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Disaster Risk Reduction in Practice

The Architecture of Earthquake Resistant Housing in Pakistan

Dr Victoria Harris, CEO of Article 25

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A team of construction professionals for International Development and Disaster Relief

- *Humanitarian architectural practice*
- *NGO*
- *Registered charity*

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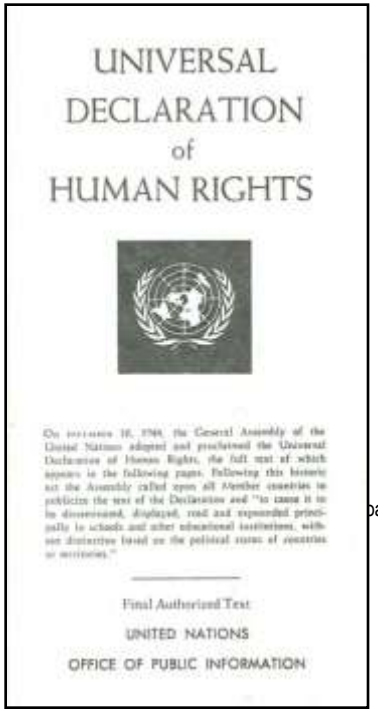
Article 25 of the Universal Declaration of Human Rights:

"Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, and housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control".

(website: http://www.article-25.org/declaration-_eng.pdf)

United Nations Millennium Development Goals (MDG's):

1. Eradicate Extreme Poverty and Hunger
2. Achieve Universal Primary Education
3. Promote Gender Equality and Empower Women
4. Reduce Child Mortality
5. Improve Maternal Health
6. Combat HIV/AIDS, Malaria and other diseases
7. Ensure Environmental Sustainability
8. Develop a Global Partnership for Development


UNIVERSAL
DECLARATION
of
HUMAN RIGHTS

Final Authorized Text

UNITED NATIONS

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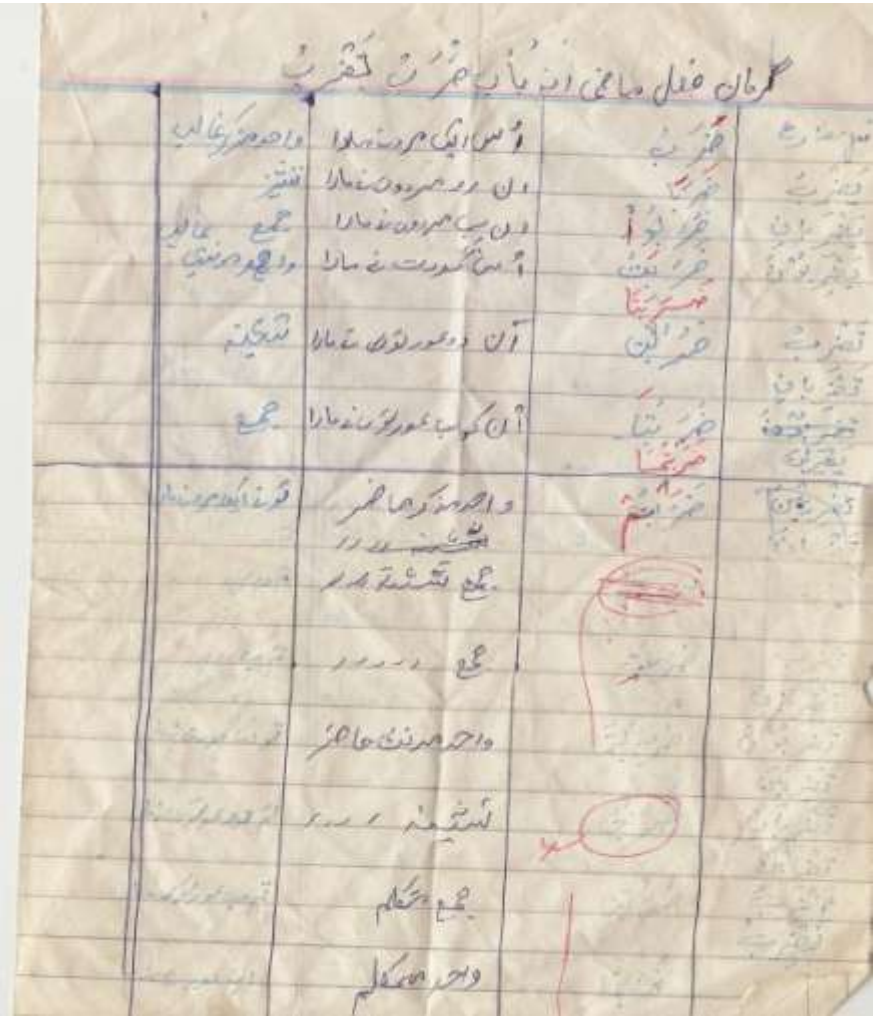

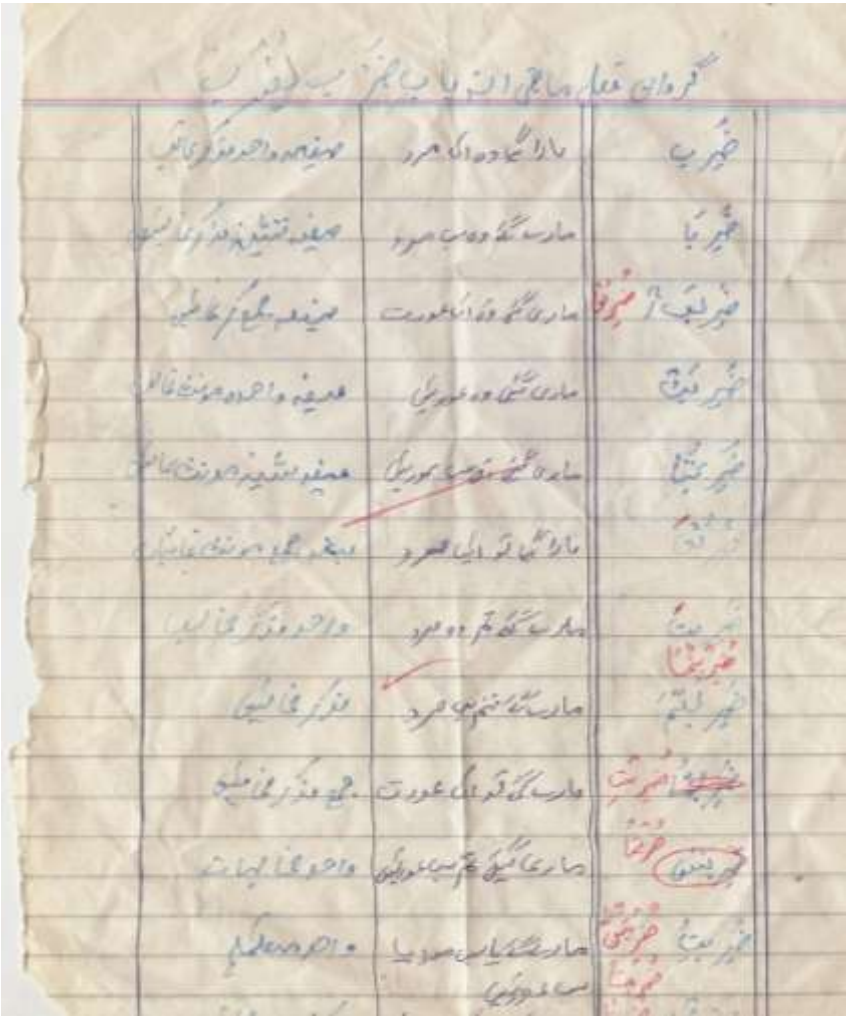

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An introduction to disaster risk reduction and seismic mitigation for non-engineered structures:

Case Study - Reconstruction following Pakistan earthquake of October 8th 2005

1. Disaster Risk Reduction

What is a disaster?

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What is a disaster?

"(A) severe disruption to the survival and livelihood systems of a society or community, resulting from their vulnerability to the impact of one or a combination of hazards involving loss of life and/or property on a scale which overwhelms the capacity of those affected to cope unaided."

White, Philip, et al, Disaster risk reduction: a development concern, (DFID, 2004) 1.

"Disasters do not just happen – they result from failures of development which increase vulnerability to hazard events." e.g. Rapid urban growth leading to increased exposure to landslides, earthquakes or fires

Ibid,3.

Some facts about disasters:

The recorded number of disasters, the number of people they effect and the property losses they have caused have risen dramatically each decade since reliable records began in 1960.

53% of disaster deaths occur in low development countries* despite the fact that only 11% of people exposed to hazards live in such countries.

On average disasters kill 60 000 people a year and affect at least a quarter of a billion.

* Countries judged by the UN to exhibit lowest indicators of socioeconomic development taking into account factors such as income, nutrition, education, literacy.

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What is vulnerability?

"(Vulnerability describes)...the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard."

Wisner, Ben, et al, At Risk: Natural hazards, peoples vulnerability and disasters, 2nd ed, (Abingdon: Routledge, 2005) 11.

Factors that effect vulnerability:

"(W)here people live and work, and in what kind of buildings, their level of hazard protection, preparedness, information, wealth and health have nothing to with nature as such, but are attributes of society...peoples exposure to risk differs according to *class* (which effects their income, how they live and where), whether they are *male or female*, what their *ethnicity* is, what *age group* they belong to, whether they are *disabled* or not, their *immigration status*..."

Wisner, Ben, et al, At Risk: Natural hazards, peoples vulnerability and disasters, 2nd ed, (Abingdon: Routledge, 2005) 6.

Vulnerability is often exacerbated as a result of poverty, reducing vulnerability therefore is also a question of dealing with poverty in society.

Guatemala earthquake, 1976 "Class-quake"

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Factors contributing to Vulnerability

1. Poor placement of settlements

2. Structures not resistant to ground motion

3. Lack of access to information about earthquake risks

Adverse effects

1. Physical damage
2. Casualties
3. Longer term public health problems
4. Water supply problems
5. Lack of food supplies/medical care
6. Damage to local/regional economy

Aftermath of a landscape triggered by the 2005 earthquake in Pakistan.

575 lost their lives and three villages were destroyed in seconds

The change to the landscape was so dramatic that a new lake was formed in the valley.

