AFGHANISTAN
Nahrin post earthquake emergency shelter rehabilitation project

Short term mission: field diagnostic, shelter design and technical recommendations for earthquake resistance

Final report by
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Commissioned by ACTED

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In order to identify the most suitable and cost-effective anti-earthquake design for the Nahrin post-earthquake emergency shelter rehabilitation project, ACTED commissioned a mission of consisting of four experts:

(a) two external experts in earth construction and earthquake resistance, one on a short-term assignment to create the shelter design and construction methodology to be used in the project, and a second expert on a middle-term assignment to implement the project

(b) two local engineers employed by ACTED who supervised the construction of 8,000 emergency shelters after the earthquakes in Rustaq in 1998, and who benefited from special on-site training from experts in earthquake-resistant construction during the Rustaq operation.

The mission had three main objectives:

(1) To adjust existing anti-earthquake design standards by taking into account best practices in the local community

(2) To create a shelter design that is either consistent with the UNHCR package that ACTED is supposed to implement for returnees in the same area, or one which represents an improvement to the UNHCR package

(3) To propose a cost-effective design that efficiently utilizes the local community and the resources available in the area

To this end, the mission took the following practical steps:

(1) Before arriving in Afghanistan, the team gathered documentation regarding the earthquake-resistant standards used in similar shelter designs, including past experiences in the region\(^1\) and building codes developed in New Mexico\(^2\). After arriving in Kabul, the mission gathered documentation from UN agencies, NGOs, and other actors about recent experiences in post-earthquake shelter design and regarding their current shelter strategies for Afghanistan.

(2) Benefiting from ACTED’s ongoing field presence in Nahrin and our relationship with the local community, the mission conducted a field survey in Nahrin which involved the following activities:

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\(^1\) The team used the work of Randolph Lagenback, Assistant Professor at the University of California Berkeley, entitled “The Earthquake Resistant Mud and Brick Architecture of Kashmir.”

\(^2\) The team also used the “New Mexico Adobe and Rammed Earth Building-Code” developed by the Regulation & Licensing Department of the General Construction Bureau in Santa Fe, New Mexico .1992
a. The team identified good local building practices that allowed houses to resist earthquake destruction. These identified practices were then discussed with local village elders to ensure that these practices could be standardized and implemented on a large scale according to internationally agreed standards.

b. The mission further examined the UNHCR package and attempted to reconcile the UNHCR shelter design with the local sociological constraints found on the field as well as with the goal of cost-efficiency. The UNHCR package and other design options were then discussed.

c. with local authorities to ensure that the final suggested design would not be inappropriate for the region.

d. The team assessed the availability of resources in the region in terms of skilled manpower and materials, with a special consideration of the scarcity of particular resources and the inflationary trends for certain building materials.

(3) The mission then proposed an earthquake-resistant shelter design which takes into account good local building practices, sociological constraints, costs, resource availability, and the UNHCR design. This design can be used either (a) to improve the UNHCR package; or (b) as an alternate, more-cost effective standard.

(4) Through discussions with local village elders, the team and the local community reached a basic agreement on the proposed design and upon the community mobilization effort, a significant component of the project. Indeed, the mission resulted in a shelter package in which ACTED and its donor will support the construction of one room and the local community will support the construction of a second room using material recovered either at the village or family level. This is a major development as it means that by funding only a one-room shelter, the donor and ACTED will be able to provide the affected population with a two-room shelter with an effective anti-earthquake component.

This report concludes the short term assignment, with the goal of implementing the framework of the project.

It has been designed to serve any of the actors concerned by Nahrin emergency shelter rehabilitation project, be they donors, in order to allow them to have a complete understanding of the matter, other agencies and NGOs as well as other experts implicated in the project and ACTED’s staff responsible for the project: project manager, logistic manager, expert architects on the field, expert engineers, field manager, and field supervisors.

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Commissioned by ACTED
May 2002
1. **Background:**

1.1 **Two Successive Earthquakes**

1.1.1 **First Earthquake**

On 25 March 2002, an earthquake hit Nahrin District in the Baghlan Province of northern Afghanistan. The earthquake, which measured 6.2 on the Richter scale, resulted in significant damage to the infrastructure of the area and destroyed the shelters and livelihoods of thousands of families living in this already drought and conflict-affected area.

The epicenter of the 25 March earthquake was located in Markaz Nahrin, one of six traditional areas in Nahrin District, at the relatively shallow depth of 33 km. Consequently, the destruction caused by the earthquake was concentrated in a 15km radius around the Markaz Nahrin area. In addition, some villages in three other areas, Sujaan, Kohgadai, and Djelga, were also affected by the 25 March earthquake though not as significantly.

1.1.2 **Second Earthquake**

A second earthquake hit Nahrin District on 12 April 2002 as a result of which further damage was wrought on the previously affected villages in the three other aforementioned areas and on Markaz Nahrin. In addition, the second earthquake severely damaged some new, previously unaffected villages in the Djelga area.

1.2 **Total and Affected Population Figures**

1.2.1 **Casualty and Emergency Relief Distribution Figures**

Immediately after the first earthquake, the first estimates of affected families ranged 25,000 to 35,000, and the number of casualties were estimated to be in the several of thousands. After a few days, the casualty figure was reduced to less than 1,000. The last of the estimates of casualties, though unofficial, ranged from 300 to 500.

The figures of affected families also had to be reduced from the relatively high initial estimates. In the days following the first earthquake, over 14,000 non-food item kits, including one tent, were distributed in Nahrin by several agencies present during the emergency relief efforts.

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3 The area of Djelga was established as a sub-district of Nahrin District a few years ago by the local authorities, however this was not recognized at the central level. As a result, according to VAMS and the WFP / ACTED survey of the area, Djelga is officially an area of Nahrin District. As such, it has been included in all estimations of total and affected populations for Nahrin District.
The population lists used for this initial distribution were provided by local authorities and were not cross-checked against previous population surveys of the area. Such cross-checking did occur for the food distribution efforts implemented by WFP and ACTED which began several days later, resulting in the distribution of food to only 10,932 families throughout the district. For the food distribution, the lists provided by local authorities were cross-checked against a WFP / ACTED survey of the local population completed in January 2002.

1.2.2 Estimates of Population and Shelter Requirements in Nahrin District

As a part of an ongoing WFP food distribution project, ACTED conducted a survey of the population in Nahrin in which the population of the district was estimated at the traditional area, village, and mosque levels. According to this WFP/ACTED survey, the total population of Nahrin District was approximately 14,000 families\(^4\) in January 2002 before the two earthquakes. The following table includes the WFP / ACTED population figures for Nahrin by area and mosque as well as the degree of earthquake damage to each area.

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of Mosques</th>
<th>Number of Families</th>
<th>Population (6 per Family)</th>
<th>Degree of Earthquake Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ARAKASH</td>
<td>22</td>
<td>1,288</td>
<td>7,728</td>
<td>Limited Affect</td>
</tr>
<tr>
<td>2 MARKAZ</td>
<td>79</td>
<td>4,373</td>
<td>26,238</td>
<td>High (nearly 100%)</td>
</tr>
<tr>
<td>3 SUJAAN</td>
<td>33</td>
<td>1,635</td>
<td>9,810</td>
<td>Medium</td>
</tr>
<tr>
<td>4 ABKHANA</td>
<td>35</td>
<td>1,644</td>
<td>9,864</td>
<td>Limited Affect</td>
</tr>
<tr>
<td>5 KOHGADAI</td>
<td>56</td>
<td>869</td>
<td>5,214</td>
<td>Medium</td>
</tr>
<tr>
<td>6 DJELGA</td>
<td>97</td>
<td>4,477</td>
<td>26,862</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>322</strong></td>
<td><strong>14,286</strong></td>
<td><strong>85,716</strong></td>
<td>N/A</td>
</tr>
</tbody>
</table>

At the district level, the WFP / ACTED figures were confirmed by VAM figures of the region.

