.
- Bracings must be installed such that there is continuity from one wall to the opposite wall without a break
- All bracings must be at approximately 45 Degrees

Retrofitting of Load Bearing Masonry Structure (MM-12) (cont.)

9. Collar Beam between opposite rafters

Since rafters are sloping they tend to push the walls out. To prevent this push install Collar Beam between opposite rafters

- Can use MS flat or timber plank.
- Pre-drill holes to prevent splitting due to hammering nails in.
- In case of clay tile roof apply Collar beam to every alternate set of rafters. In case of CGI roof apply to every Principal rafter

10. Strengthening of connections among roof members.

- Since this was already covered under new construction, if there is time to do this then use different materials

11. Anchor timber floors to walls

If the timber floor is common in the area then anchor one or two joists to walls with MS brackets for training

- One could anchor every alternate or every third joist to the wall.
- Holes will have to be drilled in to the walls to anchor the bracket. Holes should be either through the full thickness of wall or at least 75% thickness. The anchors have to be such that they do not get pulled out in disaster.
- In case of Brick or Concrete Block walls drilling can be done using power drill.
- In case of UCR wall a different option will have to be evolved to anchor the brackets since it is very difficult to make holes at precise locations.
- The bolts required for anchoring should be of diameter no less than 12mm (1/2")
- Like in Kashmir, if the joists to which the brackets will be anchored are connected to the principal rafters of the roof then stronger connection with multiple bolts (larger than 12mm dia.) will be required to attach the bracket to the underside of joist.

12. Strengthening of Opening Shutters Especially in Wind Speed Zone IV

There are several very simple measures that need to be demonstrated. It will be best to carry out these measures on a window and a door to effectively convey what is really adequate rather than leaving it to an individual artisan or a house owner to judge it.

- Strengthen glass panes- by pasting thin plastic film or paper strips.
- Install strong locking arrangements for all door and window shutter.
- Windows can be protected with guard bars or wooden battens placed across the shutters on the inside.

13. Strengthening for Flood

This point should be covered in all regions of the country irrespective of the fact whether the area is covered in the Flood Hazard Map given in MM-1 because floods or sustained rain related damage is possible in almost all the regions.

It is important to focus this at the houses of the weaker section of the society since most of them are built totally out of mud or using mud mortar.

- Do some cement pointing and/or plastering on the existing plinth
- In case of houses made of mud, the plinth could be protected by cement plaster. For cement plaster to stick to mud the "Stucco" technique will have to be used in which chicken wire mesh is first nailed to the plinth and then it is plastered.

Session 17	Duration 0:30 min	Lecture
	Topic to be covered	

Recap of important issues in Retrofitting of Existing Load Bearing Masonry Structures

- It will be best if the session is used to clarify doubts and questions that the trainees may have.
- For this to be effective the trainees will have to be encouraged to speak up and not feel bashful.
- This could be done through throwing a question or two at them which may lead to a meaningful discussion.
- This session will also give a good idea about the understanding of various participants.

Detailed Curriculum Day 5

13

Session 18 | **Duration 1:00 hr** | **Hands-on Activity Cum Discussion**

Topics to be covered

Retrofitting of Existing Load Bearing Masonry Structures

- Complete the incomplete items from the earlier session. Use 30 minutes for this.
- On each items that has been done, spend a few minutes covering the important points in regards to the execution of that item, essentially based on MM-12. Do this at the retrofitting site.

Session 19 | **Duration 0:30 min** | **Lecture**

Topic to be covered

Material Quantities for Retrofitting Features (MM-13)

Follow the instructions given in MM-13. It is important that the trainees get some understanding of the material quantity if they are going to promote these options. Trainees should also be able to understand the relation between the materials and the cost involved at the training site.

Session 20 | **Duration 0:30 min** | **Lecture**

Topic to be covered

Do's of Restoration & Retrofitting (MM-14) and Tools & Equipment for Restoration & Retrofitting (MM-15)

This is a short but very important session and much emphasis must be put on it. The trainees must be aware of the mistakes that could be committed and that they must consciously avoid making them.

- The right tools help in doing good quality work and also speed up the work. Masons must understand that for retrofitting some tools are not available in the market and they have to approach a local blacksmith and get them made.