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A study of housing safety in the Korakoram region of Pakistan (1984)

1960's/early 1970's

Traditional dwellings of stone masonry with timber bands to hold stone together (Bhatar).

+

Complex and heavy timber roofs insulated with earth.

⇩

These provided some protection from seismic shock.

During 1970's

Concrete gained favour as a building material.

These new houses were often poorly constructed by unskilled labour.

In addition they were often sited on steep slopes to avoid reducing meagre land holdings for cultivation of crops.

Vulnerability Factors

Reduced concern about building safety.

Lack of knowledge about concrete construction and seismic mitigation measures.

Poorly sited housing at risk from landslides

A shortage of skills.

Change in availability of materials.

Deforestation due to population growth which increased demand for fuelwood and building materials.

Construction of Korakoram Highway in 1970's allowed access for loggers and encouraged migration of skilled labour to cities and abroad.

VULNERABILITY
×
HAZARD (EARTHQUAKE)
=
RISK → DISASTER

PROGRESSION OF VULNERABILITY

Source: Wisner, Ben, et al, At Risk: Natural hazards, peoples vulnerability and disasters, 2nd ed, (Abingdon: Routledge, 2005) 57-59.

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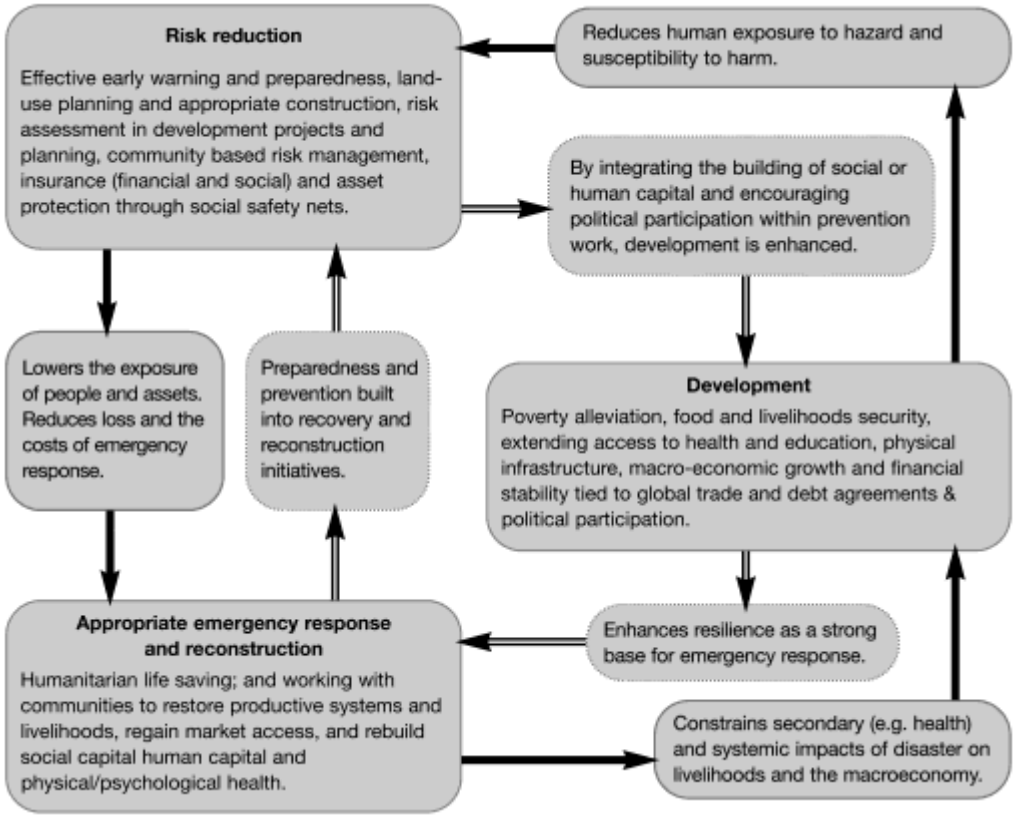
Actions to reduce the risk

1. Effective early warning and preparedness
2. Land use planning and appropriate construction
3. Risk assessment in development projects and planning
4. Community based mitigation measures
5. Insurance (financial and social)



Source: 'Virtuous spirals' of risk reduction
http://www.dfid.gov.uk/pubs/files/drr-scoping-study.pdf

What is disaster risk reduction?

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What is disaster risk reduction?

" '*Disaster Risk Reduction*' describes measures to curb disaster losses, through minimising the hazard, reducing exposure and susceptibility and enhancing coping and adaptive capacity. Good disaster risk reduction also continues after a disaster, building resilience to future hazards."

White, Philip, et al, Disaster risk reduction: a development concern, (DFID, 2004) 1.

"Culture of safety" - UN

Prerequisites for disaster risk reduction:

1...(A) clear understanding of the cultural and organizational characteristics of each society as well as of its behaviour and interactions with the physical and natural environment

2...(T)he mobilization of non-governmental organizations and participation of local communities.

The above were outlined at The International Decade for Natural Disaster Reduction mid-decade conference,Yokohama, in May 1994.

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Approaches to Mitigation of Disasters

Technology based approaches provided by the planners for the beneficiaries. Tend to emphasize measuring and monitoring techniques (e.g. Hazard mapping, weather forecasting) and physical mitigation measures (e.g. flood barriers) over addressing social factors that contribute to a disaster.

This top-down approach can have little impact on a community's ability to protect itself.

Community Based Mitigation develops policies in consultation with the local communities using techniques and actions which they can organise themselves and manage with some additional outside technical assistance.

An example of Community Based Mitigation is the rebuilding process in Pakistan following the 2005 earthquake which puts a strong emphasis on training, awareness and building capacity.

This latter method may be less technically effective, however, it will be a response to people's real needs and better contribute to the development of the community, its awareness of hazards and how to protect from them in the future.

For this to be effective however you would require an actively concerned community and agencies able to provide technical assistance and support at a decentralised level.

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Mitigation Methods

- Effective building codes
- Checking standards on-site
- Imposing fines/withholding of grants
- Control of land use
- Compulsory insurance

PROMOTE...
- Planning control
- Training and education
- Economic assistance
- Subsidies on safety equipment/construction materials

PROVIDE...
- Safer buildings – seismic resistance/ cyclone shelters
- Refuge points
- Coordinated village action plans
- Storage e.g. medical/food supplies
- Public dissemination of information

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2. Seismic Mitigation

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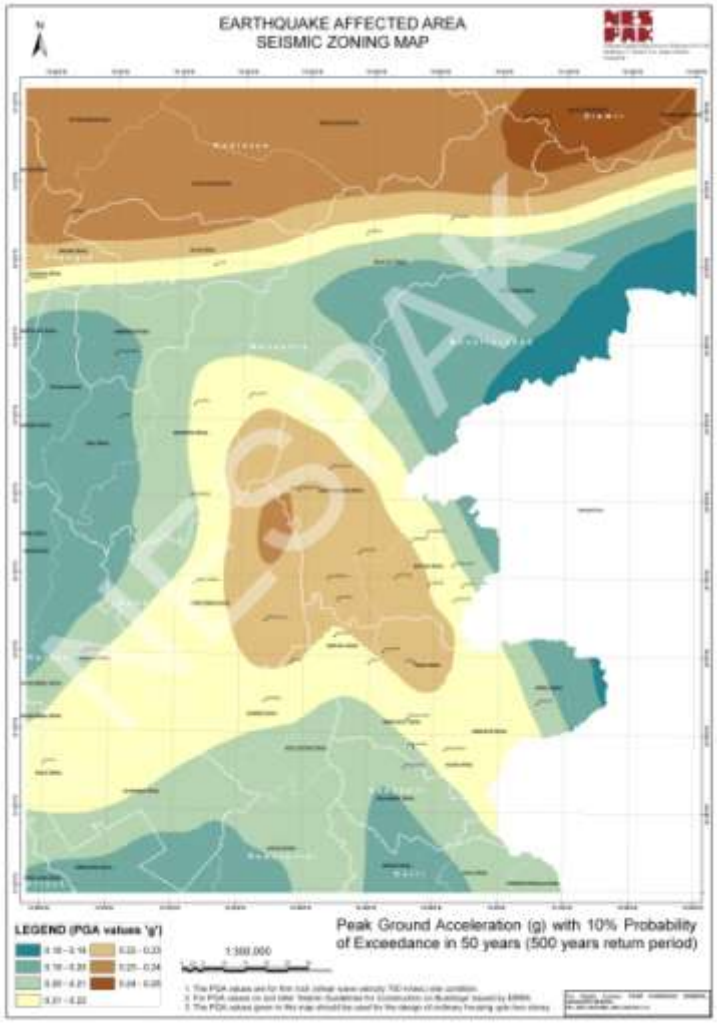
Possible Risk Reduction Measures

1. Define hazardous geographic zones & structures
2. **Establish a public awareness program**
3. **Establish a technical assistance program**
4. **Conducting a program to introduce improved construc techniques**
5. **Determine relative safety of construction sites**
6. **Remove unsafe buildings or attempt to upgrade them**
7. **Encourage future development on safer sites**



Source: http://www.nespakerp.com/downloads/hazardmap.php

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Specific Preparedness Measures

Community Preparedness

Vital for mitigating earthquake impact

Public Education

Causes of earthquakes and warning signs

How to form teams to assist in search for injured

Planning

Training teams for search and rescue

Preparing emergency communication systems

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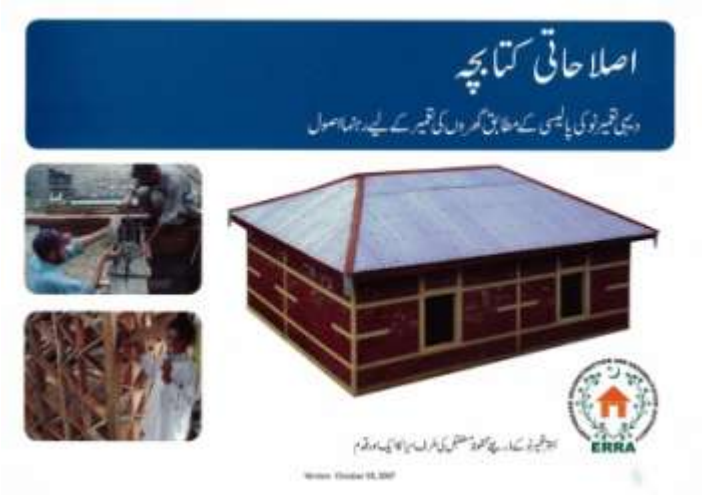
Possible Risk Reduction Measures