UNHCR estimates that between January and March, 286 families returned to the district, and that an additional 500 to 700 families, including both returnees and IDPs, returned in the months after the two earthquakes. As such, we estimate the total current population of Nahrin District to be approximately 15,000 families.

According to the WFP / ACTED survey of the area, 4,373 families inhabited Markaz Nahrin as of January 2002\(^5\). The majority of their homes were either completely destroyed or damaged to the point of being uninhabitable by the earthquake. As a planning figure, we consider that all of the shelters in this area must be reconstructed.

In the three other less-affected areas, ACTED estimates that the shelters of approximately 2,500 families in these areas were damaged to the point of being uninhabitable by the two earthquakes. In the two areas with limited affect, Arakash and Abkhana, we recommend that almost no houses be rehabilitated. The second expert in the field alongside ACTED’s field staff is implementing a house-to-house survey to further refine these figures.

\(^4\) In this region of Afghanistan, an average “family” consists of 6 individuals.
\(^5\) Please see Section 1.2 for more information on the WFP / ACTED survey of Nahrin District.
Consequently, we estimate that a total of 7,000 families in Nahrin District require shelters\(^6\) as a result of the 25 March and 12 April earthquakes.

1.3 ACTED’s Long-term Presence and Post-Earthquake Efforts in Nahrin District

ACTED is one of only two NGOs which were present in the district before the two earthquakes\(^7\) and the only one with a permanent field office and expatriate presence in the district. At the time of the earthquake, ACTED was implementing on behalf of WFP a large-scale free food distribution project\(^8\) which also covered two other districts in Baghlan Province. The WFP wheat stored in the district was used by ACTED during the emergency relief efforts after the earthquakes.

Due to its presence prior to the earthquakes, ACTED was a leading agency in the distribution of non-food and food items immediately after the earthquakes. Moreover, after the emergency relief efforts were concluded, ACTED was asked to serve as the NGO representative in a UNAMA-led mission investigating “diversions” of aid that allegedly took place during these emergency relief efforts. In brief, this mission found that the main difficulties encountered in the distribution took place primarily because the aforementioned WFP / ACTED population survey was not used in the relief efforts, even as a point of comparison for government-provided lists.

While many of the NGOs that were involved in the earthquake relief efforts left Nahrin in the weeks after the earthquakes, ACTED has maintained its ongoing long-term rural rehabilitation efforts in Nahrin while integrating two new components: (a) post-earthquake rehabilitation; and (b) return of IDPs and returnees to the area.

(a) Already, ACTED has been rehabilitating three canals in Nahrin through a grant from the U.S. Ambassador. Such rehabilitation of the traditional canal system in Nahrin has enabled the population to directly access water, which had not been possible since the two earthquakes. In addition to the current shelter proposition, ACTED has identified additional priority areas in the area such as road reconstruction and further water access rehabilitation. Moreover, ACTED is also about to begin the construction of 1,000 emergency shelters through a grant it received recently. This construction will start as soon as the recommendations of this report are agreed upon by all of the parties involved in the reconstruction of Nahrin. To this end, field arrangements and discussions with the local community regarding their contribution have already begun.

(b) As a UNHCR implementing partner for shelter construction in Baghlan Province, ACTED is planning to construct 1,000 shelters for IDPs and returnees in three districts in Baghlan, including approximately 500 to 600 specifically in Nahrin District. Alongside this project, which will commence in the next month, ACTED has begun implementing a quick-impact shelter construction project with UNHCR for 60 families in the area.

\(^6\) Two villages in Bhurka District which borders Nahrin were also moderately affected by the two earthquakes. Consequently, approximately 300 non-food item kits were distributed in Bhurka after the earthquakes. Our total figure does not include any shelter reconstruction in Bhurka, though the small number potentially required in Bhurka could be easily accommodated under the proposed figure.

\(^7\) Swedish Committee was the only NGO other than ACTED that was present in Nahrin before the 25 March and 12 April 2002 earthquakes.

\(^8\) Though the WFP project ended in April, ACTED will continue its food distribution efforts in the area as a partner of FOODAC until July 2002.
2. Maps:

![Map of Nahrin district](image1)

**Fig.1.1. Map of Nahrin district**

![Map of the area affected by the earthquakes](image2)

**Fig.1.2. Map of the area affected by the earthquakes (one square =1km)**
3. Case Study: Nahrin old village (Sharikuna/Markaz):

3.1. General situation:

Nahrin old village (Sharikuna/Markaz) has been 100% destroyed by the earthquakes: piles of dirt, wood poles sticking out everywhere. The only place already restored is the mosque in the place of the old one (with a few poles and a shade). The density of the constructions was higher than in other villages as it was the center of the area (as shown on Fig.1.2). People have placed the tents given by NGOs on their respective pieces of land and live in them. They have grown wheat everywhere even on non irrigated land (these are free lands that any peasant can use) and because rain was abundant, the season will be excellent. Winter is close and they will need shelters. Most people will be busy harvesting the wheat but they are ready to be all at work to build their shelters before winter (including women).

Fig.1.3. General view of Nahrin old village after the earthquakes
Fig. 1.4. Nahrin old village 100% destroyed
Summary:
Post earthquake situation of affected populations and villages:

1. ACTED estimate that a total of 7,000 families in Nahrin District require shelters as a result of the 25 March and 12 April earthquakes.
2. ACTED was implanted in Nahrin long before the earthquake. It was the leading agency for distributions after the earthquakes and is actually responsible for several projects in the area.
3. The studied area of Nahrin old village shows total destruction and an absolute need for shelters before winter.
1. General overview on architectural traditions in Nahrin area:

“Pressed mud (pakhsa) or sun-dried brick (khesht-i-kham) walls supporting a flat roof constitute one of the most common varieties of village building in Afghanistan. Standing alone or more often as part of a multiple-unit construction, it can be easily built with local materials. It predominates in the north eastern part of the country, central Afghanistan, and the Kabul Basin. In rural areas the walls are generally constructed of pressed mud, while in urban areas they are usually constructed of sun-dried brick. This is because brick is relatively more expensive and requires skilled masons to lay, while the pressed mud method uses materials freely available at the building site and is a technique that can be learned fairly quickly. The main factor that has restricted the spread of flat-roofed buildings throughout the country is the need for poplar poles to support the roof; hence, where wood is scarce, the use of domes. However, the increased use of trucks has begun to permit the spread of flat-roofed buildings even in these areas as the price of transport has fallen.

