2022 Southeast Afghanistan Earthquake, Rapid Technical Field Assessment Report

Kabul, Afghanistan | Structural Safety Study

August 16, 2022

miyamoto.

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Executive Summary

Early in the morning of June 22, 2022, a M5.9-6.0M[1] earthquake struck eastern Afghanistan resulting in extensive loss of life and damage to housing. Miyamoto International (Miyamoto)'s Engineering and Shelter team were engaged for a 10-day mission to identify common building typologies, common failure modes, and possible mitigation strategies. The team assessed

a) Whether the current vernacular housing typologies were appropriate for the seismic risk
b) The technical cause(s) of house failure
c) The appropriateness and financial viability of repairing/retrofitting damaged houses for use as emergency/transitional shelter prior to the onset of winter
d) The percentage of houses that could be rapidly repaired, upgraded or reconstructed
e) Strategic advice to the shelter cluster on repairs or reconstruction assistance.

Assessment

The team utilized a standardized survey form (Appendix A) to identify building typologies and common failures. The survey remains ongoing but at the time of drafting this report over 170 randomly selected compounds/homes had been assessed across the three most affected districts of Barmal, Giyan in the province of Paktika and Spera in Khost. This includes 823 family units comprising over 4,000 people and with a total area of about 39,000m^2 of undercover living space. Meetings were also conducted with a wide range of shelter assistance agencies, along with technical experts in clay and stone construction. Seismic modelling and field assessments are still ongoing.

Initial findings

So far, the ongoing assessment has found that about 10% of undercover living spaces were still habitable (no damage), and 57% were repairable, with the remaining 33% destroyed.

Housing Forms: Two predominant housing forms were observed across the affected area. The majority of the housing assessed was in the form of large multi-household family compounds, with individual rooms utilized by different households and shared use of the compound area, verandahs, wells and water, sanitation and hygiene (WASH) facilities. A lesser number of free-standing houses were also observed, along with occasional multipurpose buildings, such as shop/house structures in slightly denser community areas. Most of the housing was in remote, rural settings dispersed across valleys, slopes, and hilltops, with small clusters forming villages. Damage appears consistent across housing forms.

Walls: The team of experts visited the earthquake impacted areas of three administrative districts including Barmal, Giyan and Spera, Afghanistan and identified three primary wall construction typologies, including

- *Pakhsa*[2] (large, thick monolithic mud and aggregate walls)

[1] Variance in sources
[2] Spelling appears to vary across literature

- Mud brick
- Rock/stone wall

Individual buildings often used a combination of these three wall construction typologies, varying across the affected area. The most commonly observed form included *Pakhsa* for external compound walls with rock/stone foundations, and one or two different wall types for internal walls depending on locally available materials. Internal walls were often less well constructed than external compound walls.

For each wall construction typology, the team identified the following causes of failure

Pakhsa

- Insufficient material (clay) preparation–nonhomogeneous compaction
- Oversized and overly rounded aggregate/rock elements
- Inappropriate aspect ratio
- Out-of-plumb construction
- Walls used in retaining condition
- Construction defects

Mud brick

- Inappropriate wall coursing patterns
- Insufficiently rectilinear brick unit dimensions
- Poor mortar joints (vertical joints needs further investigation)
- Water intrusion/deterioration due to
    - Insufficient foundations
    - Insufficient rain capping
    - Insufficient plaster
- Aspect ratio
- Construction defects

Rock/stone wall

- Overly rounded shape/form of rocks
- Lack of overlapping between rocks
- Insufficient, excessive or inappropriate mortar between rocks
- Inappropriate aspect ratio
- Construction defects

Of the three wall construction systems, failures were least commonly observed in well-constructed *Pakhsa* walls.

Roofs: All of the assessed buildings were constructed using a timber framed roofing structure supporting a thick mud cladding.

Common causes of failures observed in the roofing system included

- Insufficient roof system bearing support to compound walls
- Excessive roof loading (mud)
- Unnecessarily oversized roof beams

- Insufficient penetration of roofing timbers through walls parallel to the compound wall

Foundations: Assessed buildings commonly used a rock/stone foundation, often stepped on sloped ground to varying heights.

While foundation failure was not a common cause of building failure, a number of inadequate practices were observed including

- Insufficient height or drainage away from foundations to prevent water intrusion to walls
- Poorly stepped foundations for slopes
- Poor stone/rock construction, as per rock/stone wall failure above.