Session 21 | **Duration 2:00 hr** | **Lecture**

Topic to be covered

Basics of Good Quality RC Construction (MM-16)

Many building artisans have been working with RC construction for many years. But most of them do not know the performance problems of this type of construction. The main purpose of this training is to make them understand what these problems are, how they affect the strength of the building and how these problems can be prevented.

RC Construction is becoming more and more popular. Most house owners with greater capacity to spend opt for RC construction. The main reason to opt for this is because most of them consider it stronger than masonry building. This belief is often supported by building artisans. But it is important for the building artisans to recognize two important facts about RC construction.

- Do you remember the Kutchh earthquake of January 26, 2001? That earthquake saw the collapse of large RC buildings. It showed to everyone that RC buildings can also get damaged severely in a disaster just like masonry buildings. It is also important for you all to understand why this can happen.

RC Construction cont.

- The other problem with RC construction is the significant deterioration in a period of few years because of the corrosion of steel bars. As a result its strength also decreases. It is important for you all to understand why this happens and how it can be stopped.

There are two more aspects of RC construction that all artisans need to understand:

- RC construction is a scientifically developed building technology that uses very special materials that are produced in a long and complicated industrial processes. In this type of construction to get the best result it has to be done in a very precise way (the results for which people spend a lot of money). The user must understand what these precise ways are.

- Since it is a precise technology, it is necessary to decide the size of slab, beam, column, and foundation along with type of concrete and the size and number of bars that will be used in them. This requires a lengthy and complicated procedure of designing that involves a lot of numbers. With some experience one can guess all these sizes etc. But among engineers that is not considered a right way. This is so because the design is made to meet specific needs such as the use of the building for a house or a school or a library or a hospital etc. and the size of the rooms including length, width and height. In each situation the building plans will vary and the type of loads that are expected will also vary.

Next let us look at some very important rules and correct ways of doing things.
Explain the Precautions to be Taken in RCC Construction from MM-16.

Cement

- More cement does not always mean more strength.
- Higher grade cement does not always mean higher strength. In most cases of small and moderate size construction the 43-grade cement may be preferred over the 53-grade, since the later requires much more water for curing to get the benefits of the extra cost.
- As time goes by the unused cement that is stored comes in contact with the air and moisture in it, and a chemical reaction begins. In a due course this damages the cement making it useless for construction.

Mortar & Concrete

- The aggregates and sand should be of a specific size. If the size of aggregates is much more than that 20mm or if the sand is too fine, then it does not meet the requirement of concrete.
- All different materials including cement, sand, aggregates etc. have to be mixed in specific proportions to make cement mortar as well as cement concrete. For every construction depending upon a variety of factors these proportions are decided in advance to meet requirements of the project including the strength. These should not be changed in order to save money. The quantity of each material must be measured in a fix size box. While measuring the material the top level of every material should always be level.
- Water is the most important material that gives strength to cement mortar or concrete. This too must be measured properly before mixing with rest of the materials. Very often in order to reduce the effort in mixing and in concreting or in laying cement mortar, too much of water is added. This ultimately weakens the building.
- Mixing mortar and concrete with machine is always considered better since it is possible to control the mixing, and the mixing is thorough. If electric or diesel powered mixing machine is not available then a hand operated mixer may be used.
- In the absence of a mixer, keep the quantity of mortar small and thoroughly mix the ingredients with hand.
.

Steel

- More steel does not always mean more strength.
- Steel rods must be clean. Some rust is permitted. But there should not be a lose layer of rust. There should be no oil or oil paint etc.
- Steel rods must be fully enclosed in concrete to give its strength to concrete. For this always provide a proper size packing under the bar. This packing can be a simple piece of brickbat. Ideally it should be made of cement mortar.
- There are several rules that control how the bars are arranged and how they are bent. But these rules bar arrangement and bending have to be strictly followed to ensure the desired strength as well as longevity of the structure. These rules will be next explained to you.
- The slabs that continue over a support (wall or beam) must have reinforcing bars near the top. These bars must be well anchored in to the other side of the slab.
- In a slab that continues over a support (a wall or a beam) every alternate bar must be cranked up. If this is not done then the slab cracks at the top.

Concreting and After

- The best way to do it is to use a vibrator so that all the air pockets left in concrete during mixing are removed. This results in to longer lasting concrete that does not allow water to easily pass through. So the rusting of bars is greatly reduced.
- All the centering must be strong. It should not move up and down or side ways under the load of concrete and impact of concreting. Bad centering results in to RC elements that are deformed to begin with. Such a centering can also lead to a major accident.
- After concreting, once concrete hardens it must be kept wet for a minimum of 21 days to ensure the desired strength.

