World Housing Encyclopedia

an Encyclopedia of Housing Construction in
Seismically Active Areas of the World

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HOUSING REPORT
Adobe houses

Report #	166
Report Date	23-07-2012
Country	PAKISTAN
Housing Type	Adobe / Earthen House
Housing Sub-Type	Adobe / Earthen House : Adobe block walls
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Summary

This report provides an overview of adobe housing construction, which is widely distributed all over the country. Adobe construction covers 14.6% of the total built environment of Pakistan. Majority of adobe houses comprise of single storey structures with adobe masonry walls and timber roofs with mud covering. The construction is carried out without any technical input and suffers from a number of weaknesses. Therefore, this construction type is

highly vulnerable to seismic forces.

1. General Information

Buildings of this construction type can be found in all over the country (Figure 1) and range in scale and techniques of construction from seasonal family shelters in arid desert areas of Thar, to the more permanent rural family houses of the Indus plains, to the relatively sturdy yet seismically prone multi-level residences in the Gilgit-Baltistan region. They are more common where good quality day is readily available, such as the alluvial plains of Punjab and Sindh, and, in a limited quantity, the hilly regions of Gilgit-Bultistan or Kashmir. Adobe construction comprises a surprisingly large percentage of the built environment of Pakistan, standing at 14.6% [1]. This type of housing construction is commonly found in both rural and urban areas.

Building with adobe is amongst the least expensive forms of construction in the country, and hence widely popular with the rural population of Pakistan. Although they contain absolutely no engineering input and are increasingly prone to earthquakes and floods, adobe houses are still the abode of choice for a large proportion of the rural population. Local masons and craftsmen have great expertise in handling adobe. Apart from its construction cost, adobe is also popular because of its exceptional properties of insulation, and so is used both in very hot as well as very cold regions. Figure 2 and 3 show the adobe bricks used in upper Sindh and typical adobe house in Larkana, Sindh, respectively. The external walls of adobe houses can be covered in a variety of finishes. These indude plastering (in mud or cement), whitewashing on the plaster, and coating with lime or organic materials such as manure mixed with straw The aim of the external treatment is twofold to help bond the individual adobe blocks together against a smooth surface, and to protect the adobe blocks from absorbing heat directly. This layer of finish generally requires periodic repairs as wind, water, or extreme heat causes it to disintegrate and spall off. Despite these economic factors that influence the heavy usage of adobe in rural construction, adobe has some serious drawbacks. Apart from being seismically inadequate, adobe structures tend to be highly prone to abrasion by wind and erosion by rising water levels. The seepage of subterranean moisture tends to weaken their foundations and plinth. Also, it is uncommon to see adobe structures beyond a single story height, except in the northern hilly regions, as adobe blocks have limited strength and can only support a lightweight roof. In Pakistan, adobe is the material of choice for the poorer rural population, who has a limited choice of material when it comes to economical construction.

This construction type has been in practice for more than 200 years.

Currently, this type of construction is being built. .

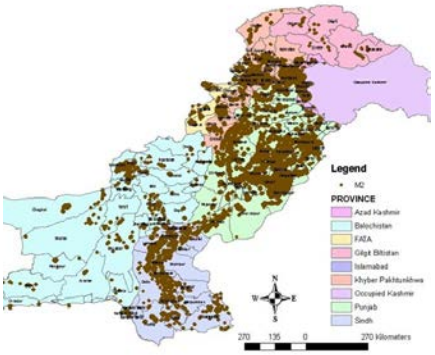

Figure 1: Spatial distribution of adobe masonry buildings in Pakistan [1].


Figure 2: Adobe blocks.


Figure 3: A typical adobe house, Larkana, Sindh.

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat, sloped and hilly terrain. They do not share common walls with adjacent buildings. Adobe construction is limited to the rural areas of Pakistan. It may also be present in substantial numbers within the outskirts of secondary cities or market towns as residences for daily wage workers and labourers. More precisely, adobe structures can be built on flat as well as moderately hilly terrain, but only rarely on rugged or steep

slopes. Hence, it is common to find adobe houses in the villages of the Gilgit-Baltistan and Chitral region. The abundance of suitable clay in the vast alluvial plains of the Indus River makes adobe houses a common sight in Punjab and interior Sindh. Adobe houses are also built in parts of Baluchistan as rudimentary, semi-permanent shelters. Each adobe house is an independent unit. Adjacent houses are placed a considerable distance apart, and do not share common walls. Often, a group of houses may be clustered together and surrounded by a crude palisade wall made of dried grass or twigs. This organizes the colony into a single consolidated arrangement, complete with an enclosed communal space for children, women, and elders, keeping strangers and stray animals out of the enclosure When separated from adjacent buildings, the typical distance from a neighboring building is more than 10 meters.