Construction of the walls often begins by digging a foundation trench about 50 cm deep that is then filled with stone. Although not absolutely necessary, such a foundation protects the wall from erosion produced by the capillary action of groundwater. The mud needed for the walls is obtained at the site by digging a pit in which the soil is mixed with water and allowed to stand overnight. The resulting mix is trampled until it becomes malleable and then thrown forcefully into place, using melon-sized lumps to create a horizontal wall of material in tiers, each approximately 50 cm in height. Each tier is allowed to dry before the next is added. This procedure continues until the desired height of 230-300 cm is achieved. When the last course of pakhsa is complete, each of the load-bearing walls is topped with a poplar pole (ketyaba) running its entire length which will evenly distribute the weight of the roof joists. The roof joists are also poplar, averaging 20 cm in diameter, and span the space between the walls at 25-40 cm intervals depending on the length of the span. Because poplar poles have a slight taper, they must be set so that thicker and thinner ends alternate to keep an overall evenness. These roof joists are secured by nailing them to the poles previously set into the top of the walls. The roof itself is about 20 cm thick and is constructed by placing laths of split poplar (or sometimes brush) at right angles to the roof joists, covering these with layers of reeds, and then sealing the roof with two or three different layers of clay coatings. The roof surface can be damaged by standing water, so melting snow must be removed by means of wooden shovels. The roof is also provided with a slight slope that channels any rain to scuppers which overhang the roofline so that dripping water will not damage the walls (Azizi 1980:47-51, 56-59).

From “Afghanistan, an atlas of indigenous domestic architecture” by Albert Szabo and Thomas Barfield, University of Texas Press. Austin.
A key design problem in any traditional architecture is the challenge of coping with the variation in the sun's radiation on a seasonal and daily basis. Under the semiarid conditions found in Afghanistan, people must cope with both heat and cold. This is done by taking advantage of the inherent heat storage capacity of *pakhsa*, stone, or brick walls and by orienting the building in a way that will maximize heat gain (insulation) in the winter and minimize it in summer.

The massive walls and the heavy flat roofs all act to moderate temperature fluctuations inside the structure. They trap solar heat during the day, but because the walls are so thick this heat does not penetrate into the interior, keeping the house cool. At night the walls radiate heat, and even though the outside temperature drops, the house stays warm. In a study of a similar type of adobe house in the American southwest, Fitch and Branch (1960: 139) produced the results shown in Table 2 for a hot summer day.

Table 2: Adobe House Temperatures (C) for a Summer Day

<table>
<thead>
<tr>
<th></th>
<th>Low (2 AM)</th>
<th>High (2 PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof surface</td>
<td>21.1°</td>
<td>60°</td>
</tr>
<tr>
<td>Outside temperature</td>
<td>18.3°</td>
<td>40.6°</td>
</tr>
<tr>
<td>Inside temperature</td>
<td>23.8°</td>
<td>26.7°</td>
</tr>
</tbody>
</table>

In terms of dealing with hot weather, curved roofs would serve just as well as or better than flat roofs, for the curved roof has a larger surface area to radiate heat gained during the day, but the flat roof has an advantage when the structure must also cope with cold weather. In Afghanistan, structures found in regions with cold winters, particularly in the mountains, are invariably flat-roofed. This is because the flat roof, with its poplar pole beams, wood or brush lathing, and layers of clay roof finish, is a much better insulator than a curved roof that consists of a single layer of bricks with a mudded exterior. Moreover, if the structure must be heated during the winter, the high ceilings found in curved-roof buildings are a disadvantage, since the hot air collects above the living space.

The other important way of maintaining a temperature equilibrium within a structure is by orienting it to get the maximum amount of solar energy during the winter and the minimum in the summer. To obtain these conditions, the orientation of apertures in the study villages demonstrates a keen appreciation of passive solar exploitation, with a great predominance of apertures located on southern or south eastern exposures and an avoidance of western and northern exposures.” *From “Afghanistan, an atlas of indigenous domestic architecture” by Albert Szabo and Thomas Barfield, University of Texas Press. Austin.*
2. Typical house design:

The house described below has the characteristics of most houses in rural areas of Nahrin district. It is implanted on the northern part of the land inside a surrounding wall. It is composed of a guest room 3.5m/6m which is the first one to be seen when you enter the land, 2 or 3 family rooms in a row (3m/4m each), a large storage room at an angle, a separate kitchen and a latrine at the opposite angle of the land. In front of the family rooms is a covered terrace facing south which protects the rooms from summer sunshine and allow the sun to enter the rooms in winter.

Each room has at least one door and a large window (1,5m/1,5m). The base of window is placed at 50 cm eight from the finished floor (as the family sits on mattresses placed directly on the ground). The guest room has 2 windows and lime plaster on inside wall in the place of mud. The kitchen has large openings but no windows as it is naturally heated by several cooking fires and needs good ventilation.

Each room has a stove with a pipe conducting the heat around the room and exhaust on the roof.
Fig. 2.1. Typical house; Terrace and family rooms
3. Land organisation and community uses:

Though several meetings both formal and informal with a Nahrin old village representative, completed with information gathered from ACTED’s afghani sociologist, and through a study on local community organisation\(^\text{10}\) we got a close idea of people’s uses concerning their properties: the way they use to inhabit their land related to the wealth of a family, and the way the house grows on the land related to the growth of a family. These are important considerations that will serve us as a guideline for shelters implantations:

\(^{10}\) Les “Manteqas”: Le puzzle souterrain de l’Afghanistan” par Frédéric Roussel et Marie-Pierre Caley. 1994
- Wealthy families have their house on a land surrounded by walls with their fields away from the surrounding walls. Numerous families work for them and live close to the fields with their own piece of land. The shelter that the wealthy families will build before winter is likely to become a secondary room (for storage) as soon as they will be able to build their own house with the usual wealthy uses: large rooms, large windows oriented to the south or south east, lime plaster to cover walls inside, covered terrace oriented south, separate kitchen, and all the constructive improvements for durability and earthquake resistance.

- Other families usually work for wealthy families but live on their own piece of land. They often grow wheat on their land where their house is situated. The house is implanted in a corner of the land, with the windows oriented south or south east. The rooms are 4m /3m, their number depend of the size of the family with a minimum of two. For most families, the shelter that they will build before winter is likely to become the seed of their future house.

- When the family grows (when a son gets married), the new couple builds a new room next to the house. It builds it directly against an existing wall except if the house is very poor (in that case the new room is built a little away to avoid weakening the existing building while digging the foundations). In all cases, the extension of a house is always on the same piece of land, never away from the main house (a son who wishes to build a house away from his parents, is considered a bad son). We can conclude that a house is usually built to serve several generations, with the regular necessary maintenance, and rarely left to build somewhere else.

Summary:
Architectural traditions in Nahrin area:

1. Rural houses in Nahrin area are simple flat roof construction using earth as the main building material and poplar poles for the roof. Their design and construction include strong climat component.
2. A typical house is a complex organisation including several important principles related to people way of live and cultural uses as well as solar considerations.
3. The land organisation and community uses give us the guidelines for shelters implantation.
The last word of the *malek* (village representative) of Sharikuna (Nahrin old village) was: “*If the shelters you are planning to design for us are the same as we have always built, we don’t need you, we can do it ourselves. What we are expecting from you is a design that will resist the next earthquake.*”  
*This is in case we forget, on the way, the meaning of our presence in Nahrin…*

Observing very closely the impacts of the earthquake on the buildings of Nahrin old village (almost 100% destroyed), we made a survey of the major weaknesses and strengths of typical design principles and construction techniques in relation to earthquake resistance.

1. **Rammed earth and brick walls:**

Comparing the behaviour of rammed-earth walls and mud brick walls during earthquake, we notice that mud brick walls have resisted much better. This is easily understandable if we analyse the technical process of making those walls:

- Rammed-earth or pressed earth (see in Chapter 2. description of *Pakhsa* technique) does not constitute a cohesive material, it has no tensile quality. This weakness allows the walls to crack at any point from top to bottom when lateral motion happens.