Placement of Bars

The above precautions concern how the materials like cement, sand, aggregates and steel in the RC construction should be used. There is one more issue in which a large number of mistakes are observed that result in to catastrophic failure in the event of a disaster. This concerns the rules on the placement of steel bars. They dictate how the bars are to be placed once the form-work is ready. This is highly technical topic. As a result the artisans do not have its know-how. The most important rules are as follows. The numerical aspect of these rules mainly depends upon the size of RC member, its span and the diameter of bars that are used. So the rules that we are going to cover here are for small buildings that artisans make without input from an engineer. MM-16 has simple sketches that show the rules concerning the placement of bars.

a. Spacing Between Bars

- In a beam if the bars are placed very close then the concrete would not pass through the space between them. This will result in to poor quality and weak construction. So the spacing between the bars should not be less than the minimum spacing that is given here.
- On the other hand if the spacing between the bars should not be more than the maximum bar spacing given here

b. Concrete Cover Over Bars

- The steel is able to contribute its strength to concrete only if it properly bonded to concrete. This requires that steel is fully encased in concrete.
- The concrete cover protects steel from corrosion. So this cover should not be less than a minimum permissible concrete cover. As a result in foundation where the footing is in contact with the ground which can be wet, the minimum cover required is the highest. Similarly in areas near sea where there is high humidity and also salinity the chances of corrosion are also higher than elsewhere. Hence, the cover in such areas is more.

c. Arrangement of Bars in Slab & Beams

- In a beam it may not be enough to have just two bars at the bottom and at the top.
- There is a rule that decides how many bars placed at the bottom must be bent up and taken to the top near the supports and how far from the face of the support this must be done.
- The rule also makes a distinction between support near the end of the beam and the support over which the beam continues without ending.
- Similarly there are rules for the slabs.
- If these rules are not followed then the beam and the slab can develop cracks at the top or bottom..

d. Spacing of Ties/Rings in Beam

- The ties/rings that are placed in the beam not only hold the bars together but also add to the strength of the beam.
- Hence, there are rules that decide the spacing of rings and where the spacing could be different.

e. Anchorage of Bars and Overlapping Joints

- In beams there are special rules that dictate how far the bars at the top and bottom should be taken in to the support for adequate anchorage.
- The overlapping joint of bars can be done only in certain parts of the beam as governed by special rules

f. Spacing of Ties/Rings in Column & Right way of Making a Tie

- The rings play a very important role in ensuring the strength of the RC column.
- So there are rules that dictate the spacing of these rings in different portions of the columns, especially in relation to its joint with the beams.
- The rings must also be installed around the vertical bars of the column as they pass within the footing
- The rules also dictate how the ring is bent so that it would not open up under the impact of an earthquake.
- If rings are not made properly, during an earthquake they can open up and the column can fail.

g. Column Beam Joint

- The bars of beam as they pass through the column should not be bent. Hence, it is important to arrange the bars in a column in a particular way that would permit this.

> There are many other rules which too are also important. But the above mentioned rules are most critical and these are the rules that are most frequently violated.

Lunch Break - Duration - 1 Hr.

Session 22 Duration 3:00 hr Evaluation of Participant

This could be done through discussion, a test paper, as well as through actual hands on work. This assessment at the end of the training program should be coupled with the assessment that should be done continuously during the training program.

14 Trainee Performance Assessment

The performance of every trainee could be assessed in three stages. These are as follows.

a. During the training:

It will be best to observe the trainees for three different aspects that are

(i) Responses to questions,
(ii) Quality of hands on work from the view point of adherence to the instructions/rules,
(iii) Participation in discussion on various issues,
(iv) Questions raised by the trainee him

b. Hands-on Test:

This is to assess the understanding of various critical issues and its translation in to the actual practice by the individual. The trainee could be asked to construct a small piece of masonry, or to prepare the reinforcing cage for various critical details, or to plan to undertake a particular retrofitting measure etc.

c. Written test/Oral Test:

If the mason is literate then the Performance Assessment Form provided here can be given to him to fill out. If the mason is only semi-literate then instead of the written test it would have to be oral aided by this form. The form is fairly exhaustive. One may take only a few of the questions for the assessment of each trainee. So two or three test papers could be evolved out of this form. The trainer/examiner could evolve more questions on this line to cover the topics missed out.