2.2 Building Configuration

Adobe buildings normally have a rectangular or linear plan arrangement. The rooms are divided symmetrically on either side of the main axis, with a limited number of small and well-placed openings on walls. These features make the adobe house a robust, compact structure, but one that may still require seismic strengthening. Local appendages to adobe houses include an outhouse (separate toilet and bathroom), a sehen/verandah, and a semi-covered porch space in front of the main entrance, with an extension of roof beams that shade the porch. Figure 4 illustrates the plan of a typical adobe house in the rural areas of Sind and Punjab. .

2.3 Functional Planning

The main function of this building typology is single-family house. They are small, 2 to 3-room structures, offering a balance between intimate space and social space. In the rural flatlands, the interior spaces of adobe houses are seldom explicitly marked out for specific functions. Spaces are shared between the everyday roles of sleeping, preparing meals, spending family time, and storing items of daily use all happening in the same room at times. An attached exterior space, if available, may be used as a spill over zone for family activities during the daytime as it is better ventilated and well-illuminated, Figure 5. In the northern areas, adobe houses tend to be closed, introverted spaces, to protect against the cold outside. The interior spaces are organized around a central living room (Figure 6), to which bedrooms, a raised kitchen/dining area, and a spare/store room is attached. Heat gets trapped efficiently inside the low-ceilinged kitchen space during cooking, and so less fuel needs to be burnt for keeping the house warm. Also, the main entrance to the house often consists of a small double-door lobby space, with one door opening to the exterior environment and the other to the interior living space. This helps prevent heat loss when the doors are opened to let people move indoors or outdoors. The living room itself is roughly 20 feet by 21 feet, the largest room of the house. It is divided into three parts through changes in floor levels. Two elevated platforms to the sides, about 7 feet by 20 feet and raised 6 from the ground, are used for sleeping and/or dining, whereas the lower, middle portion is used for cooking. A finished floor consisting of wooden planks may be provided on the raised platforms to reduce heat losses through the floor. In a typical building of this type, there are no elevators and no fire-protected exit staircases.

2.4 Modification to Building

Buildings are open to incremental modification as resources become available, or as functional or climatic improvements including seasonal repairs after floods or earthquakes. It is not possible to add vertically to an adobe house, especially those with a light roof (thick reeds or plastic sheets). A small room or storage area may be added to one side-wall of the house, but care should be taken that it does not lean upon the main wall and cause it to tilt inwards.

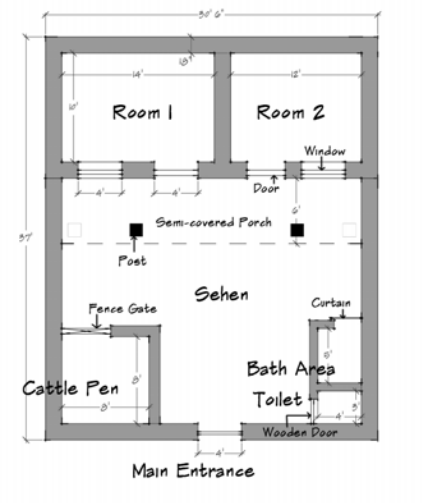

Figure 4: Typical adobe house in rural areas of Sind and Punjab.

Figure 5: Typical adobe house in Village Vikia Sangi, Larkana.

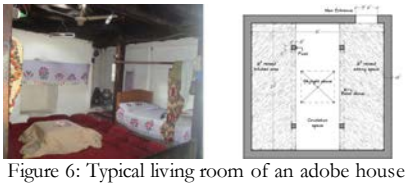

Figure 6: Typical living room of an adobe house in Gilgit.