Material and Labor supply: Nearly all materials and labor used in construction across the affected area either came directly from the site/family or had been procured locally with very little imported material visible in the built environment. Notable exceptions included some use of treated bamboo, plastic sheeting and drainage pipes found in some roofs, along with solar cells for lighting and a range of non-structural household non-food items. High volumes of salvageable materials were observed on all sites, with most households already commencing to sort and store reusable materials.

Conclusions

Seismic appropriateness: The survey and assessment have revealed that although the seismic risk in the area is quite real, when well-located and well-constructed, the local traditional vernacular construction systems in stone, mud and timber are adequate for the seismic risk, i.e., meet the building code objective of “reducing the risk of great bodily injury and or death”. The *Pakhsa* compound wall-based construction system, while robust, is a delicate balance between rigidity and flexibility, therefore changes to the system should not be undertaken without significant research, which is beyond the timeframe of current shelter needs. The main causes of failure were due to poor selection of materials and poor quality of construction, likely due to poverty, increased population, the length of time between seismic events and other considerations.

Repairs as Shelter: Initial assessments indicate that more than 50% of enclosed living spaces could be rapidly repaired using vernacular construction best practices to provide adequate, appropriate, rapid, and durable transitional shelter for much of the affected population. The exact proportion of the population that can be sheltered through repairs will depend on the ratio of pre-existing living space per person/family in each compound to agreed cluster standards. In some more highly devastated sites, repairable space may be inadequate and new rooms may need to be constructed (approximately 17% of compounds). In a limited number of areas with extreme risk from rock fall, flash flooding or severe slope instability, appropriate engineering solutions may be impractical and unaffordable, so HLP and support to pursue alternate options may be more appropriate than onsite repairs and reconstruction.

Compounds: One notable finding from the assessment is that few families live in freestanding houses. Most live in a compound that is shared with their extended family. Much of the daily activity of life is carried on under open terraces or within the compound, with rooms predominantly used for sleeping and storing valuable possessions. Compounds were observed to house livestock, wells, cooking areas, gardens, and guest rooms. Repairs to compound walls must be seen as an essential component of house repairs. This is of particular importance for women, who—due to cultural norms—may otherwise find much of their lives limited to small rooms or tents for extended periods.

Materials: In most cases, sufficient salvageable clay, rocks, and timber were observed to provide the bulk of materials required for the limited repairs that could provide adequate transitional shelter. Some additional timbers may be needed to support future self-recovery efforts and reduce localized deforestation. Support for procurement and movement of higher-quality clay and stone between locations may also be required by some households. No other external procurement of materials is likely to be required other than for winterization and temporary compound privacy screening

Labor: The specialized skills needed to assess damage and determine appropriate repairs, along with the skills needed to repair and reconstruct, are locally insufficient for the scale of damage and the time frame required to house people before winter. Rapid training programs will be needed to enhance available labor resources in the area, along with cash to substitute for other livelihoods. In some more severely damaged areas, additional skilled construction workers may be required, though they may require training in the local vernacular practices.

Common standards, key messages, and Communicating with Communities (CwC): The unique nature of the construction systems and housing forms in the affected area mean that new agreed standards and key messages on safe repairs and reconstruction will need to be developed and agreed upon by SNFI cluster partners. Once developed, appropriate methods for communicating these with communities will need to be identified. This should include not only technical advice but also information on the types and scale of available assistance.

Limitations

The findings presented herein are based on experience, professional opinion, and a limited field assessment. Building typologies, construction contexts, and unique site conditions vary and may impact the opinions presented herein. This document has been developed to provide insights to the technical behavior of the vernacular construction found in the earthquake impacted areas resulting from this seismic event, as well to provide advice on appropriate transitional shelter solutions. The assessments used to form the basis of this document were conducted approximately one month following the initial June 22, 2022 seismic event; as time passes, field conditions and damage states can change as a consequence of natural and human phenomena. All phases of any further assessment and construction based on this report should be implemented by qualified skilled professionals operating within their field of expertise and under an established and accepted quality control and assurance plan.