- On the other hand, brick walls offers stronger resistance to lateral motion as it tends to separate the bricks from one another : 1. because bricks stick well together with mortar made of the same mud as the brick itself and 2. because the bricks are laid with sufficient overlap of all joints which plays as a weaving between them particularly at angles.
2. **Brick walls:**

In order to achieve good resistance of mud brick walls, bricks are usually laid by skilled mason over stone foundations with special care respecting basic principles: enough overlap of bricks over each joint and enough mortar to fill all joints. If the bricks are not laid properly, the walls show the same weaknesses as the rammed earth walls (lack of cohesion).

![Image 1] Fig.3.3.Not enough overlap of bricks causes vertical continuous joint

![Image 2] Fig.3.4.Not enough mortar in between the bricks causes bricks to separate

3. **Stone foundations:**

Stone foundations usually raise above the surface at a minimum of 20 cm to protect the walls from ground water, and are laid 50 cm minimum underground.

During earthquakes, they ensure the stability of the building but they cannot play the part of a low bond beam as the stones are laid without cement. To achieve stability the stones are laid with a lot of care by a skilled mason without mud mortar. Any stone wall found with mud mortar will cause disorders as the mud will melt through the time and the stones will loose their stability (mud mortar will also cause capillary action of groundwater).

![Image 3] Fig.3.5.Stones that are laid properly
4. Wood reinforcements:

Typical earthquake resistant wood reinforcements can be seen on the buildings that have totally or partially resisted the earthquake. This, again, is easy to understand: wood is the only material used in the buildings that can resist tensile forces. The more wood is used in appropriate locations, the better the walls will support strong horizontal movement without falling apart.

Fig. 3.6 reinforced buildings with wood bond beams on top and bottom

Fig. 3.7. Wood angles reinforcement

Fig. 3.8. Bond beams connected at angles
The weaknesses, regarding wood reinforcements, are found 1. in the lack of linkage between roof beams and bond beams, 2. in the lack of connections at angles between bond beams and 3. in the weak anchorage of window and door frames.

The lack of skilled carpenters is obviously the main reason for these weaknesses, as good wood connections can be achieved with no extra material.

The consequence is 1. the sliding of roof beams away from the wall when a strong lateral movement occurs causing the entire roof to collapse and 2. the separation of bond beams at angles which does not enable the beams to play their part as a ring and therefore keep the walls together and 3. the falling away of window and door frames causing the weakening of the wall.
Summary:
Post earthquake field observations and diagnostic have raised 4 major points:

1. brick walls resist better than rammed earth walls to horizontal loads caused by earthquake only if laid properly by skilled mason.
2. stone foundations are needed for the stability of the building if the stones are laid properly but they cannot act as low bond beams.
3. wood reinforcement features such as: top and low bond beams, angle reinforcements, large lintels and frame anchors are major constructive points for earthquake resistance.
4. lack of efficient connections between wood pieces is the weak point of Nahrin constructions.

Note: a better knowledge of traditional uses in Nahrin area brought us to understand that skilled masons are always hired by wealthy families to lay stone foundations and brick walls. As wood is a scarce material, wood reinforcements increase with the wealth of a family as well as the size of doors and windows.
The anti-seismic attributes of traditional construction in Kashmir\textsuperscript{11} give us precious information on the efficiency of simple reinforcement principles using a minimum quantity of wood that can be therefore applied to Nahrin shelter project.

“Earthquakes in Kashmir have occurred with regularity over the centuries, and the Kashmiri houses reflect an adaptation to this threat through the interlacing of heavy timbers within the plane of the exterior walls of the masonry buildings. In Kashmir, as in most countries, \textit{wood and nails are simply too precious to be used for more than what is absolutely necessary}, so masonry is the primary building material. The house were almost always raised on a plinth made up of stone masonry laced with heavy timbers measuring at least one meter in height. Above this stone the exterior walls were constructed of a mixture of brick and rubble stone set into a thick bed of mud mortar (\textit{Taq}).

The timber beams in the \textit{Taq} buildings do not constitute complete frames. Instead, large timber “runners” rest along the load bearing masonry wall, with the floor beams and the “runners” for the cross walls lapping over them. The wood serves to tie the walls of the structure together with the floors. The wood is well jointed. The weight of the masonry serve to “pre-stress” the wall, contributing to its resistance to lateral forces.

After the earthquake of 1967 in Kashmir, two Indian engineers describe the damage caused on traditional buildings in this words:

- The timber runners tie the short wall to the long wall and also bind the pier and the infill to some extent. Perhaps the greatest advantage gained from such runners is that they impart \textit{ductility} to an otherwise very brittle structure. An increase of ductility augments the energy absorbing capacity of the structure, thereby increasing its chances of survival during the course of an earthquake shock.

According to the Indian engineers, the reason why 1967 Kashmir earthquake buildings of 3 to 5 stories survived relatively undamaged, was the damping of the motion of the building caused by the friction induced in the masonry of the \textit{Taq} walls when it begins to crack and move along the mortar joints. \textit{It is the distribution of the forces throughout a large area of the wall}, preventing destructive cracking in one area, that leads to a much greater level of energy dissipation than would otherwise be possible. As a result, even though the mortar is extremely weak, causing the walls to yield under a much smaller load, the masonry continues to have a good chance of holding together. The timber runner beams and floor diaphragms keep the individual piers from separating, which would cause the house to break apart. In Kashmir, rigidity carries the potential for destruction. The more rigid a building is, the stronger it must be in order to avoid fracture.

\textsuperscript{11}From “The Earthquake Resistant Mud and Brick Architecture of Kashmir.” by Randolph Lagenback, Assistant Professor at the University of California Berkeley
Because the primitive material and means of construction used in Kashmir did not provide strength, flexibility was essential.”
From “The Earthquake Resistant Mud and Brick Architecture of Kashmir.” by Randolph Lagenback, Assistant Professor at the University of California Berkeley

Note: the large size of the windows with their heavy frames tends to consolidate the building. This tends to contradict the common rule that the smaller the windows are, the better the building will resist to earthquake loads.

A similar form of construction can be found in Afghanistan (in Nouristan). Houses found in parts of Greece affected by earthquakes also have horizontal wood members, but the walls are far more massive. The use of horizontal wood ties is also common in seismic areas of Turkey, with less use in non-seismic areas, thus supporting the claim that they were used deliberately for earthquake resistance. The bond beams in Turkey are credited with “incorporating ductility to the adobe walls, substantially increasing their earthquake resistant qualities.”

Summary:
Kashmir example of traditional earthquake resistant construction:
1. Kashmir traditional Taq construction use a minimum of wood for a good resistance to earthquakes
2. Horizontal beams are used to tie together the structure of the walls with the floors; they impart ductility to an otherwise very brittle structure.
3. The beams serve to distribute equally the forces on a large area of the wall and to keep the walls tied together.
4. The flexibility and ductility given by the timber beams allow the construction to resist strong earthquakes shocks.
1. Introduction:

Following is a list of 10 basic technical specifications to be used as a guideline during the design as well as the construction process. Most points treated below are related to earthquake resistance; for more information concerning current design and construction principles see References at the end of Chapter 5 and for specifications about brick making see Annex.

Reinforcement and construction principles listed below take into account the strengths and weaknesses of local building practices observed on the field, related to earthquake resistance (Chapter 3) and include the necessary improvements using the materials and skills available on the site or close. These reinforcement and construction principles might be used to (a) improve the UNHCR shelter package or (b) as a base for an alternative design proposed by the mission (Chapter 6).