3. Structural Details

3.1 Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	Most appropriate type
Masonry	Stone Masonry Walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	☐
		2	Dressed stone masonry (in lime/cement mortar)	☐
	Adobe/ Earthen Walls	3	Mud walls	☐
		4	Mud walls with horizontal wood elements	☐
		5	Adobe block walls	☑
		6	Rammed earth/Pise construction	☐
	Unreinforced masonry walls	7	Brick masonry in mud/lime mortar	☐
		8	Brick masonry in mud/lime mortar with vertical posts	☐
		9	Brick masonry in lime/cement mortar	☐
		10	Concrete block masonry in cement mortar	☐
	Confined masonry	11	Clay brick/tile masonry, with wooden posts and beams	☐
		12	Clay brick masonry, with concrete posts/tie columns and beams	☐
		13	Concrete blocks, tie columns and beams	☐
	Reinforced masonry	14	Stone masonry in cement mortar	☐
		15	Clay brick masonry in cement mortar	☐
		16	Concrete block masonry in cement mortar	☐
	Moment resisting frame	17	Flat slab structure	☐
		18	Designed for gravity loads only, with URM infill walls	☐
		19	Designed for seismic effects, with URM infill walls	☐
			Designed for seismic effects,	

Structural concrete		20	with structural infill walls	☐
		21	Dual system – Frame with shear wall	☐
	Structural wall	22	Moment frame with in-situ shear walls	☐
		23	Moment frame with precast shear walls	☐
	Precast concrete	24	Moment frame	☐
		25	Prestressed moment frame with shear walls	☐
		26	Large panel precast walls	☐
		27	Shear wall structure with walls cast-in-situ	☐
		28	Shear wall structure with precast wall panel structure	☐
Steel	Moment-resisting frame	29	With brick masonry partitions	☐
		30	With cast in-situ concrete walls	☐
		31	With lightweight partitions	☐
	Braced frame	32	Concentric connections in all panels	☐
		33	Eccentric connections in a few panels	☐
	Structural wall	34	Bolted plate	☐
		35	Welded plate	☐
Timber	Load-bearing timber frame	36	Thatch	☐
		37	Walls with bamboo/reed mesh and post (Wattle and Daub)	☐
		38	Masonry with horizontal beams/planks at intermediate levels	☐
		39	Post and beam frame (no special connections)	☐
		40	Wood frame (with special connections)	☐
		41	Stud-wall frame with plywood/gypsum board sheathing	☐
		42	Wooden panel walls	☐
Other	Seismic protection systems	43	Building protected with base-isolation systems	☐
		44	Building protected with seismic dampers	☐
	Hybrid systems	45	other (described below)	☐

3.2 Gravity Load-Resisting System

The vertical load-resisting system is earthen walls. The loads from the roof are transferred to the walls (adobe block masonry or earthen) and to the foundations.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is earthen walls. The walls have a very low resistance to out-of-plane forces. There is no proper connection between the roof and the walls.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 3 and 5 meters, and widths between 3 and 5

meters. The building is 1 storey high. The typical span of the roofing/flooring system is 3-5 meters. The typical storey height in such buildings is 2.50 meters. The typical structural wall density is up to 20 %. More precisely, typical structural wall density ranges from 10 to 15%.

3.5 Floor and Roof System

Material	Description of floor/roof system	Most appropriate floor	Most appropriate roof
Masonry	Vaulted	☐	☐
	Composite system of concrete joists and masonry panels	☐	☐
Structural concrete	Solid slabs (cast-in-place)	☐	☐
	Waffle slabs (cast-in-place)	☐	☐
	Flat slabs (cast-in-place)	☐	☐
	Precast joist system	☐	☐
	Hollow core slab (precast)	☐	☐
	Solid slabs (precast)	☐	☐
	Beams and planks (precast) with concrete topping (cast-in-situ)	☐	☐
	Slabs (post-tensioned)	☐	☐
Steel	Composite steel deck with concrete slab (cast-in-situ)	☐	☐
Timber	Rammed earth with ballast and concrete or plaster finishing	☐	☐
	Wood planks or beams with ballast and concrete or plaster finishing	☐	☐
	Thatched roof supported on wood purlins	☐	☐
	Wood shingle roof	☐	☐
	Wood planks or beams that support clay tiles	☐	☐
	Wood planks or beams supporting natural stones slates	☐	☐
	Wood planks or beams that support slate, metal, asbestos-cement or plastic corrugated sheets or tiles	☐	☐
	Wood plank, plywood or manufactured wood panels on joists supported by beams or walls	☐	☐
Other	Described below	☐	☑

The roof of a typical adobe house usually comprises of timber or bamboo with mud layer (Figure 7). Timber rafters covered with a layer of wooden reeds (chick), act as the main horizontal supporting members. A typical 100-150 mm thick layer of mud is applied. Where wood in not available, generally bamboo is used. New constructions may employ I-beams or steel girders instead of wooden planks with bamboo stalks. Another alternative roofing material is galvanized iron (GI) sheets supported on a light wooden truss system.