Trainee Performance Assessment Form

Full Name_____ Father's Name_____

Address_____

Village_____ Taluka_____ Nearest City_____

Contact telephone no._____

- Educational Qualification - Class Passed — 0 / 4th / 8th / 10th / 12th / More
- Read local language — Yes / No
- Write local language — Yes / No
- Mason work — Full time / Part time
- What other occupation — Farming / Farm labour / Other

1)Did you learn anything in this training? Yes / No

2) Is there any difference in regular construction and disaster-resisting construction? Yes / No

3) Describe most important thing you learnt for new construction

a)_____

b)_____

c)_____

d)_____

4) Is it possible to improve the strength of an existing building? Yes/No

5) If "yes", what is it called?

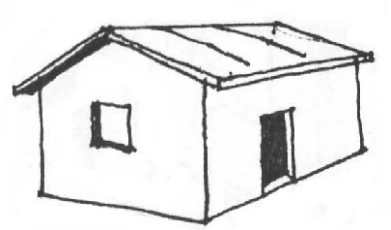
6) If "yes", what are the most important steps?:(a)_____

B)_____ c)_____

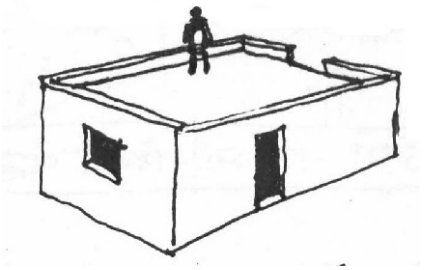
7)In a building with RC beams and column what supports the roof and upper floor?_____

8)In a building without RC beams and columns what supports the roof and upper floor? _____

9) Show where you have to put a band in new construction.



10) In a building with RCC roof where will you put a band?

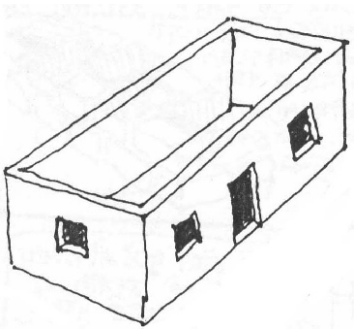


11) Besides band what other special features are needed in disaster resisting building ?

_____

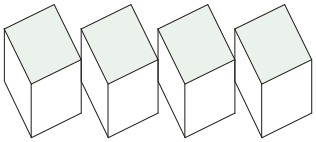
Where?._____

12) What feature you use to prevent cracks starting from the corners of window and door openings in disaster ? Show this in the sketch below.

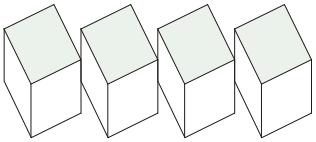


12) What do you mean by 1:2:4 concrete mix?

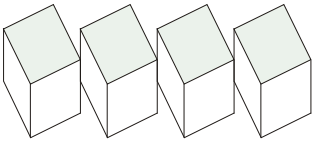
How many boxes of Cement?
1/ 2/ 3/ 4



How many boxes of Sand?
1/ 2/ 3/ 4

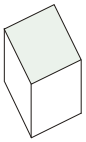


How many boxes of Aggregate?
1/ 2/ 3/ 4

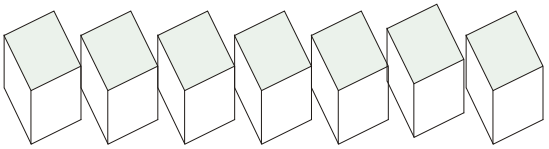


13) What will be the cement =sand proportion in brick / stone masonry?

For 1 Box of Cement



How many boxes of Sand?