1. **Establish a technical assistance program:**
2. **Encourage development on safer sites**



Source: UN-Habitat Compliance Catalogue – Urdu version

Sites

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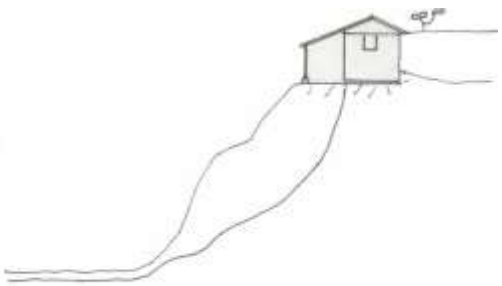
DONT BUILD: On steep/ unstable slopes or loose ground



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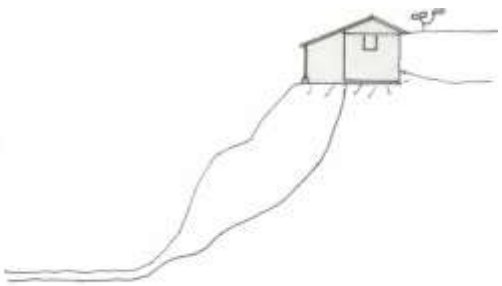
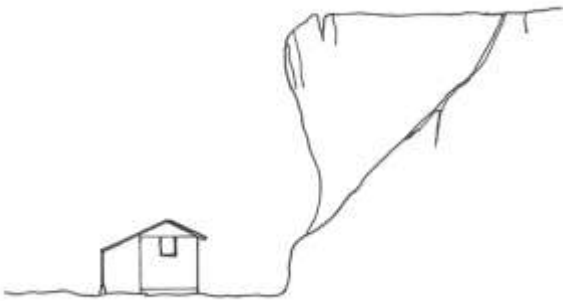
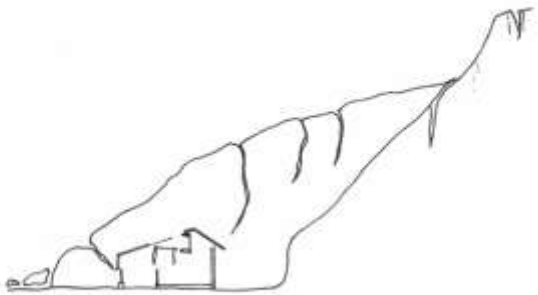
DONT BUILD: On steep/ unstable slopes or loose ground

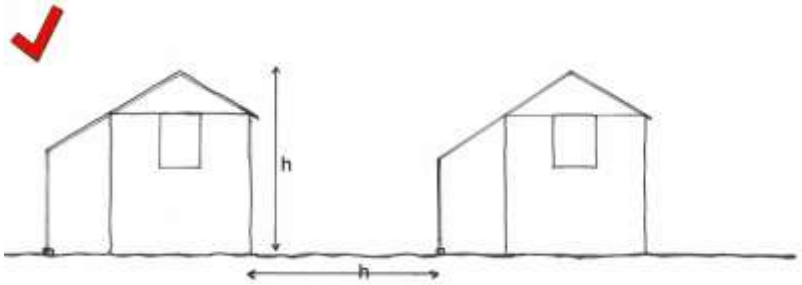


DON'T BUILD: On areas susceptible to landslides and rock fall





DO: Place buildings a good distance between each other (at least equal to height of tree or house).



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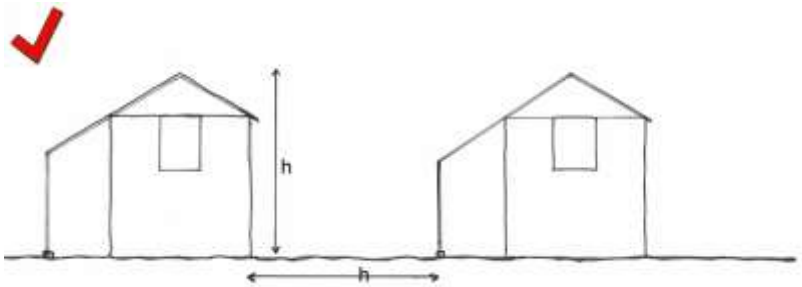
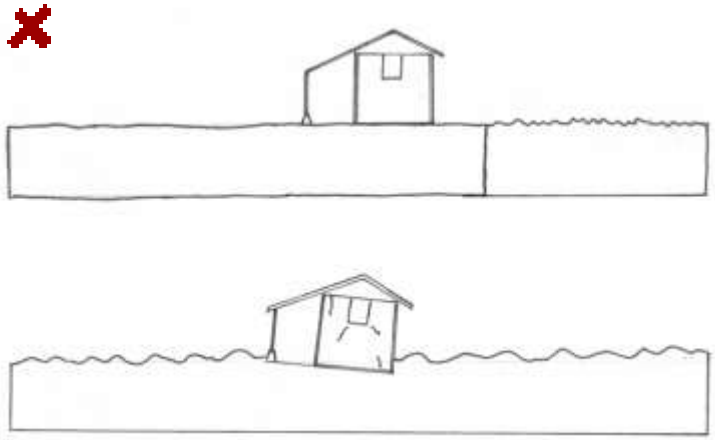
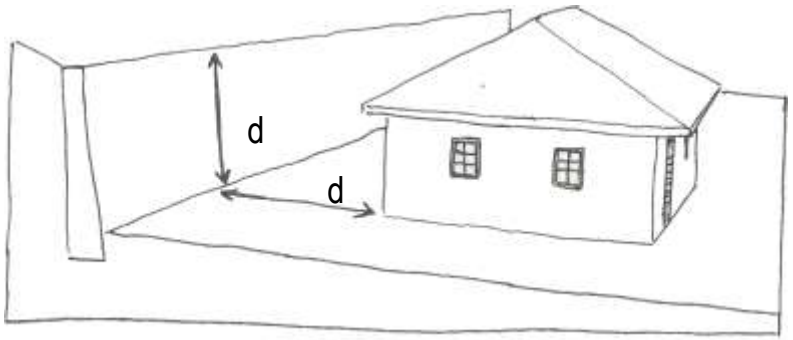


DON'T BUILD: Near rivers as water saturated soils can lose bearing capacity during ground shaking (this is termed liquefaction) and flooding can be a risk.



If building near a slope position house a minimum of 4ft from the slope and provide a retaining wall if necessary.



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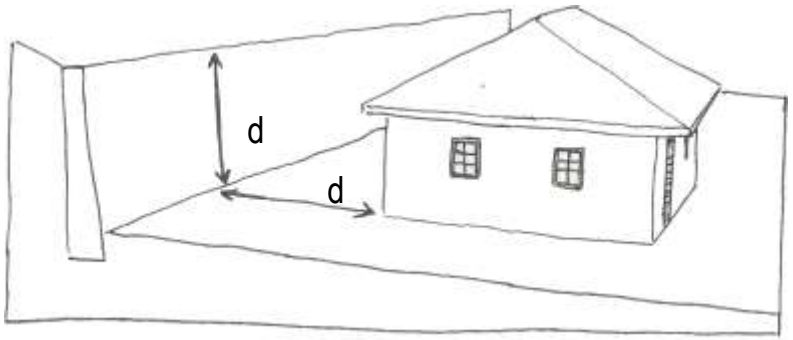
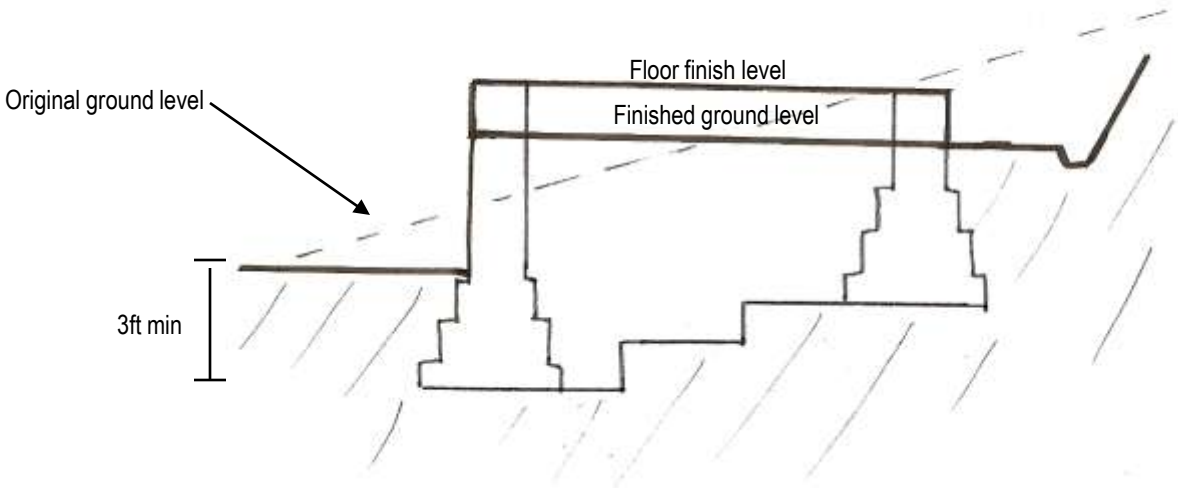


If building on a sloping site terrace and level the land prior to beginning house construction.



A small site with steep slope at rear and close neighbour.

Many areas sites are prone to the risk of landslides with no alternative option.

However...

Be aware that site and resource constraints (e.g. finances, available materials) might make it difficult to meet these requirements exactly.

Remember...