3.6 Foundation

Type	Description	Most appropriate type
Shallow foundation	Wall or column embedded in soil, without footing	☑
	Rubble stone, fieldstone isolated footing	☐
	Rubble stone, fieldstone strip footing	☐
	Reinforced-concrete isolated footing	☐
	Reinforced-concrete strip footing	☐

	Mat foundation	☐
	No foundation	☑
Deep foundation	Reinforced-concrete bearing piles	☐
	Reinforced-concrete skin friction piles	☐
	Steel bearing piles	☐
	Steel skin friction piles	☐
	Wood piles	☐
	Cast-in-place concrete piers	☐
	Caissons	☐
Other	Described below	☐

Figure 7: Adobe house roof - interior. Timber planks with bamboo stalks supporting wooden chick.

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 1 housing unit(s). Adobe houses act as single family residence only or may house a small extended family, as each house usually has just one or two rooms (bed/store). The number of inhabitants in a building during the day or business hours is others (as described below). The number of inhabitants during the evening and night is others (as described below). The number of people in each house varies from 2-8, ranging over two or three generations. As sons in the family grow to a marriageable age, they may choose to build a separate unit for themselves, either as an appendage to the existing building or an independent structure a small distance away from it.

4.2 Patterns of Occupancy

An adobe house contains one rural family, which typically consists of a few working men, womenfolk, and elders. The house is inhabited by womenfolk and the elderly during the daytime, while children use the attached semi-covered or open court as play space. The external court is also used by women for additional household chores like washing and drying out laundry, and cooking if an appropriate indoors cooking space is not available. This helps in the elimination of harmful fumes from the interior living spaces as well. Men arrive later in the evening or towards nightfall, and the family spends time socializing in the open verandah till dusk. Activities include eating, drinking tea, smoking hookah pipes, and exchanging the days stories. The inhabitants move into the covered interior spaces as night closes in. During severe climatic conditions, like extreme heat or heavy rain, inhabitants retreat indoors. Otherwise, the indoor spaces are used primarily for sleeping and storage of precious belongings.

4.3 Economic Level of Inhabitants

Income class	Most appropriate type
a) very low-income class (very poor)	☑

b) low-income class (poor)	☑
c) middle-income class	☐
d) high-income class (rich)	☐

Adobe houses are the primary choice of residence for low income households of single families. Men build new houses for themselves as they marry and become independent from their extended family. The new house is usually located within close proximity to the original family home, which eventually results in a cluster of single-family homes on the same parcel of land, sometimes enclosed by a rudimentary boundary wall made out of dead or dried branches.

Ratio of housing unit price to annual income	Most appropriate type
5:1 or worse	☐
4:1	☐
3:1	☐
1:1 or better	☑

What is a typical source of financing for buildings of this type?	Most appropriate type
Owner financed	☑
Personal savings	☑
Informal network: friends and relatives	☑
Small lending institutions / micro-finance institutions	☐
Commercial banks/mortgages	☐
Employers	☐
Investment pools	☐
Government-owned housing	☐
Combination (explain below)	☐
other (explain below)	☐

In each housing unit, there are no bathroom(s) without toilet(s), no toilet(s) only and no bathroom(s) including toilet(s).

Bathrooms and toilets are separated from the main house in a certain distance. .

4.4 Ownership

The type of ownership or occupancy is outright ownership, ownership with debt (mortgage or other) and individual ownership.

Type of ownership or occupancy?	Most appropriate type
Renting	☐
outright ownership	☑
Ownership with debt (mortgage or other)	☑
Individual ownership	☑
Ownership by a group or pool of persons	☐
Long-term lease	☐
other (explain below)	☐

Men (heads of the family) own the house, and it is common practice for the sons to build their own houses once independent, as space is very limited within an adobe house (2-3 rooms). In some rural areas, the landlord owns all the land that the worker family lives on, and so a new house may be built on lease or with loans from the landlord. The house then remains the property of the landlord, being leased to the occupants for a defined period of time (e.g. for the harvest season, or for one summer, etc.). These kinds of temporary houses may employ lighter roofs or vertical supports such as bamboo stalks, items that the family can carry away to rebuild somewhere else once their agreement with the landlord expires.