14. Within how much time Cement Concrete / Cement Mortar must be used up after water is added?

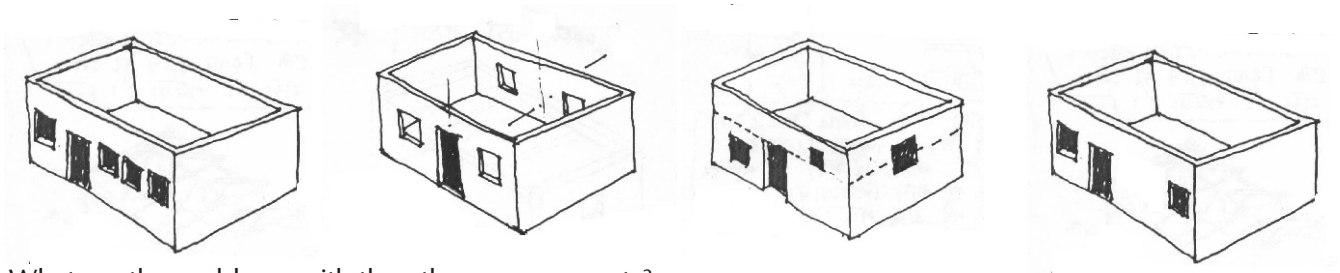
15 min. / 60 min. / 90 min. / 3hrs. / 8hrs.

15.How long the construction with cement needs to be cured? 1 day / 3 days / 10 days / 15 days / 31 days.

16.What does curing mean? Putting water twice a day / Putting water every two hours / Keeping it continuously wet

17. What should be the minimum depth of foundation? 1ft. / 2ft. / 4ft. / Depends on soil condition

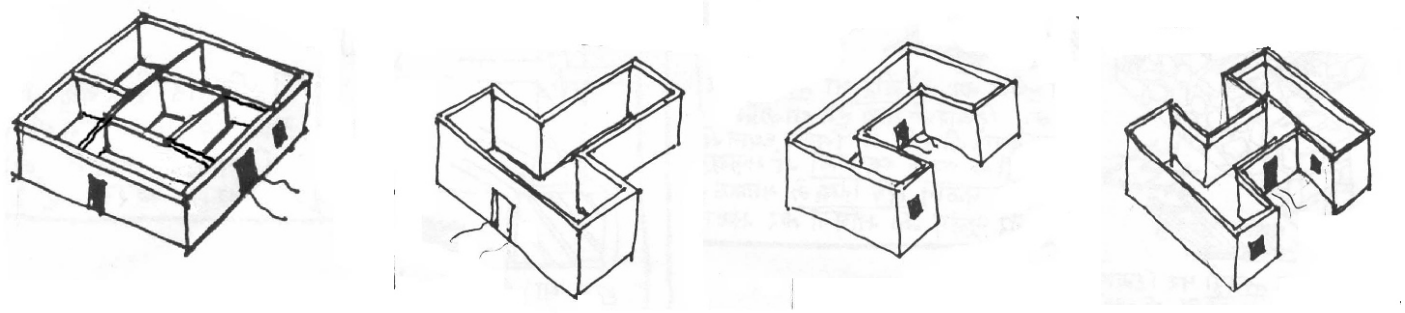
18. Select the best arrangement of door and window openings in this building? Why?



What are the problems with the other arrangements?

_____ _____ _____ _____

19. Which plan is better for construction of a new house from the angle of earthquake safety?



Square **'T' shape** **'C' shape** **'H' shape**

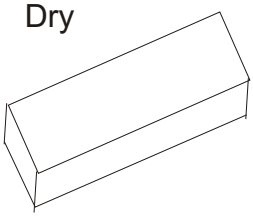
10. How will you wet the bricks before using it in masonry.?