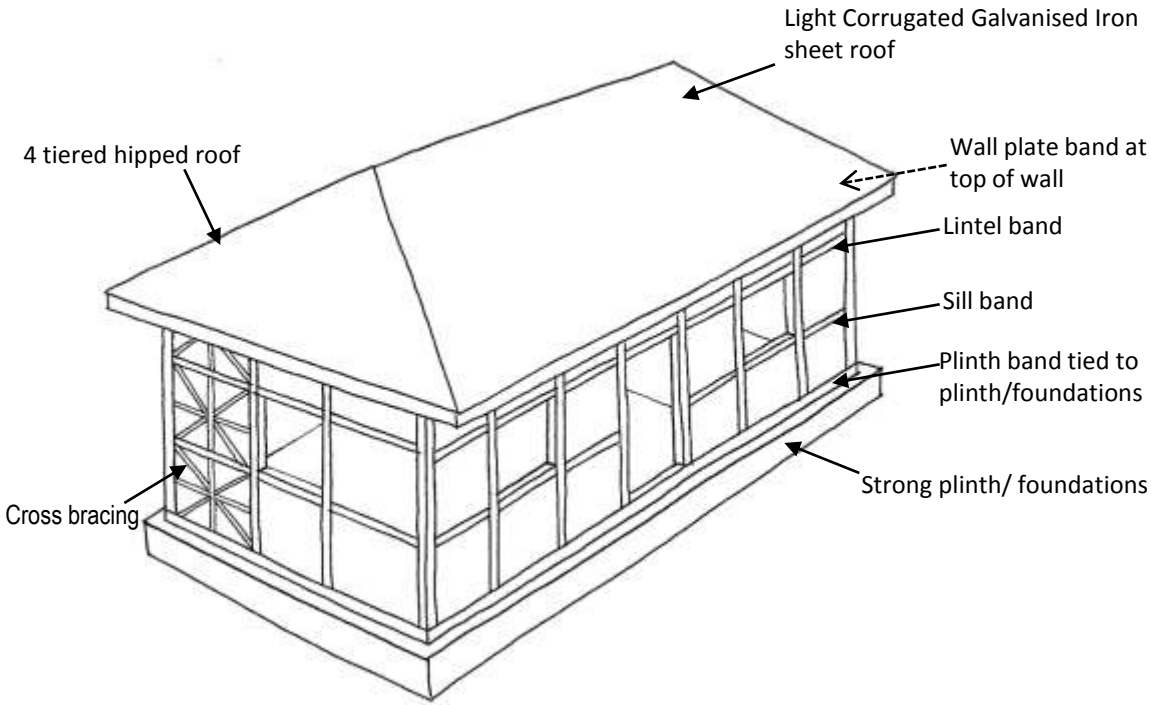
The ideal solution is rarely possible. Considered compromise is often necessary.

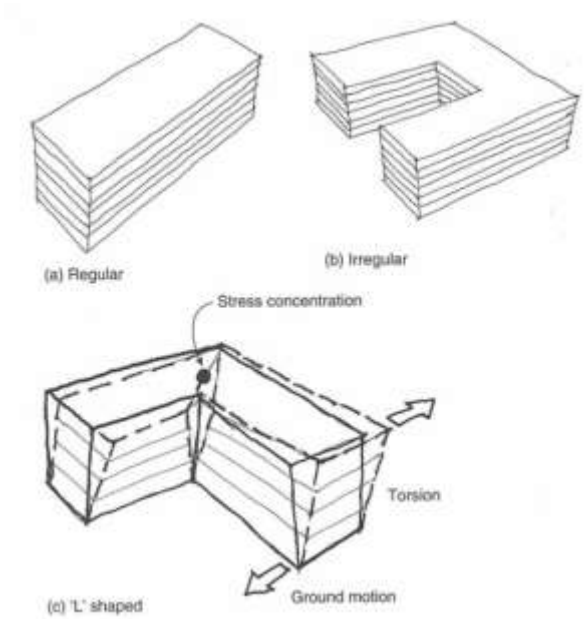
Basic concepts of construction for seismic resistance

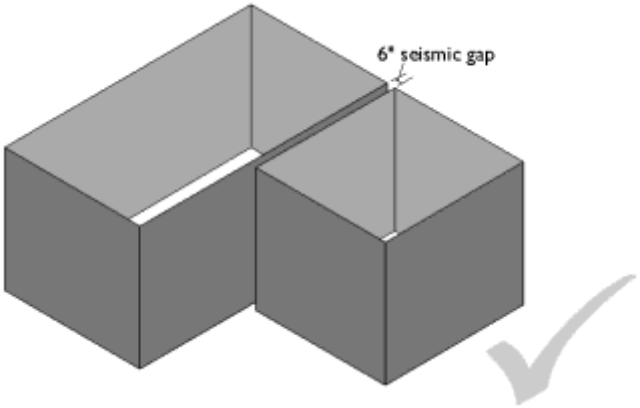
"Specialist studies show that the ability to construct buildings that have both flexibility and cohesion , is one of the most important considerations when designing earthquake resistant structures. A main objective is to provide an effective linking of different parts of a building so as to enable them to work together and avoid the dislocation which causes collapse."

McDonald, Roxanna, Introduction to Man-made disasters and their effects on buildings, (Oxford: Architectural Press, 2003) 36.

Above: A pre-earthquake school building in Pakistan incorporating seismic mitigation measures. Current regulation in the country would prohibit the unrestrained gable end. Nevertheless the building survived with very little damage and remains in use today.







Use regular shapes...

Regular shapes like square, rectangular and circular resist an earthquake more effectively as compared to irregular shapes. This is because during ground shaking the corner points of irregular shapes concentrate stress and consequently are more easily damaged

An essential principle is to use box-type structures. Furthermore all components such as wall, roof and floor should be well tied together to allow the building to act as a unified box.

If irregular shapes are required then a seismic separation gap should be made at points to create structurally isolated boxes.

Diagram Sources: Source:McDonald, Roxanna, Introduction to Man-made disasters and their effects on buildings, (Oxford: Architectural Press, 2003) 24./ UN-HABITAT Compliance Catalogue

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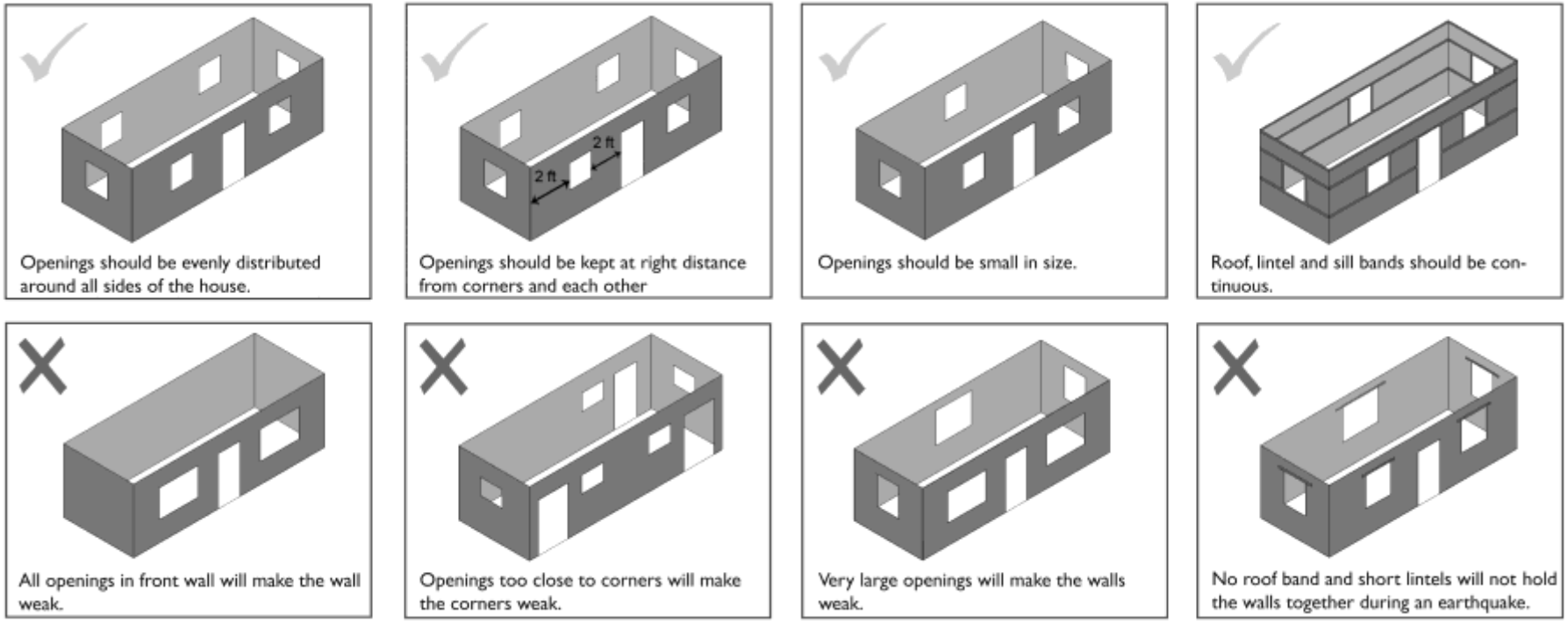

Source: UN-HABITAT Compliance Catalogue

Door and window openings...

1. Keep opening sizes small - 4ft wide maximum (stone walls 3ft wide).
2. Total length of openings should not exceed 50% of the wall length between cross walls.
3. Always provide continuous lintel band and roof band.
4. Best to provide continuous sill band.
5. Distribute openings evenly around all sides of the building.
6. If this is not possible avoid putting all openings on one side only.

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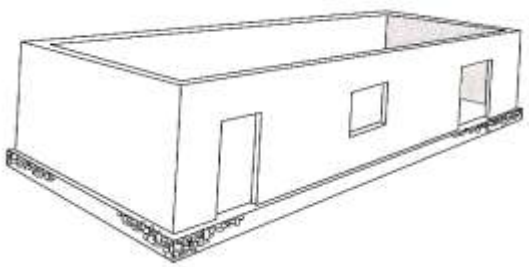
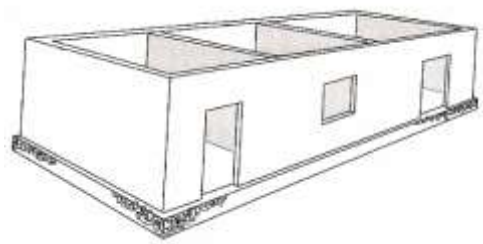
Short walls….