2. Basic structural engineering for earth buildings related to earthquake loading\textsuperscript{12}:

To understand the following specifications, below is a scheme (Fig.5.1) that describes the behaviour of a structure exposed to lateral loads as they occur in earthquake conditions. The walls submitted to lateral loads will tend to crack severely as reversal of the acceleration direction causes cracks to open on both diagonals of a wall. But the major damage occurs when intersecting walls separate at corners causing partial or total collapse of the structure.

\textsuperscript{12} See Chapter 13 Structural Engineering for Earth Buildings by Gerald W. May, Ph.D in ”Adobe and Rammed Earth Buildings. Paul Graham McHenry, Jr”
For the reasons evoked above, the most important single factor to be kept in mind is the necessity to tie structural components together. A continuous structure is always more damage resistant due to the redundancy lent by its interconnected parts. Moreover, a redundant structure can often survive partial collapse that would otherwise be catastrophic.

The most critical structural connections are those between adjacent walls, particularly at corners. Many different ways of assuring successful interconnection have historically evolved. Other details that must be given proper attention with regard to structural continuity are those occurring at door and window lintels, at roof-wall intersection, wall at foundation level and at intermediate cross wall intersections. The ultimately practical way of assuring that the building does act redundantly is the use of the tie beam (also called ring, bond or collar beam). The tie beam is a ring, or belt, encircling the building near each floor or roof level (Fig.5.2). It is constructed of a material capable of carrying tension (wood, in our case).

3. Reinforcement principles:

The proposed wood reinforcement principles illustrated in the sketches below (Fig. 5.1 and 5.2) include the following elements: (1) low and top bond beams; (2) wall angle reinforcements; (3) lintels with sufficient bearing length; and (4) anchors for windows and door frames.

![Fig.5.2. Reinforcement principles](image)

![Fig.5.3. Corner reinforcement](image)
It should be noted that all of the costs associated with these reinforcement principles have been integrated into the proposed budget.

ACTED’s field team in Nahrin, supervised by the experts (both architects and engineers), is currently working to set up procedures and training materials in order to ensure that the following ten points are integrated into the construction process.

4. Technical specifications:

   Specification 1. Foundations:

   Foundations should be made of stones and built with care with the less space possible between the stones as stones need to fit well without mud mortar (Fig 3.5). The stones have to be laid by a skilled mason.

   Foundations should be 50 cm wide minimum, be built 50cm under ground level and raise 20cm minimum above the ground surface (in the case of building on a slope the total foundation height needs to be increased).

   They cannot act as a low ring because the stones are not tied together (the only way to do so would be to use cement which is out of our budget possibilities). For that reason a wooden bond beam at foundation level needs to be introduced.

   Note: for mud construction it is essential to protect the base of the walls from groundwater and prevent any water or moisture from raising up the walls (which is likely to happen if there is mortar laying between the stones).

   Specification 2. Bond beam at foundation level:

   A wooden bond beam at the base of the wall is highly recommended as earthquake reinforcement to keep the four walls of a room linked together in case of a strong lateral load. The lack of ring effect of foundations due to the lack of cement imposes the use of a bond beam above foundations. The beams, laid horizontally need to cover the whole width of the wall which can be achieved by using 2 beams tied together (Fig.5.5 and 5.9). The beams should be anchored vertically into the wall and strongly linked together at all angles of the building including angle reinforcements (Fig.5.2 and 5.3)

   Note: basic systems and simple tools can be used to make wooden connections and anchors. However this will need a carpenter skill.
Fig. 5.5 Specifications 2 and 7: low and top bond beams with wood anchors.

Specification 3. Brick walls:

Brick walls are highly recommended for earthquake resistance under certain conditions:\ref{13}:

- The soil selection should be made by field tests, and adjusted to proper composition through additional sand or straw (see Annex),
- The bricks should be made and dried properly and regularly tested (see Annex),
- Their size should be large enough to overlap minimum 10 cm from one row to the other,
- They should be laid up carefully alternating corner bond,
- They should be laid with enough mortar to fill all joints. The mortar should be made of the same mixture as the bricks themselves, in order to stick to them properly.

Note: The wall will then form a monolith, particularly at angles with a good resistance to horizontal forces that tend to separate walls from each others; On the opposite, rammed earth (an other technique commonly used) can barely resist the horizontal movement which occur in earthquake conditions and cracks severely at angles.

\ref{13} See Annex for specifications about brick making
Specification 4. In wall angle reinforcements:

Angle reinforcements should be achieved by adding wooden pieces strongly attached together to form triangles (with a side length of 1m minimum) in each corner, at four points: 2 connected to the bond beams, and 2 in between 2 rows of bricks (Fig 5.2 and 5.3).

Specification 5. Window, door frames and anchors:

- Usually, the rule applied in earthquake conditions in order to prevent the openings from weakening the walls is that the surface of the openings should be less than 1/3 of the surface of the wall. In North Afghanistan, however, windows and door frames commonly available play the opposite role. Because of their large section (10/10cm) and their multiple partitions (both horizontal and vertical) they tend to strengthen the general structure. Their size, then, will affect the structure on the opposite way: the larger they are the stronger it is (post earthquake field observations have confirmed this principle).

- The window and door frames should be properly anchored in the walls with wood pieces in the place of a brick, introduced in the process of laying the bricks (Fig.5.6 and 5.7). The frames need to be fixed in place as soon as their foot is ready: right above the low bond beam for doors and 2 or 3 rows of bricks above the low bond beam for windows.

Note: traditionally the size of the windows increases with the wealth of a family.
Specification 6. Large lintels:

Wood lintels above doors and windows should be laid with sufficient bearing length on both sides of the opening (50 cm minimum). They should cover the whole width of the wall which can be achieved by using 3 poles of 10cm diameter each, tied together (Fig.5.10).

Specification 7. Bond beam at roof level:

As the lower one, the top bond beam is highly recommended as a ring that surrounds the building in order to keep the walls linked together. It also serve to distribute equally on the wall the weight of the roof beams (Fig. 5.4). It should have the same characteristics as the lower one and be securely anchored into the wall and to door lintels situated directly under them (Fig.5.9 and 5.10).

Specification 8. Roof structure and wood connections:

Wooden beams with 15 cm diameter should be laid across the width of each room (3m to 3m50) with a space between them of 30 cm from axis to axis (Fig.5.8). They should be properly tied to the bond beam both with wood mortise and nails.

Note: in earthquake conditions most damage are caused by the beams sliding away from the walls causing the roof to collapse which can be avoided with simple wood connections. To make the connexions a skilled carpenter will be needed.

Fig. 5.8. Specification 8: typical roof structure
Specification 9. Roof cover:

Bamboo mat and a layer of reeds should be laid above the beams, then a plastic sheet, and finally 20 cm of dirt (no more, as it would increase the dead load in case of an earthquake). The dirt should be properly compressed to resist erosion. On top of the surrounding walls a crown maid like a butte and gutters to conduct raining water away from the roof will assure the protection of the walls against water erosion (Fig.5.9 and 5.10).