With lots of water sprayed from a hose

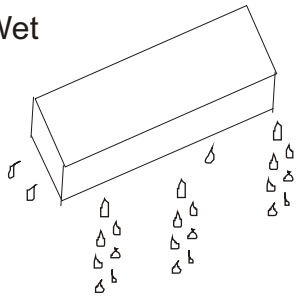
Soaking them in a drum full of water

11. Which brick will you use in constructing a wall with cement mortar?

Dry

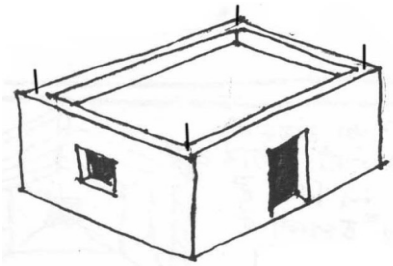


Wet

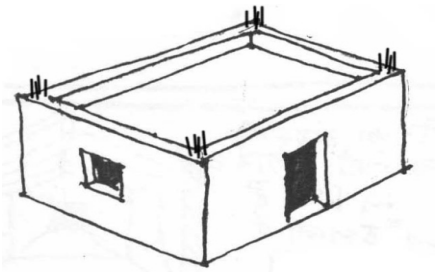


12. How much reinforcement will you use in the corners of masonry structures?

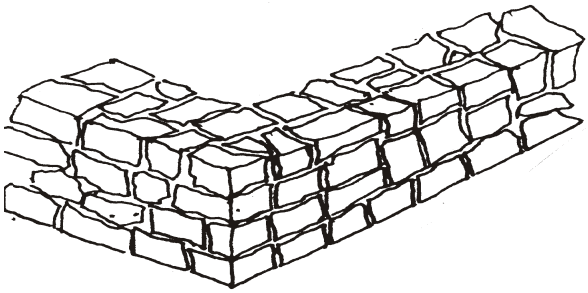
Single bar

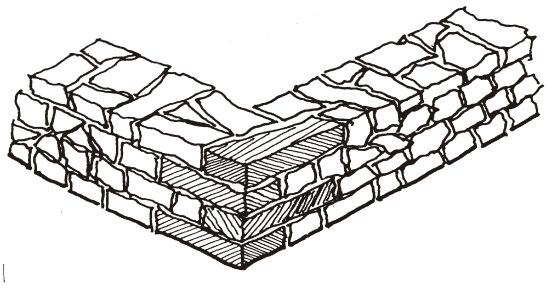


Four bars



13. What are the most important rules in constructing stone wall?



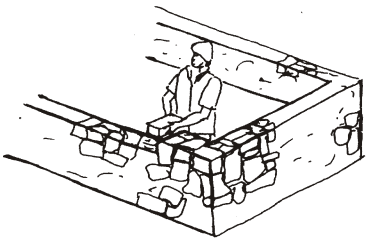


_____ _____

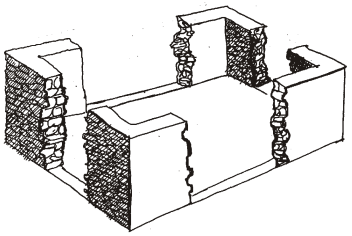
_____ _____

14. How will you construct walls?

Construct all walls together

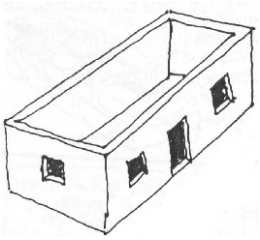


Construct all the corners first and then gaps between the corners

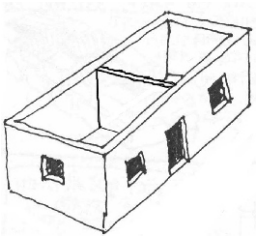


15. When will you build partition walls?

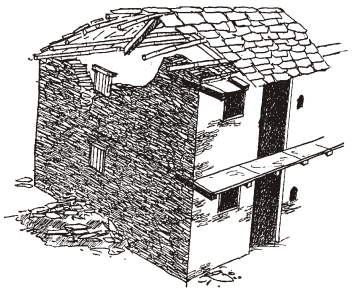
Build outer walls first and then the partition walls.



Build partition walls along with all outer walls.



16 If this damaged house is your, what will you do with it?



17. To make an existing building stronger against a disaster what will you do?

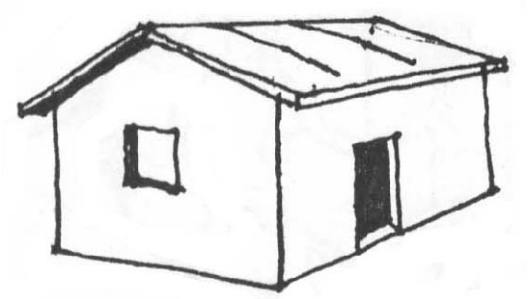
Re-plaser on one face of walls / Re-plaster on both faces of walls / Install Belt / Put new tiles on floor / Install RC headers in stone walls

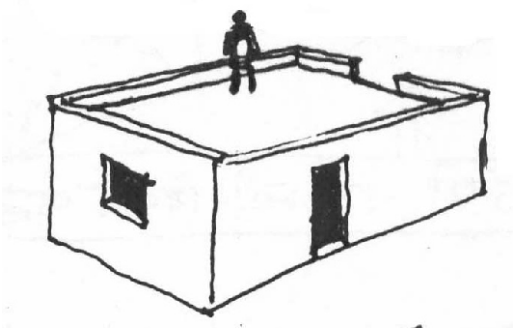
18. What are the main features used for retrofitting a masonry building ?