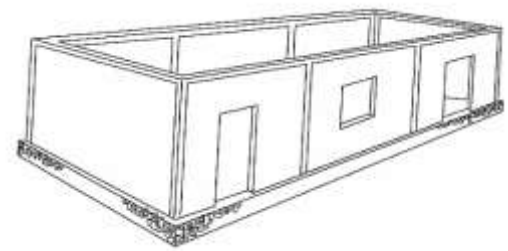
If long and narrow buildings are built they should be divided into separate rooms rather than one long room. If this is not possible framing elements should be introduced.



✗ Large box, not seismically strong



✓ Many crosswalls (small boxes), seismically strong



✓ Wall with framing elements, usually reinforced concrete, seismically strong

Pakistan Earthquake, 8th October 2005

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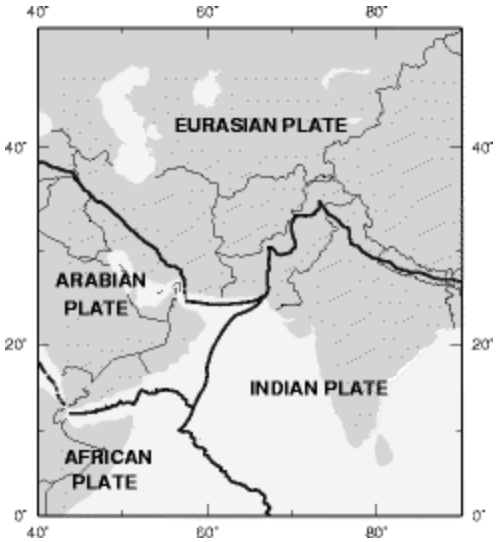
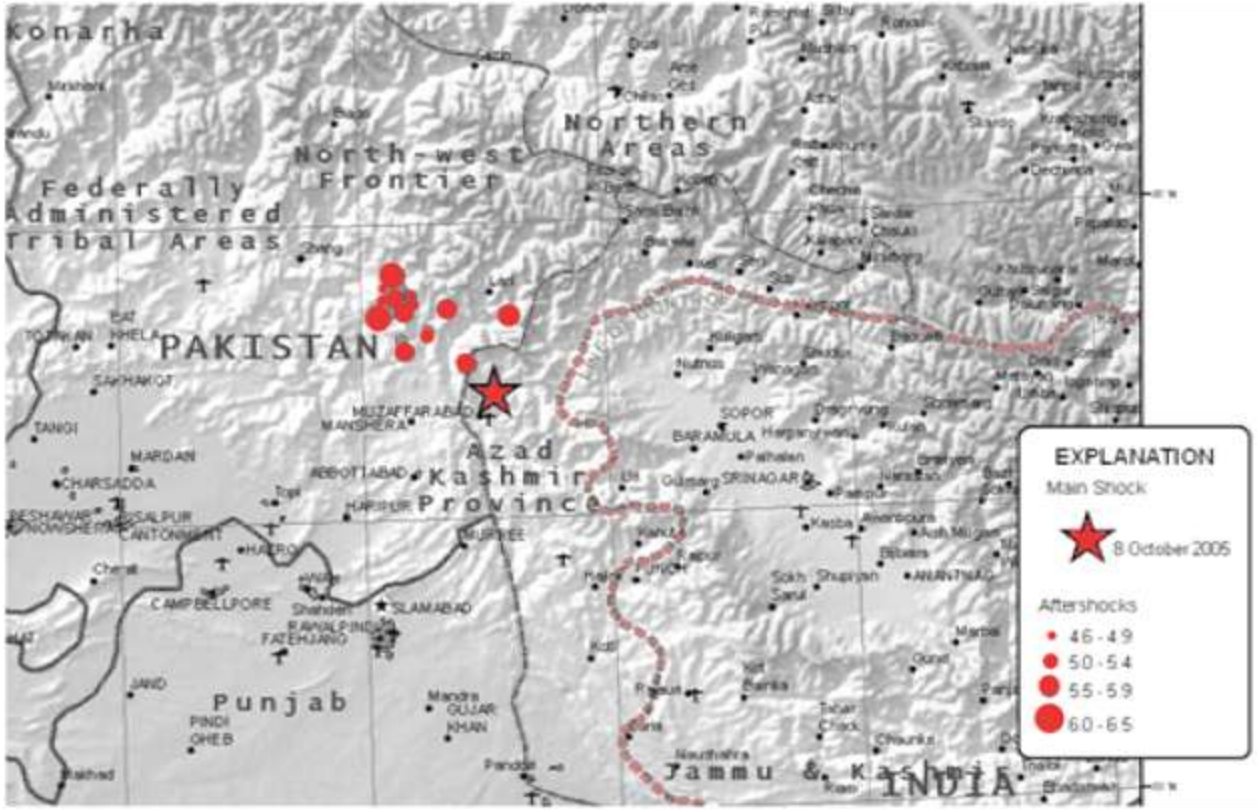
- October 8th 2005
- 7.6 on the Richter Scale
- 74,500+ died
- 106,000 injured
- 3.3 million + homeless





2. Seismic Mitigation/Pakistan Earthquake, 8th October 2005

National partners

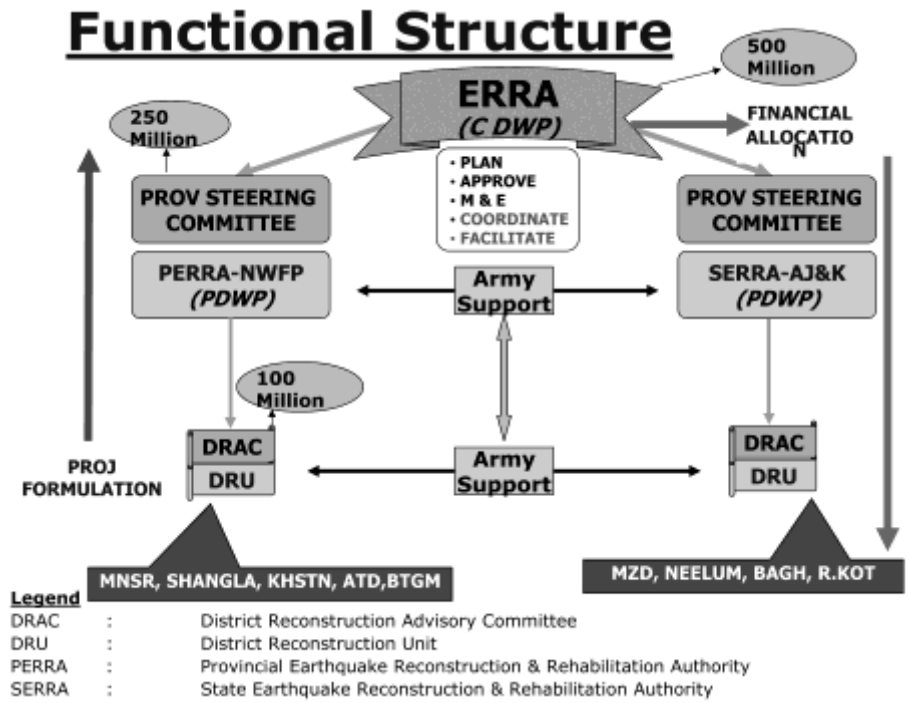
ERRA – Earthquake Reconstruction and Rehabilitation Authority

Post-earthquake government body with responsibility to:
"Plan, coordinate, monitor and regulate reconstruction & rehabilitation activities in earthquake affected areas, encouraging self reliance via private public partnership and community participation".

ERRA provide funding for beneficiaries whose houses meet the requirements of their approved inspectors.

Inspection is undertaken by various parties from the government, the army and selected NGOs.

Funding is provided directly to the beneficiaries in three instalments.



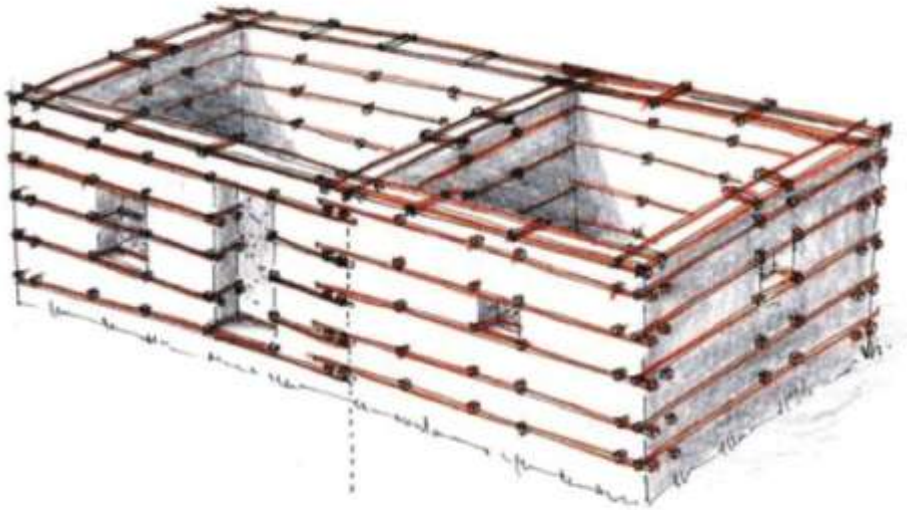
http://www.erra.gov.pk/Reports/Functional%20Chart.pdf

NESPAK (National Engineering Services Pakistan)

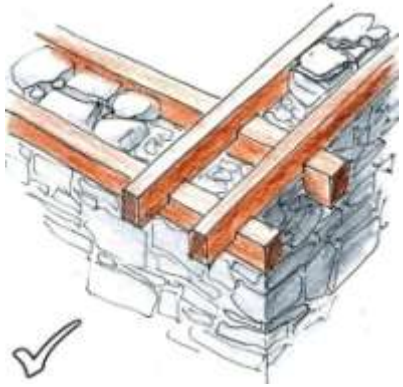
National Engineering Services Pakistan (Pvt) Limited (NESPAK) is an engineering consultancy established in Pakistan in 1973. This group works on behalf of ERRA to assess and approve construction proposals for seismic suitability during the design development stage.

Construction types implemented (in rural areas)

Bhatar Type Construction



Source: UN-HABITAT Compliance Catalogue



Timber reinforced masonry construction is traditional in parts of the affected area.

Stone masonry reinforced with horizontal ladders (bands) to improve the integrity of the wall and to tie the walls together.

Stone masonry must be constructed with through stones and well packed, using flat or dressed stones.