5. Seismic Vulnerability

5.1 Structural and Architectural Features

Structural/ Architectural Feature	Statement	Most appropriate type		
		Yes	No	N/A
Lateral load path	The structure contains a complete load path for seismic force effects from any horizontal direction that serves to transfer inertial forces from the building to the foundation.	☐	☑	☐
Building Configuration	The building is regular with regards to both the plan and the elevation.	☑	☐	☐
Roof construction	The roof diaphragm is considered to be rigid and it is expected that the roof structure will maintain its integrity, i.e. shape and form, during an earthquake of intensity expected in this area.	☐	☑	☐
Floor construction	The floor diaphragm(s) are considered to be rigid and it is expected that the floor structure(s) will maintain its integrity during an earthquake of intensity expected in this area.	☐	☐	☑
Foundation performance	There is no evidence of excessive foundation movement (e.g. settlement) that would affect the integrity or performance of the structure in an earthquake.	☐	☑	☐
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	☑	☐	☐
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: Less than 25 (concrete walls); Less than 30 (reinforced masonry walls); Less than 13 (unreinforced masonry walls);	☑	☐	☐
Foundation-wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	☐	☑	☐
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps	☐	☑	☐
Wall openings	The total width of door and window openings in a wall is: For brick masonry construction in cement mortar : less than ½ of the distance between the adjacent cross walls; For adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; For precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	☐	☑	☐
Quality of building materials	Quality of building materials is considered to be adequate per the requirements of national codes and	☐	☑	☐

	standards (an estimate).			
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).	☐	☑	☐
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber)	☐	☑	☐
Additional Comments				

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake Resilient Features	Earthquake Damage Patterns
Wall	Poor lateral resistance, weak in out of plane direction, no lintel band, improper opening proportions	There are no earthquake resistant features.	Collapse of wall due to out of plane effects and shear
Frame (columns, beams)	-	-	-
Roof and floors	Heavy dead loads (5-6 inch mud layer usually topped up every year), no connection between roof elements and walls, lack of diaphragm action	-	Collapse of roof due to out of plane failure of walls.

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is A: HIGH VULNERABILITY (i.e, very poor seismic performance), the lower bound (i.e., the worst possible) is A: HIGH VULNERABILITY (i.e., very poor seismic performance), and the upper bound (i.e., the best possible) is A: HIGH VULNERABILITY (i.e, very poor seismic performance).

Vulnerability	high	medium-high	medium	medium-low	low	very low
	very poor	poor	moderate	good	very good	excellent
Vulnerability Class	A	B	C	D	E	F
	☑	☐	☐	☐	☐	☐

5.4 History of Past Earthquakes

Date	Epicenter, region	Magnitude	Max. Intensity
1819	Allahbund, Sindh	7.2	IX to X
1852	Kahan, Balochistan	8	IX
1892	Qilla Abdullah, Balochistan	6.8	VIII to IX
1909	Sibi, Balochistan	7	VIII to IX
1931	Sharigh Valley, Balochistan	7	VIII to IX
1935	Quetta, Balochistan	7.5	VIII
1945	Pasni, Makran	8.3	VII to VIII

2005	Kashmir	7.6	X
2008	Ziarat, Balochistan	6.4	VII
2011	Dalbandin, Baluchistan	7.2	IV to V

Indian plate upon which Pakistan, India and Nepal lie, is continuously moving northward and sub-ducting under the Eurasian plate, thus triggering earthquakes in the process and forming Himalayan mountains. Within the Suleiman, Hindu Kush and Karakoram mountain ranges, the Northern Areas and Chitral district in NWFP, Kashmir including Muzaffarabad, and Quetta, Chaman, Sibi, Zhob, Khuzdar, Dalbandin, the Makran coast including Gwadar and Pasni in Balochistan are located in high or very high risk areas. Cities of Islamabad, Karachi and Peshawar are located on the edges of high risk areas. Figure 8 shows the seismic zoning map of Pakistan, which was developed after 2005 Kashmir earthquake [2]. A large number of major earthquakes have hit Pakistan in 20th Century including: 1935 Quetta earthquake, 1945 Makran coast earthquake, 2001 Bhuj earthquake and 2005 Kashmir earthquake [3]. Figure 9 and 10 show the total collapse of adobe houses in Ziarat 2008 Earthquake and Dalbandin 2011 earthquake in Balochistan.