*Note: even if these are not specific improvements for earthquake resistance, they are essential to protect the construction against damage caused by raining water, which are likely to weaken the building through the years.*

Specification 10. Plaster:

Mud plaster should cover all wall surfaces inside (for minimum finish) and outside including roof (to protect from erosion). Its composition should be 2/3 mud and 1/3 straw or fine sand. A special waterproof coat should be added later on the roof to meet the needs for efficient long term protection (little asphalt emulsion mixed with the water or cactus juice, if available, will reach that goal).

*Note: most buildings in Nahrin area show a true weakness with wall plasters. Even if this seems unimportant compared to earthquake issues, it is interesting to know that with little improvements in the laying of the plaster (2 coats instead of one with only mud in the first one) plaster will last much longer and will protect efficiently the wall from long term erosion.*

*Note: wood work:*

*As the major weakness observed on the field is the lack of proper wood work on the wooden reinforcement and structure in order to tie them together, it will be highly recommended to hire skilled carpenters for those particular works (Specifications 2;4;5;6;7;8).*
Summary:

Technical specifications:
1. Stone foundations should be laid carefully by a skilled mason but cannot act as a ring.
2. A wood bond beam at foundation level is necessary and needs to be reinforced at angles and anchored in the masonry.
3. Brick walls need to be properly maid by a skilled mason to resist earthquakes loads.
4. Angles wood reinforcement are necessary to keep walls from separating at angles.
5. Window and door frames act as reinforcement and need to be anchored in the masonry.
7. Bond beam at roof level is necessary as a ring and to spread the roof loads over the entire wall. It has the same characteristic as the low bond beam.
8. Roof beams should be properly spaced and connected to the bond beam.
9. Mud cover should not be too thick.
10. Mud plaster on walls and roof is necessary to protect from raining water.

Note: Need for skilled carpenters for all wood works.

References:
2. "New Mexico Adobe and Rammed Earth Building-Code" developed by the Regulation & Licensing Department of the General Construction Bureau in Santa Fe, New Mexico. 1992
Chap.6. Recommendations related to Afghanistan UNHCR guideline

1. Actual UNHCR package proposal:

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard model</th>
<th>Dome. type model</th>
<th>Reinforcement model</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 2 rooms (3.3mx 4m)</td>
<td>20 beams 3.5m</td>
<td>2 windows 1.5/1.5m</td>
<td>20 beams 3.5m</td>
</tr>
<tr>
<td></td>
<td>2 windows 1.5/1.5m</td>
<td>1 door 1.9/0.8m</td>
<td>2 windows 1.5/1.5m</td>
</tr>
<tr>
<td></td>
<td>1 door 1.9/0.8m</td>
<td>12 lintels</td>
<td>1 door 1.9/0.8m</td>
</tr>
<tr>
<td></td>
<td>12 lintels</td>
<td>Window glass</td>
<td>12 lintels</td>
</tr>
<tr>
<td></td>
<td>Window glass</td>
<td>Window glass</td>
<td>Window glass</td>
</tr>
<tr>
<td>B. 1 corridor (1.5m x 3.3m)</td>
<td>8 beams 1.5m</td>
<td>1 door</td>
<td>8 beams 1.5m</td>
</tr>
<tr>
<td></td>
<td>1 door</td>
<td>3 lintels</td>
<td>1 door</td>
</tr>
<tr>
<td></td>
<td>3 lintels</td>
<td>Sign board</td>
<td>3 lintels</td>
</tr>
<tr>
<td></td>
<td>Sign board</td>
<td>Exhaust PVC pipe</td>
<td>Sign board</td>
</tr>
<tr>
<td>C. 1 Latrine (1.5m x 1.5m)</td>
<td>10 beams 1.5m</td>
<td>10 beams 1.5m</td>
<td>10 beams 1.5m</td>
</tr>
<tr>
<td></td>
<td>Exhaust PVC pipe</td>
<td>Exhaust PVC pipe</td>
<td>Exhaust PVC pipe</td>
</tr>
<tr>
<td>D. Cash-for-Work</td>
<td>USD 50</td>
<td>USD 100</td>
<td>USD 50</td>
</tr>
<tr>
<td>E. Earthquake-resistance enforcement</td>
<td>Beams for ring 4m x 4</td>
<td>Beams for ring 3.5m x 4</td>
<td>Beams for ring 2m x 2</td>
</tr>
<tr>
<td></td>
<td>Beams for ring 3.5m x 4</td>
<td>Wooden joint 20m</td>
<td>Nail (5&quot;) 2kg</td>
</tr>
<tr>
<td>F. Total Cost for UNHCR</td>
<td>USD 321.9</td>
<td>USD 254.3</td>
<td>USD 375.9</td>
</tr>
<tr>
<td>G. Applicable areas</td>
<td>Central, Eastern, Northern, and part of Southern regions</td>
<td>Western and part of southern regions</td>
<td>Part of Northern, Eastern and Central region</td>
</tr>
</tbody>
</table>
Recommendation 1: Earthquake reinforcement features:
- stone foundations 50cm under the ground level, raising 20 cm minimum above ground level
- a collar bond beam to be placed just on top of the stone foundation with anchors into the foundation itself and into the wall.
- Reinforcements in all corners through triangular connections, linked to the bond beams
- Wood anchors into the wall for all window and door frames
- Top bond beam should be anchored into the wall and have the triangular reinforcement connections.

Recommendation 2: Stone foundations:
Stone foundations are recommended in the case of mud walls to avoid ground water from seeping into the walls, which if it did would considerably weaken the walls.

As the English say, “Earth construction can last forever, if it has good boots and a good hat.”

Recommendation 3: Window and door frames:
Window frames must be delivered to the beneficiaries of the shelters as soon as they reach 50cm height in the wall. This is necessary in order to anchor the frames into the walls during the process of building up the walls. If this is delivered after the walls have been built the frames can not be anchored in, then they will not strengthen the wall as it should.

Recommendation 4: Architectural details:
There are numerous examples raising from field observation which are architectural recommendations that should be added as an annex: 1. The very top of the surrounding walls have to be protected from water erosion (most traditional houses have a protective crown), 2. Each room needs a fire hole for a stove (needs a specific design in the process of constructing the roof)). Many other details have to be included in the design at the very beginning as they can affect the costs estimate and the schedule of materials distribution.

Recommendation 5: Shelter design:
- For a two rooms shelter, 2 doors are needed as women and men need separate entrances
- The design of the shelter and position on the site must be bear in mind the orientation of the windows toward South or East exposure as it is needed in areas with a cold winter.

- It should also include a scheme for future or further expansion by the families, whether be additional rooms, kitchen, or terrace. This means that the position of doors and windows must be strategically placed to permit this kind of extensions which are likely to happen as a natural of evolvement of any household.

**Recommendation 6: Skilled labour:**

Skilled labour is needed for masonry and carpentry work particularly as we introduce new skills for earthquake resistance. It is a need even for wall construction as we recommend strong improvements in the making of bricks and in the laying of them.

A mason is traditionally employed by the home owner for foundations making, brick laying and roof making. As we have to introduce fine carpentry work for bond beams connections and anchors, a skilled carpenter will also be needed. Site supervision cannot replace the need for skilled labour.

**Summary:**

**Recommendations related to HNHCR guideline:**

1. The reinforcement features for earthquake resistance have to be improved and detailed
2. Stone foundations need to be included in the package
3. The timing in delivering the materials needs to fit with the logic of the construction
4. More architectural recommendations have to be added
5. The design of the shelter needs to include its relation to local uses, orientation to the sun and natural expansion.
6. Auto construction is possible if guided by skilled labour (both masons and carpenters).
Chap.7. Three alternative design proposals

The three following designs are inspired from UNHCR design proposal. Their architectural components are all issued from traditional rural house designs in Nahrin area, including their shape and dimensions, orientation of the windows to the sun, and future extensions possibilities (see Chapter 2). They also include the recommended construction principles and specifications for earthquake resistance (see Chapter 5).