Timber bands are provided at regular intervals of max 2ft.

Timber bands must have cross pieces at every 3ft horizontally and good joints and overlapping.

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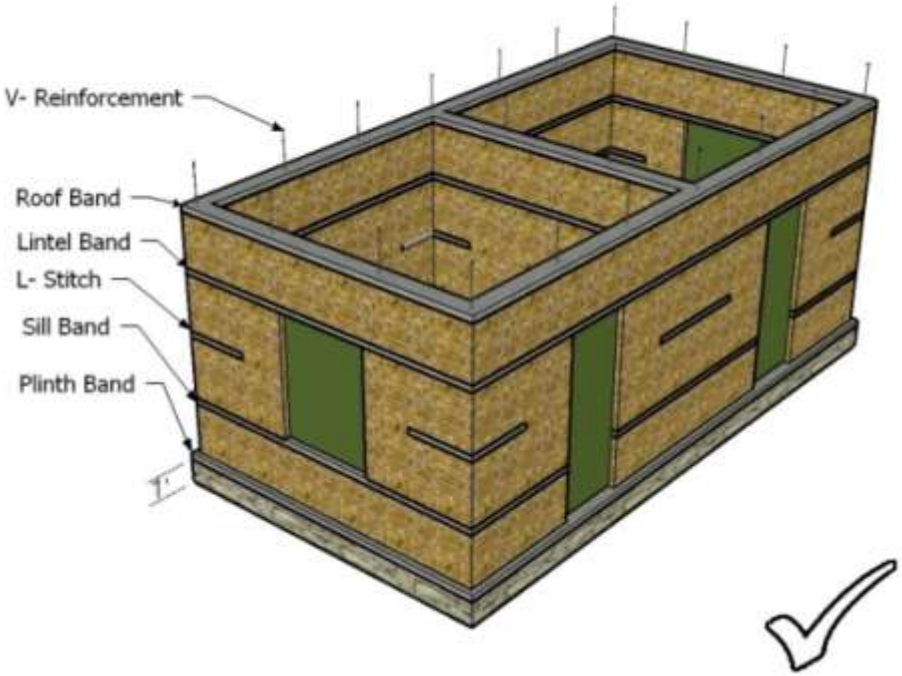
Reinforced Masonry Type Construction



Source: UN-HABITAT Compliance Catalogue

Reinforced masonry consists of stone, brick or block masonry with vertical and horizontal steel reinforcement bars.

Reinforcement is located at all junctions and is evenly spaced throughout the wall tying the masonry and walls together.

Horizontal reinforcement consists of reinforced concrete bands at plinth, sill, lintel and roof levels

Additional stitches are provided to reinforce corners

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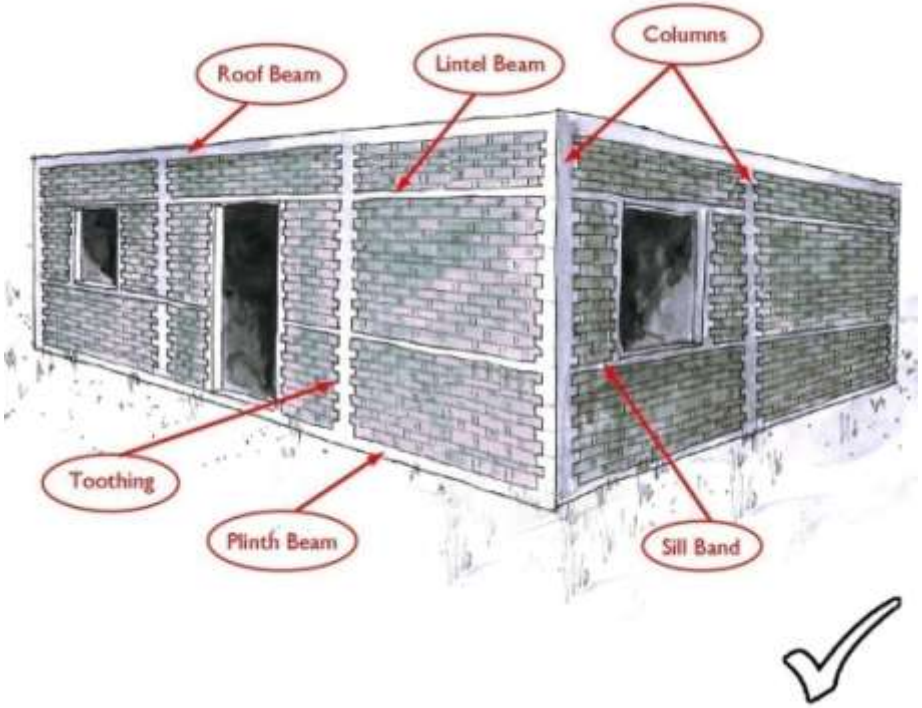
Confined Masonry Type Construction



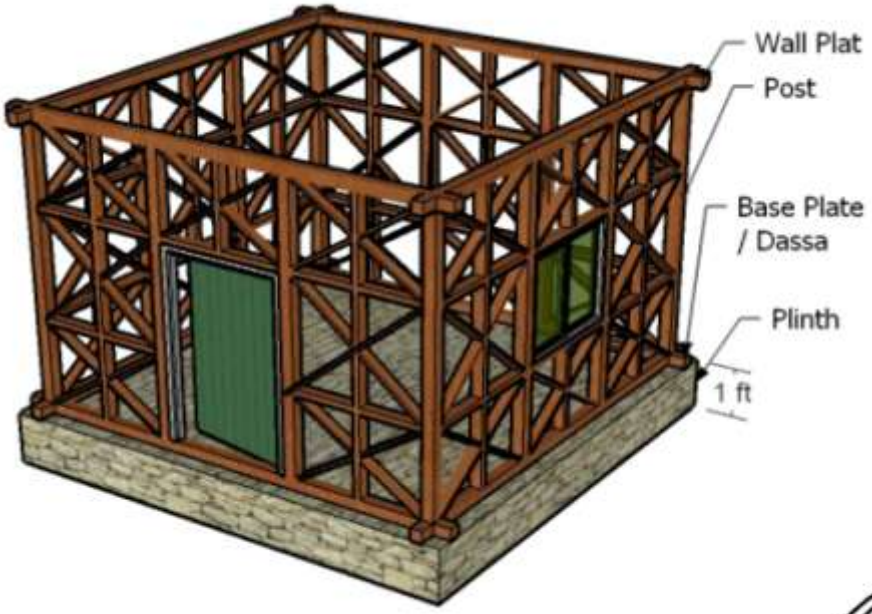
Source: UN-HABITAT Compliance Catalogue

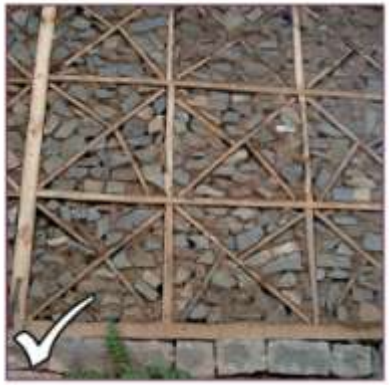
Confined masonry consists of load bearing brick or block masonry or in situ concrete panels surrounded by horizontal and vertical 'confining' elements made from reinforced concrete.

Wall panels are built first and then the reinforced concrete columns poured afterwards. The wall should be built with toothing to ensure a good connection with the concrete column. Walls should also be tied to columns with horizontal reinforcement.

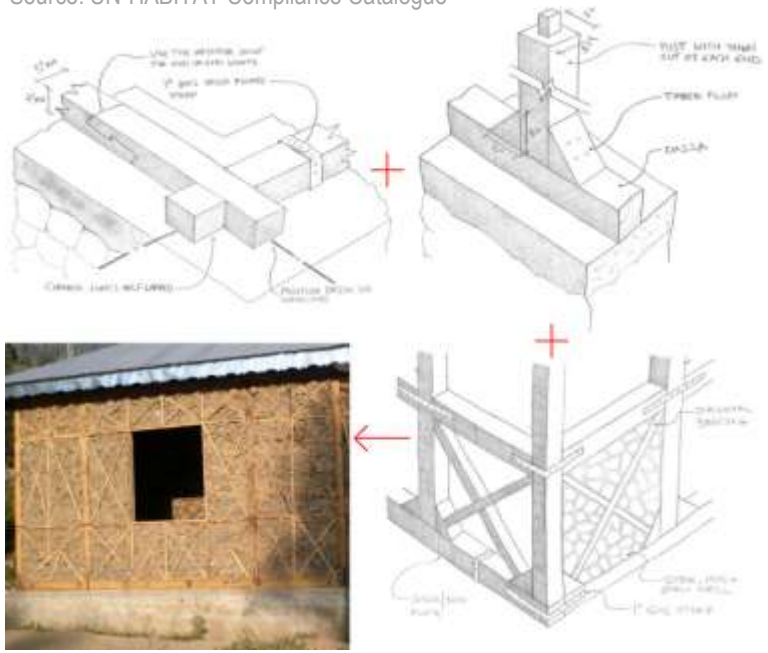
Horizontal reinforcement consists of reinforced concrete beams at plinth, sill, lintel and roof level.

Dhajji Da (Timber Frame) Type Construction





Source: UN-HABITAT Compliance Catalogue



The timber frame should be constructed as a well-connected box with adequate bracing in all directions.

The panels should be small and evenly sized.

The base plate and wall plate should be continuous

All timber should be well protected from moisture, especially from the ground.

The timber should be good quality with joint connections.

Masonry infill provides additional compressive strength.

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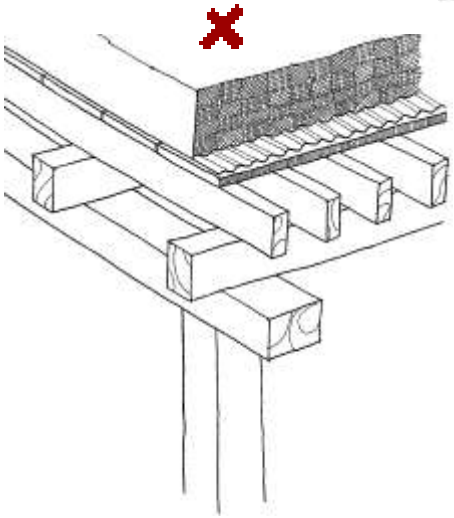
Vernacular Construction In Manoor, Kaghan Valley (NWFP)

Throughout the earthquake effected regions housing was typically constructed with very heavy roof structures be it a concrete slab or the traditional timber and rammed earth roof seen below.