_____

_____

19. Show retrofitting measures on both the buildings shown below.





Additional Reading material A1

Mason Training Tips

Important Considerations for Planning of Mason Training Program

- **Basic assumption**
  - Resources for training programs are limited
  - Keep the program of making **new masons** totally separate from **skill up-gradation** program since the former requires much more input
  - The economic condition of building artisans is not good. Hence, allocate some funds for a reasonable stipend.
  - Literacy level among masons is generally low to very low.
  - Masons will be able to enroll for a short duration of one or two days at a time for a stipend that may be equal to 50% of the routine daily wage. For longer duration at one stretch as much as 80% to 100% of the daily wage may have to be paid.
  - In booming construction market it is difficult to find the artisan to enroll for the skill up-gradation program on account of much work on hand or the demand of their clients etc.
  - During peak agriculture season they may not join because many of them have some land. Timing for the training must be suitable to them.
  - Once the reputation of a program is established and/or its need is established through **mandatory** certification, then the artisans may join for a lower stipend (for short duration only).
  - In case of program coupled with certification, it must not be repelling or intimidating, or its successful completion must appear attainable to the potential participants.

- **Focus on the root cause of the poor performance of buildings in disasters**
  - Poor workmanship
  - Violation of basic construction rules and specification, and its fallout in relation to disasters
  - Poor understanding of technologies and materials and its fallout in relation to disasters
  - Problems observed in the local building technologies

- **Understanding the masons To ensure maximum enrollment and optimal effectiveness**
  - By simple oral interview assess the Individuals' level of expertise
  - General preferences and limitations regarding duration, timing, and stipend
  - Literacy level

- **Certification Program**
  - Strengths & weaknesses of artisans Decide entry point in to certification
  - There is a difference between artisan and artisan helper. The latter can not participate in skill up-gradation program. This has to be assessed through an oral interview
  - Create a minimum of 3 levels to encourage more participation of artisans, to make it less threatening
  - Flexible Entry and re-entry at convenient times

- **Training Focus Most important**
  - Fundamentals of commonly practiced masonry construction
  - Critical aspects of know-how of new materials commonly used
  - Understanding of building behavior in earthquake/cyclone
  - Relationship between mistakes and outcome Do's and Don'ts
  - Restoration of damaged structure Right ways of doing it
  - Retrofitting of Existing Structure Understand the weaknesses followed by their remedies
  - Building of confidence
  - Strengthening mason's sales capability to counter wrong market pressure or demand of technically wrong items
  - Use of handouts given for ready reference

Additional Reading material A2

Why Retrofit A Building?

Background

Natural phenomena cannot be prevented but it is possible to prevent them from turning into disasters or emergencies. In most disasters resulting from earthquakes, cyclones and floods the inadequacy of the buildings, especially the houses, to stand up against the natural phenomena is the single most cause of the loss of life and loss of property. In Latur earthquake, nearly 9000 lives were lost under the debris of the houses that collapsed in the quake that was of moderate magnitude. It is certainly important to ensure that the new structures are adequately strong. But even more important is to strengthen or retrofit the existing structures, especially the houses, schools and places of work. This is so because most of the existing houses will remain in use for next several decades.

What is Retrofitting?
This is a time-tested concept commonly used in our day-to-day lives. One retrofits an old worn-out cardboard carton with the help of tapes along the corners or with strings wrapped around it, instead of throwing it away and buying a new one, so that it would not fall apart when loaded heavily. Or one provides extra stitching on the handles of a cloth carry bag so that handles would not separate from the bag while carrying heavy loads.