The 2 first ones (Design 1 and 2) are the two steps of our proposed shelter package in which ACTED and its donor would support the construction of one room and the local community will support the construction of a second room using material recovered either at the village or family level with the help of skilled labor provided in the package. The third one (Design 3) is the reinterpretation of the actual UNHCR design that would include all the recommended improvements (see Chapter 6).

Design 1: 1 room (3.3m/ 4m) 12.5 m2.

Design 2: 2 rooms (3.3m/ 4m) 25 m2 with an open corridor.
Design 3: UNHCR reinterpreted 2 rooms
(3.3m/4m interior) with corridor (1.5m/3.3m)
30m²
ACTED mission’s complete design proposal

Design 2: 2 rooms (3.3m/4m interior) with an open corridor (1.5m/3.3m).
(For descriptive and quantities of materials see chapter 9)
1. Proposed intervention strategy: self help construction with provision of materials, tools and technical assistance:

It is clear that the objectives of most donors and NGOs concerning the project is to help the people build a shelter before winter and not to build it for them. However, because of the absolute need for earthquake resistant construction reinforcement, self help construction will have to be completed with technical assistance as well as provision of certain building materials and tools.

1.1. Skilled labour:

As developed in Chapter 5 and 6, skilled masons and carpenters will have to be hired in addition with experts and site supervisors. A mason is needed for each shelter to lay foundations, bricks for the wall and roof cover. A carpenter will be needed for each group of 20 shelters to carefully prepare all the wood connections: for bond beams, angle reinforcements, roof beams and all the wood anchors. The number of man/days of skilled labour necessary per shelter, in addition with unskilled labour has been evaluated and its cost in cash for work integrated in the cost estimate (Chapter 9).

1.2. Provision of construction materials:

The quantities of materials needed per shelter have been calculated in addition with the materials freely available on the site, and their cost estimated (Chapter 9)

1.2.1. Stones

For stones collection (for foundations), because they are not directly available on the site, ACTED proposes to organise the collection of stones through Food AC project. ACTED has been WFP implementing partner in the district for WFP free food distributions. In January of 2002 ACTED compiled a list of 100% of the local population, which was used to distribute to 80% of the most vulnerable families. In March 2002 ACTED completed its free food distributions, and was approached to start Food AC in the Nahrin for a period of three months. One of the main activities that will be part of this project is the collecting of stone. We have calculated this for around 5,000 homes, which will cut the cost for stone per shelter. This project can start as soon as possible.

1.2.2. Wood:

The provision of wood is the most difficult issue of the project. Poplar poles are commonly used for construction purposes in Nahrin area, they are easily available and they grow quite fast. But because of the impressive number of shelter constructions in the whole country, they become rare and their cost is rising every day. Their transport to the site is long and costly. A certain quantity will be provisioned rapidly by the surrounding villages which can serve to build the
low bond beam and allow the construction of the walls to continue before the other wood will arrive (3 months after the order is confirmed). However, rapidity is the key factor for this issue, to unable ACTED to respect the cost estimate.

1.2.3. Sun dried brick making:
Another important issue is the making of bricks. For earthquake resistance the use of bricks has been highly recommended. The skills to make bricks varies because, even if they are quite common in the area, they are not always used. For earthquake resistance, we recommend the use of large bricks 35cm/35cm/9cm which are not common in the area (to allow an overlap of 10 cm minimum and to cover the entire thickness of the wall). For these reasons we highly recommend a good supervising of brick making (see Annex for brick making and manufacturing principles).

1.3. Tools:
A list of the minimum necessary tools per shelter has been defined and included in the cost estimate (Chapter 9)

2. Clearing of site and collection of useable materials:
Before starting with the actual reconstruction of the shelters, the first activity will be clearing the sites of the previous debris. Job duration will depend on the villages. In places like Sharikuna (old Nahrin) this is more difficult than in villages which are mostly surrounded by agricultural fields;

During the clearing of the sites, families will also collect the usable material from their previous houses, which they have already started at a community level (Fig.8.1) They can either be stored for future reconstruction of their homes, or for part of them they will be used to build the additional room recommended onto the shelter provided by ACTED.

Fig.8.1. Collection of usable materials at community level
3. Recommended principles for shelters implantation:

As seen in Chapter 2, for most families, the shelter that they will build before winter is likely to become the seed of their future house. For that reason, the implantation of the shelter on each family’s land has to respond to the following principles:

The house is implanted on the north side of the land, preferably in a corner, with the windows oriented south or south east. One of the two small side of the shelter will have no window to allow future extension. The latrine will be implanted in the opposite corner of the land.

For wealthy families, the implantation of the shelter should be at their convenience, depending on the use they plan to make of the shelter in the close future - family room or storage - and to allow them to keep the best oriented part of their land for their future house.

Summary:

Intervention strategy:

1. Self help construction is the only mean to achieve the goal of the project. But to achieve earthquake resistance, it needs to be supported with the provision of certain materials, tools and technical assistance.
2. Skilled labour, collecting of stone with food AC, wood beams provision, brick making supervision are the main issues of the project.
3. Clearing the site and collecting the usable materials have already started at a community level.
4. Basic principles of shelter implantation should allow the shelter to become the seed of the future houses.
The descriptive and quantities of materials listed below are taking into account all the recommended reinforcements for earthquake resistance described in Chapter 5. The cost estimate and skilled labour time estimate takes into account the issues described in Chapter 8.

**The first proposal** is a simulation for our proposed shelter package in which ACTED and its donor would support the construction of one room and the local community will support the construction of a second room and an open corridor using material recovered either at the village or family level, with the help of skilled labor provided in the package.

**The second proposal** includes the provision of material for an extra room and an open corridor.

**The third proposal** is the adjustment of UNHCR proposal that includes all the recommended improvements (see Chapter 6) for 2 rooms with a corridor.

**Proposal 1:**

### One Room design

<table>
<thead>
<tr>
<th>Description</th>
<th>Reinforced model</th>
<th>Unit</th>
<th>Total Unit</th>
<th>Cost USD</th>
</tr>
</thead>
<tbody>
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<td>pcs</td>
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</tr>
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<td></td>
<td>1 window with glass 1.5m/1.5m</td>
<td>pcs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 door 1.9m/0.8m</td>
<td>pcs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 lintels (10cm/2.5m)</td>
<td>pcs</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>C. 1 Latrine (1.5m x 1.5m)</td>
<td>10 beams (15cm/2.5m)</td>
<td>pcs</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust PVC pipe</td>
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</tr>
<tr>
<td>D. Cash-for-Work</td>
<td>Skilled labour</td>
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<td>E. Earthquake-resistance reinforcement</td>
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<td>Beams for ring 2m x 2</td>
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<td>Wooden joint 10m</td>
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<td></td>
<td>Nail (5&quot;) 2kg</td>
<td>Kg</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>F. Recommended additional items</td>
<td>stones for foundations</td>
<td>M3</td>
<td>5,3</td>
<td>Food AC</td>
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<tr>
<td></td>
<td>bamboo</td>
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</tr>
<tr>
<td></td>
<td>bamboo mat (3x1)</td>
<td>pcs</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>straw</td>
<td>kg</td>
<td>180</td>
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</tr>
<tr>
<td></td>
<td>plastic sheet</td>
<td>M2</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>gutter</td>
<td>pcs</td>
<td>1</td>
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</tbody>
</table>