The collapse of such heavy structures contributed to much death and injury.

In response reconstruction efforts promote lighter, pitched roof structures of timber truss and CGI sheet. In the examples below the original two storey house is retained and a new roof added.



Below Right: Traditional heavy flat roof construction/ Below Centre and Left: Post earthquake 'light' roof construction of timber and CGI sheet .

Muslim Aid/Article 25 housing programme

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December 2005 – Article 25 began working in partnership with Muslim Aid UK to design and build non-engineered, seismic resistant housing in the earthquake effected region.

Beneficiaries - Selected through community consultation and on the basis of vulnerability with preference given to:

1. Widows with children under 18yrs old
2. Those unable to work as a result of a disability
3. Those unable to work as a result of age
4. The poorest as identified by the community.

'Mock' construction - 4 houses were constructed initially to assess the relative benefit of blockwork and timber (dhajji da) construction.

Dhajji-daweri - Selected for all future housing as beneficiaries can participate in the construction process by supplying timber and stone from pre-earthquake houses.

Participatory approach - Intended to foster a sense of ownership.

House types - 2 house types have been developed to accommodate the varying plots and family sizes.

NESPAK have approved both types for construction.

60 - 80 houses planned for construction

Muslim Aid/Article 25 housing program

Drawings

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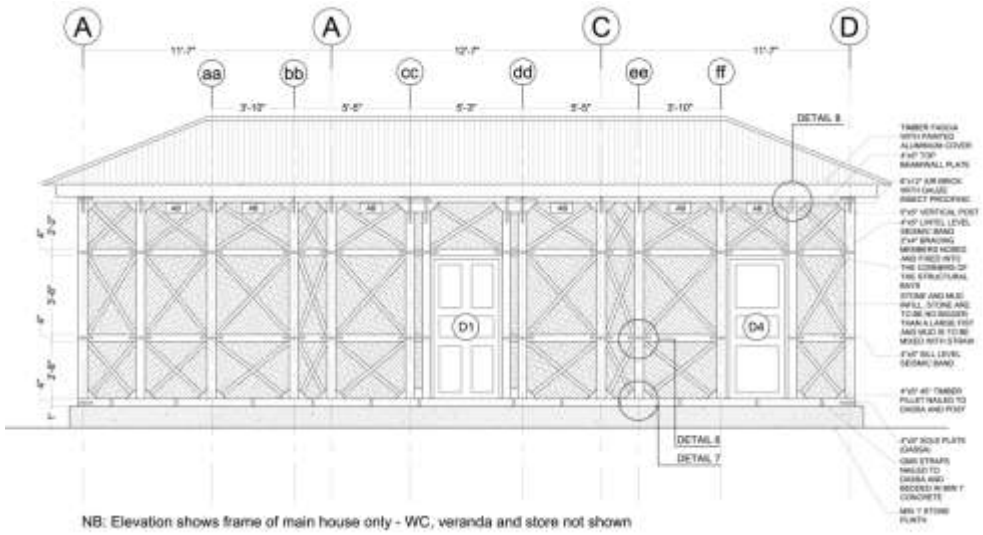

A package of drawings was prepared for each house type following research into:

1. **Vernacular construction techniques**
2. **Average family sizes**
3. **Characteristics of available plots e.g. plot size, ease of access**
4. **Appropriate seismic construction techniques**

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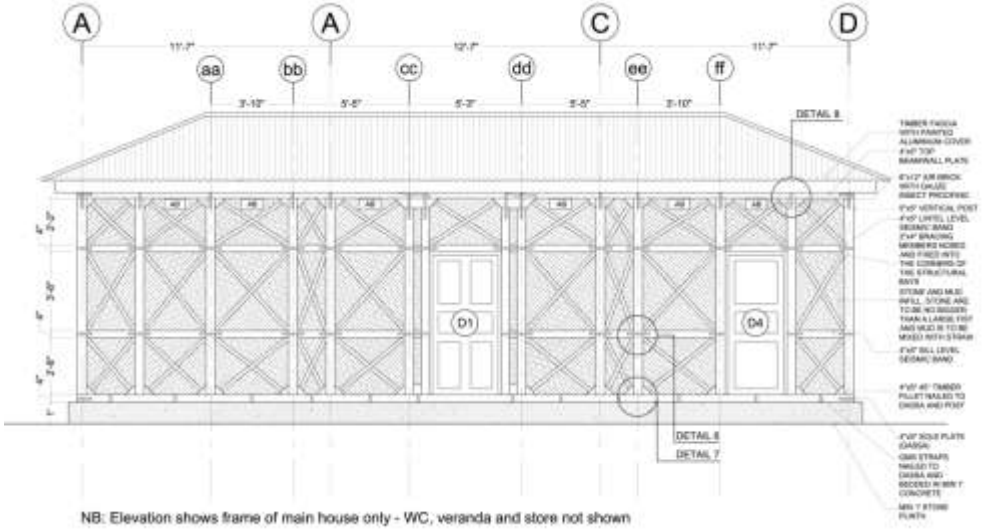

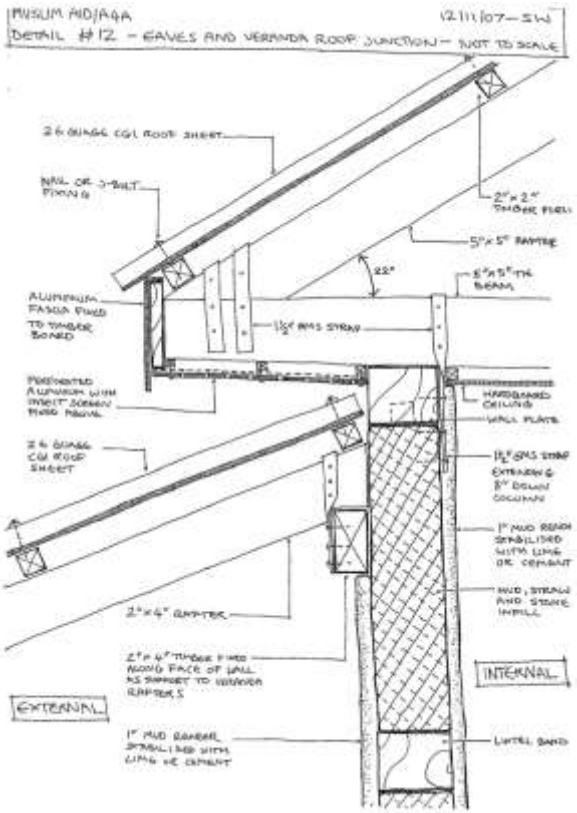

A package of drawings was prepared for each house type following research into:

1. **Vernacular construction techniques**
2. **Average family sizes**
3. **Characteristics of available plots e.g. plot size, ease of access**
4. **Appropriate seismic construction techniques**

During the initial construction stages further details were produced on site to clarify aspects of the design for Muslim Aid's site engineers.

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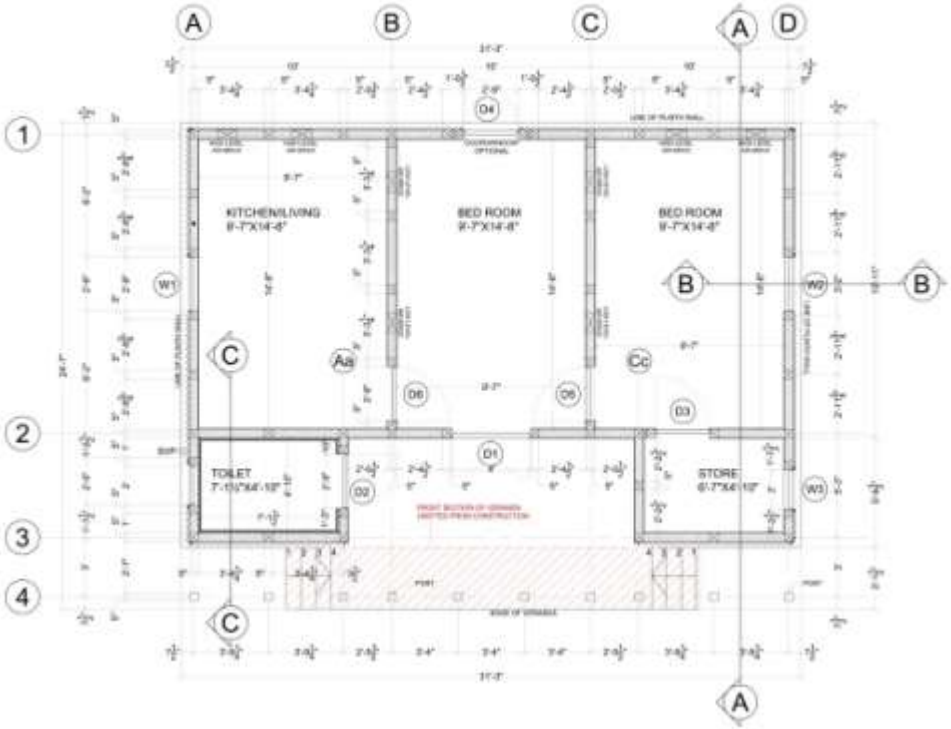