Economics & Convenience
Just as in the case of a carton, instead of dismantling an existing house and building a stronger one it is best to strengthen it or retrofit it. It is indeed the most economical option that one could exercise to ensure one's safety. The option of building anew involves the cost of dismantling the existing house, carting cost for the debris, and the cost of reconstruction. With the rapidly escalating costs the expenditure involved may be several times that invested in the house. On the other hand the retrofitting costs anywhere from 6% to 20% of the cost of building anew depending upon the type of building and the damage if any. A major advantage of this option is the inbuilt flexibility. Of the several different measures that need to be applied one can apply one or more at a time. In addition there is no need to apply these measures to the whole house in one go. One could certainly take a decision based on the availability of the funds and the convenience, although ensuring the technical soundness of the overall scheme.
In short…

- Reconstruction means first demolition and removal of debris, and then reconstruction.
- Retrofitting means making small changes to only some components of a existing structure
- Retrofitting is five times cheaper than reconstruction.
- Retrofitting is faster than reconstructing.
- Retrofitting means all the conveniences created in the house are not lost. Reconstruction means re-doing all that.
- Retrofitting can be done in phases - only one or more parts of the house at a time. Hence, its use can be continued and economically it is more manageable.
- Finally. It ensures long term safety against future earthquakes for most number or people with least amount of money

Present Retrofitting Scenario
There has been little retrofitting as a part of pre-disaster action. In the aftermath of disaster, the structures fit for retrofitting have largely been abandoned or demolished, and rebuilt.
Because…

- Contractors/Masons are ignorant about retrofitting
- People do not readily accept retrofitting as an option that can be adopted
- Few authorities promote retrofitting as the most viable option for long term security against quake

Principal Causes…

- Most engineers (the principal actors) are ignorant about it and/or find it economically unattractive. Hence, they do not recommend it.
- Load bearing building systems are used in majority of buildings. These systems vary greatly from area to area. Engineers have little understanding of them.
- Many retrofitting examples that people see around them are economically unattractive because of wrong techniques adopted.
- Many poorly executed retrofitting examples fail to inspire confidence in the people.
- Delivery system for retrofitting does not exist.

Principle Steps Involved

The process of retrofitting involves several steps. These are…

- Understand the existing construction in detail, especially the "what" and the "why" aspects of its construction, and the stress path due to the seismic or cyclonic forces.
- Assess the weaknesses in the structure, and the outcome of an earthquake or a cyclone of an expected intensity.
- Identify the measures to counter the weaknesses.
- Evolve the cost of the application of each one of the measures.
- Decide the budget
- Decide on the sequence and mix (all v/s a few) of measures and their extent (whole house v/s portions of it) at the given time based on the budget as well as the convenience of the house owner.

Weaknesses In Load Bearing Construction

Baring large metropolitan cities, even today, a majority of the inhabitants in urban as well as rural areas live in structures with Load-bearing construction. Hence, it is most important to address the weaknesses of this type of structures. Walls and roofs have different types of weaknesses. But the weakness of one adversely affects the other. Hence, it is important to retrofit both. These could be summarized as follows…

Walls

Walls develop a variety of cracks which can be vertical, horizontal or slant because of the tension caused in them by the earthquake or cyclonic forces. Walls also tend to separate at the corners. To prevent all this a Ferrocement belt all around the building securely connected to it is very effective.

In stone walls the inside and the outside faces tend to separate when shaken by ground shaking if the headers are absent or inadequate in number. This is rectified by the making holes in the walls and casting reinforced concrete headers in them.

Roofs-

The RCC slab tend to slide on top of the wall causing a crack at its junction with the walls. This can be prevented by providing a secure connection with the walls with the help of vertical bars in the walls that are properly connected to the reinforcement in the slab.

The tiled pitched roof tends to break up with timber elements separating. This in turn weakens the building resulting in to greater damage. This can be prevented by properly securing together various timber elements with the help of wooden planks or angles, and by tying GI wire cables along the diagonals of the roof.

The tiles need to be secured along the eave with the help of a steel rod or a flat bar. In addition load walls over the gable walls also prevent the roof from getting lifted up in the event of a cyclone.

Roof properly anchored to the walls makes the whole structure stronger. In addition vertical steel bars in the inside corners of room anchored securely to the walls also significantly increase the strength of the building.

Summary-
All types of structure can be retrofitted. It does not matter if they are made of mud or stone or bricks or timber. There are a variety of retrofitting measures that need to be applied to take care of various weaknesses. Each measure costs. Hence, the house owner has to decide how much he can do at a given time. It is, nonetheless, possible to retrofit a structure fully over a period of a couple of years, if one cannot afford to finish it in on go. This is precisely why even a person of ordinary means can afford to retrofit his house.

Finally…
If You are in Disaster Zone

Use retrofitting to bring long-term safety against future disasters because it is the cheapest, fastest and most convenient.

Retrofit critical facilities like schools, health care, police stations, government office buildings, etc. without wasting scarce resource of the country