**Total estimated cost with skilled labour** 324,52

**Additional skilled labour for one extra room and open corridor** 125,00

**Total estimated cost including skilled labour for extra room and open corridor** 449,52
### Proposal 2:

#### 2 Rooms with an open corridor

<table>
<thead>
<tr>
<th>Description</th>
<th>Reinforced model</th>
<th>Unit</th>
<th>Total Unit</th>
<th>Cost USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 2 rooms (3.3mx 4m)</td>
<td>20 beams (15 cm/3.5m)</td>
<td>pcs</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 windows with glass 1.5m/1.5m</td>
<td>pcs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 doors 1.9m/0.8m</td>
<td>pcs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 lintels (10cm/2.5m)</td>
<td>pcs</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>B. 1 open corridor (1.5m x 3.3m)</td>
<td>8 beams(15cm/2m)</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>C. 1 Latrine (1.5m x 1.5m)</td>
<td>10 beams</td>
<td>pcs</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust PVC pipe</td>
<td>pcs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>D. Cast-for-Work</td>
<td>Skilled labour</td>
<td></td>
<td></td>
<td>230.00</td>
</tr>
<tr>
<td>E. Earthquake-resistance</td>
<td>Beams for ring 4.5m x 8</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>reinforcement</td>
<td>Beams for ring 3.5m x 8</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beams for ring 2m x 4</td>
<td>pcs</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wooden joint 20m</td>
<td>M</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nail (5”) 5kg</td>
<td>Kg</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>F. Recommended additional</td>
<td>stones for foundations</td>
<td>M3</td>
<td>13</td>
<td>Food AC</td>
</tr>
<tr>
<td>items</td>
<td>bamboo</td>
<td>pile</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bamboo mat (3x1)</td>
<td>pcs</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>straw</td>
<td>kg</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td></td>
<td>plastic sheet</td>
<td>M2</td>
<td>43</td>
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</tr>
<tr>
<td></td>
<td>gutter</td>
<td>pcs</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**Total estimated cost with skilled labour** 689.00

### Proposal 3:

#### UNHCR adjusted 2 rooms with corridor

<table>
<thead>
<tr>
<th>Description</th>
<th>Reinforced model</th>
<th>Unit</th>
<th>Total Unit</th>
<th>Cost USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 2 rooms (3.3mx 4m)</td>
<td>20 beams 15cm/3.5m</td>
<td>pcs</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 windows with glass 1.5/1.5m</td>
<td>pcs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 doors 1.9/0.8m</td>
<td>pcs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 lintels 10cm/2.5m</td>
<td>pcs</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>B. 1 corridor(1.5m x 3.3m)</td>
<td>8 beams 15cm/2.5m</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 door 1.9m/0.9m</td>
<td>pcs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 lintels 10cm/2m</td>
<td>pcs</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>C. 1 Latrine (1.5m x 1.5m)</td>
<td>10 beams 15cm/1.5m</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust PVC pipe</td>
<td>pcs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>D. Cash-for-Work</td>
<td>Skilled labour</td>
<td></td>
<td></td>
<td>235.00</td>
</tr>
<tr>
<td>E. Earthquake-resistance</td>
<td>Beams for ring 4.5m x 8</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>reinforcement</td>
<td>Beams for ring 3.5m x 8</td>
<td>pcs</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beams for ring 2m x 4</td>
<td>pcs</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wooden joint 20m</td>
<td>M</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nails (5”)5 kg</td>
<td>kg</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Suggestion for tools needed for 20 shelters:

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Cost/unit USD</th>
<th>Total Cost USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>chip axe</td>
<td>1</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>saw</td>
<td>1</td>
<td>.94</td>
<td>.94</td>
</tr>
<tr>
<td>string</td>
<td>200</td>
<td>.007</td>
<td>1.4</td>
</tr>
<tr>
<td>mould</td>
<td>20</td>
<td>.8</td>
<td>16</td>
</tr>
<tr>
<td>hammer</td>
<td>2</td>
<td>5.4</td>
<td>10.8</td>
</tr>
<tr>
<td>level</td>
<td>1</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>hand barrow</td>
<td>10</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>72.44</strong></td>
</tr>
</tbody>
</table>

Pick axe and shovels are community donation

**Total estimated cost for tools per shelter 3.6 USD**

Summary:

Draft for cost estimate:

1. The cost estimate for ACTED proposed shelter (2 rooms with an open corridor with provision of materials for one room only) is : 453,12 USD. It includes the necessary materials for earthquake resistance as well as cash for work for sufficient skilled labour and tools.
2. The two other proposals are respectively estimated 693,60 USD and 746,60 USD.

*Note: These estimations have to be taken as a first draft. They are actually re-evaluated on the site by a mission composed of ACTED project manager, the expert architect, the expert engineers and the logistic supervisor.*
The necessity to emphasise the question of brick making has imposed itself for simple reasons: As we introduce larger bricks for earthquake resistance (Chapter 5 and 8) which are not in use in Afghanistan, we also need to introduce new skills for making them.

Sun dried brick making is very similar whichever size they have, however, by enlarging their dimensions we also increase the risk for lower quality of bricks.

To prevent from that risk which could have dramatic consequences on the strength of the building, simple field tests can be done at each stage of the process:

1. **Soil tests** (jar test and rope test) to verify the composition of the dirt and define the quantity of tempering agents needed (Fig.A.1 (a) (b) (c)).
2. **Dryness test** to verify if the brick is fully cured and ready to be laid on the wall (Fig.A.2)
3. **Drop test** to verify if the brick has sufficient cohesion and compressive resistance (Fig.A.3)

1. **Soil tests in Nahrin:**

During the field mission we have made soil tests in several locations in Nahrin old village, finding an extremely high clay soil. Clay has an excellent plasticity as well as good water resistance but causes large shrinkage cracks on the bricks while they dry. On small bricks there will be little damage, when on large bricks the cracks will cause bricks to break into pieces.

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To temper the soil, sand may be added or if not readily available, straw, hay, or other fibrous vegetal matters may be used. The proximity of a large river and quantities of freely available sand should make the tempering of soil feasible at no cost. The amount of sand that needs to be added must be determined by the making of sample bricks. Tempering should only be added to the point that cracking reaches acceptable levels.

2. Sample bricks and simple field tests:

The qualities of the soil proposed for use and the quality of the process of moulding and drying can be simply supervised on the field by the making of several sample bricks. The following pictures illustrate simple field test.
3. Brick manufacturing:

With regard to the quantities of bricks required and the need for good supervision, the introducing of a simple manufacturing scheme at a community level could be appropriate. The following pictures show a mechanized production of sun dried bricks in New Mexico. The same principles could be easily introduced with the use of hand barrels in the place of a tractor to transport the mud. Several multiple moulds would be positioned next to each other and filled with mud all at the same time. Bricks dry in place while the moulds can be taken away. After a few days the bricks are tipped for drying on the side, then stacked on edge on stock pile to finish drying. They are then ready to be used.

Fig.A.4. Brick mould with multiple partition

Fig.A.5 Several moulds placed together allow faster filling process
Fig. A.6. Leveling the pour with screed rakes

Fig. A.7. Bricks tipped for drying

Fig. A.8. Bricks stockpile allowing air circulation