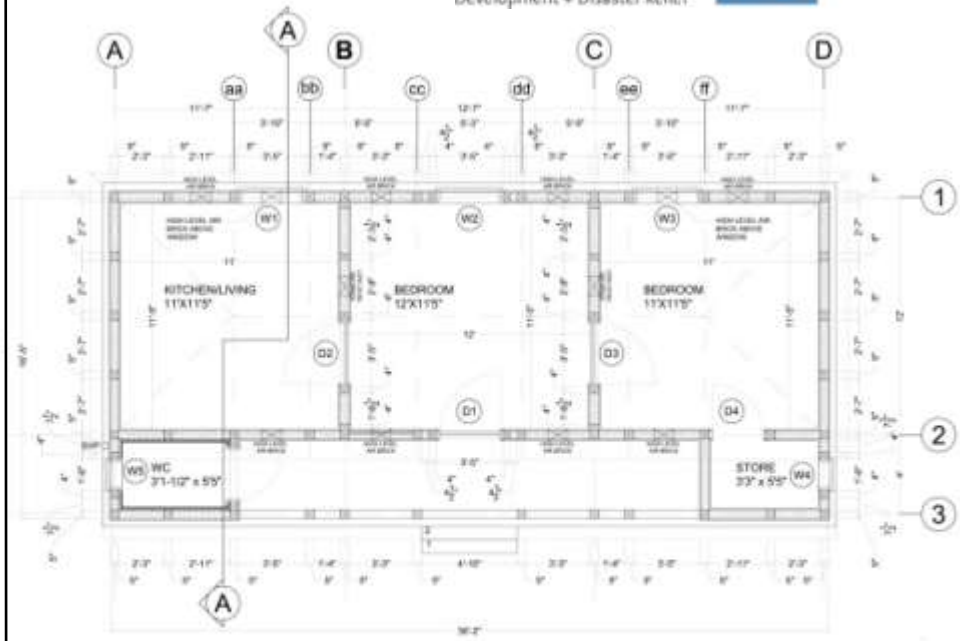

House Type 1

Gross area

721sqft or 70m²

Gross internal area

502sqft or 46m²

House Type 2

Gross area

641sqft or 60m²

Gross internal area

445sqft or 41m²

Muslim Aid/Article 25 housing program

Construction

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Plinth construction stages (approx 7 weeks to complete)

1 – Site selection

2 – Demarcation

3 – Excavation

4 – Pouring of foundation

5 – Construction of plinth wall

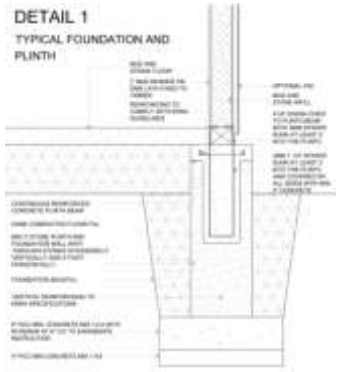
6 – Pouring of plinth band

Primary functions of the plinth:

1- To provide a stable base for the house construction

If a house has an unstable base there is an increased risk of structural failure during an earthquake. All plinths are reinforced and constructed on sound foundations to promote stability.

2 – To protect the timber structure from water damage



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Dhajji-daweri means patchwork quilt.

A dhajji-daweri house is a patchwork of timber and stone.

This construction type is indigenous to the earthquake effected areas.

Dhajji-daweri resists seismic forces as follows:

1. Small timber bracing members distribute earthquake energy evenly across the wall.

2. This energy is further dissipated in the friction of bracing moving against stone infill.

3. In this manner the risk of large cracks resulting in structural failure is reduced.

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Joint samples prepared by carpenters at UN HABITAT's field office, Bagh

Above Left: Half lap corner joint and Kashmir joint

Above Centre: Wall plate and post connection with metal strapping and corner fillets

Above Right: Metal strapping of roof truss and ridge beam

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Joints as implemented on site

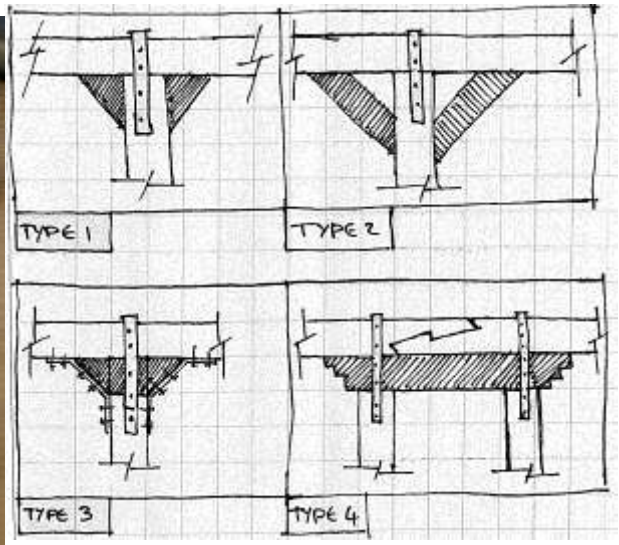
Above left: Half lap at corner joint in base plate (dassa).

Above centre: Wall plate/truss strapping.

Above right: Wall plate/post/beam junction with metal strap and corner fillets.

Far right: Sketch of variations on fillet bracing to column/wall plate junction.

Near right: Truss structure with metal straps.



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Primary goals:

1.To provide safer homes and a platform for future stability to those most vulnerable in the community.

2. To increase local capacity to construct improved seismically resistant housing through training of contractors and labour and by built example.

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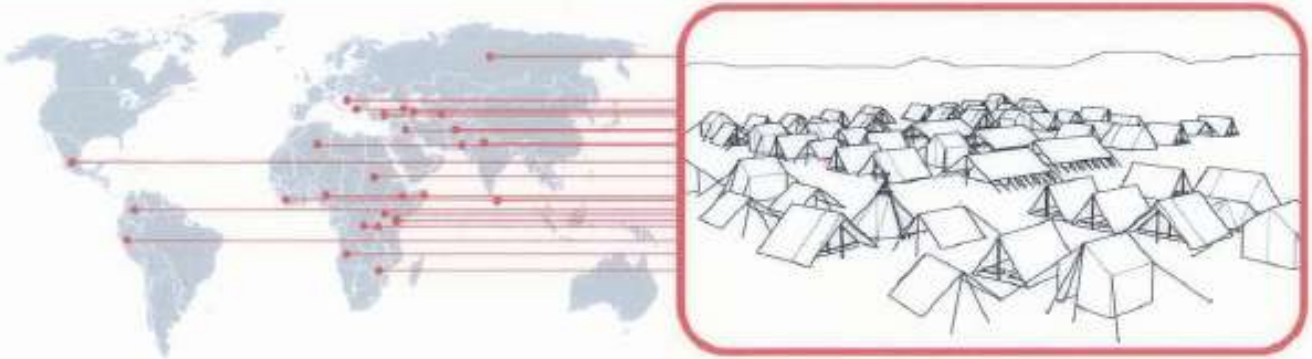
Using Human Urine in Mud Brick Manufacture

by Architects for Aid and The School of Architecture: University of Sheffield - 01liveproject07.wordpress.com



Currently there are **23,700,000** internally displaced persons (IDPs) in at least **49** countries, and over half the worlds population - more than **3,000,000,000** people - lack access to clean water or proper sanitation facilities. In arid regions of the world in particular, many of the resources necessary to provide and rebuild shelter for IDPs are simply unavailable. One solution is using mud bricks but these use too much precious water in making the dry soil workable. Human urine, therfore, could be used as an alternative.

3. Academic Collaborations

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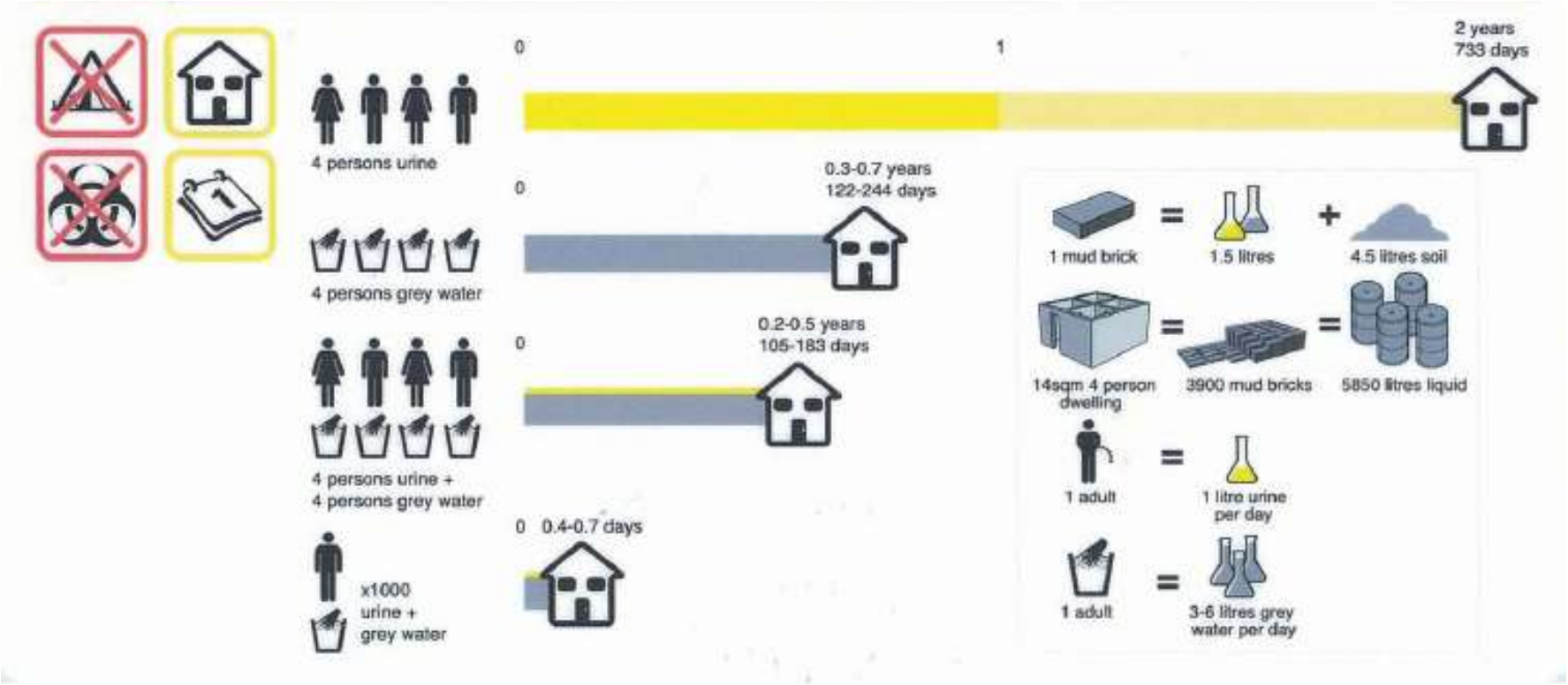






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- University Based Research generated by NGO project findings/needs with Sheffield University

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