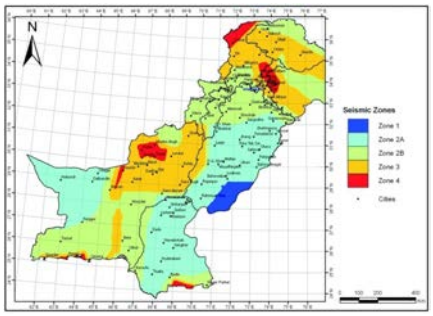

Figure 8: Seismic zoning map of Pakistan [2].



Figure 9: Total collapse of adobe houses during the Ziarat earthquake in 2008.



Figure 10: Typical damage caused by the Dalbandin earthquake in 2011.

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Adobe bricks with mud mortar	Not available	1:10:1 (Sand, Clay, Straw). The blocks are available in different sizes described below.	Detailed description given below.
Foundation	Adobe or Rubble stone or baked bricks	Not available	Not available	Detailed description given below.
Frames (beams & columns)	N/A	N/A	N/A	N/A
Roof and floor(s)	Roof is constructed from timber or bamboo with layer of mud.	Not available	Not available	Detailed description given below.

6.2 Builder

Adobe houses are constructed by poor rural folk. They have little engineering knowledge but have mastered the art of mass-producing and laying adobe blocks using appropriate mortar and finishes. The builder is usually the owner of the house, who occupies it with his family when it is completed.

6.3 Construction Process, Problems and Phasing

Adobe houses are quite weak against the action of water, either in the form of heavy precipitation or flooding which erode the walls and damage the roof, or a rising water table which weakens the foundations and the plinth. The lower portion of walls is now constructed using baked brick in cement mortar, with a finish of cement based plaster. This helps reduce the disintegration of the plinth and lower wall when there is stagnant water. The rest of the wall can be mud brick with mud mortar and plaster. Furthermore, the walls can be made of burnt brick on the exterior face, and

mud brick on the interior. Generally, a simple mud plaster is not an efficient binding agent. In this case, an external finish of cement sand plaster helps reduce abrasion. Adding lime to the plaster makes it more water resistant, as well as helps reflect heat back to the exterior. The construction of this type of housing takes place incrementally over time. Typically, the building is originally not designed for its final constructed size.

6.4 Design and Construction Expertise

This type of construction is generally carried out by unskilled persons and villagers without any technical input. Mostly, the construction is carried out by the owners themselves. In some cases local masons are involved who have acquired the basic knowledge through experience. However, there is no engineering or design involved. Architects and engineers have no role in the design or construction of this housing type.

6.5 Building Codes and Standards

This construction type is not addressed by the codes/standards of the country. There is no specific code available to address this construction type.

6.6 Building Permits and Development Control Rules

This type of construction is a non-engineered, and not authorized as per development control rules. Building permits are not required to build this housing type.

6.7 Building Maintenance

Typically, the building of this housing type is maintained by Owner(s). The most affected part of an adobe structure over the period of a year are its walls, the surfaces of which become cracked as plaster (or mud overlapping) dries or wears off, or becomes weak due to the action of rising water or erosion by wind. Foundations are also affected badly by rising water tables or stagnant water after heavy rainfall or a flood season, and need to be checked after the water has been drained. Roofs of adobe houses, containing a number of layers of different materials, are completely exposed to the adversities of nature, induding the action of wind currents, harsh sunlight, and direct contact with precipitation, which reduces their stability as the year progresses. Walls and roofs of adobe houses need to be periodically repaired, which means applying a fresh layer of plaster to the walls and roof in parts where plaster has cracked or withered away, to ensure that the house poses no imminent threat to human inhabitancy.

6.8 Construction Economics

The cost of construction is roughly Rs. 1,000 per m2 (US$ 10.00). The construction of a typical housing unit takes approximately 2 to 3 months to complete.

7. Insurance

Earthquake insurance for this construction type is typically unavailable. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is unavailable.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

There are no specific set of provisions available for seismic strengthening and retro-fitting of adobe houses.

8.2 Seismic Strengthening Adopted

Has seismic strengthening described in the above table been performed in design and construction practice, and if so, to what extent?

Not applicable.

Was the work done as a mitigation effort on an undamaged building, or as repair following an earthquake?

Not applicable.

8.3 Construction and Performance of Seismic Strengthening

Was the construction inspected in the same manner as the new construction?

Not applicable.

Who performed the construction seismic retrofit measures: a contractor, or owner/user? Was an architect or engineer involved?

Not applicable.

What was the performance of retrofitted buildings of this type in subsequent earthquakes?

Not applicable.

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