Authorship and Acknowledgments

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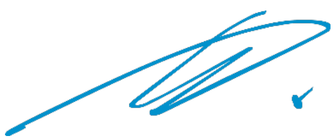
Global CEO



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Acronyms and Abbreviations

CwC	Communicating with Communities
HCT	Humanitarian Country Team
HLP	House Land and Property Rights
Key Messages	Simple Build Back Safer messages focusing on overcoming common mistakes
IOM	International Organization for Migration
Miyamoto	Miyamoto International
MMI	Modified Mercalli Intensity
MSRAF	Multi-Sector Rapid Assessment Form (used to refer to the Joint Rapid Needs Assessment, undertaken jointly by multiple agencies early in the response)
NFI	Non-Food Items as distributed for humanitarian assistance
OCHA	United Nations Office of the Coordination of Humanitarian Affairs
Pakhsa	Traditional vernacular mud and aggregate wall construction system
SAPs	Shelter Assistance Packages
SNFI	Afghanistan National Shelter and Non-Food Items Cluster
TWiG	Technical Working Group
URM	Unreinforced masonry
UN	United Nations
UNHCR	United Nations High Commission for Refugees
USGS	United States Geological Survey
WASH	Water, Sanitation and Hygiene

1. Introduction

1.1 Overview

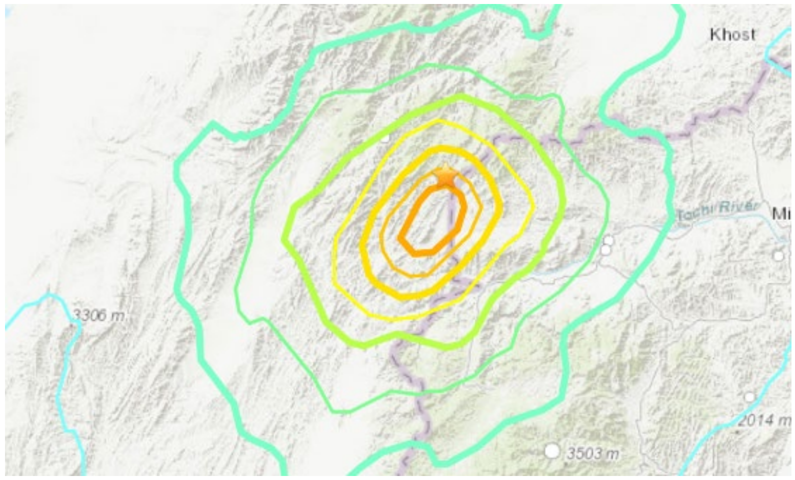

Figure 1-1 Earthquake epicenter

On June 22, 2022 (local time), an earthquake struck eastern Afghanistan, primarily impacting the three administrative provinces of Paktika, Khost, and Paktya. The earthquake resulted in the loss of over 1,000 lives, 6,000 injuries[3], and extensive damage. Estimates after the earthquake approximate over 13,000 families (between 80,000 and 100,000 people) have been rendered homeless. The affected region of Afghanistan is remote, resulting in some of the most vulnerable populations being at significant risk with winter only a few months away.

The earthquake was centered at 33.055°N 69.483°E near the border of Afghanistan and Pakistan; it measured Mw 5.9[4] by the United States Geological Survey (USGS), with a shallow 10km depth.

1.2 Regional Geography

The impacted area is generally situated in mountainous geography with populations primarily situated in elevations between 1,500m and 2,250m. The populations are situated in villages and community groups distributed throughout the impacted area.

1.3 Seismicity of Afghanistan

Afghanistan is situated north and west of the subduction region resulting from the Indian plate subducting below the Eurasian plate. The Indian plate is generally moving in northernly direction and subducting below the Eurasian plate. The colliding plates result in buckling of the earth (Himalaya Mountains) and stresses building up within the rock layers; these stresses accumulate and are relieved by earthquakes. **Figure 1-2** below illustrates the plate boundary (in red) and shows the proximity of the June 22, 2022, seismic event (star).

[3] https://news.un.org/en/story/2022/07/1122492
[4] https://earthquake.usgs.gov/earthquakes/eventpage/us7000hj3u/region-info

As a result of the geographic phenomena, Afghanistan generally has significant seismic risk. This is particularly visible within the northern half and eastern extent of the country. The seismicity of Afghanistan is illustrated in **Figure 1-3.** The map includes the reference point for the June 22, 2022, earthquake. The map below illustrates the epicenter's location near the interface of the two most seismically risky (ground accelerations) tranches in Afghanistan.

Figure 1-2. Tectonic setting of Afghanistan[4].

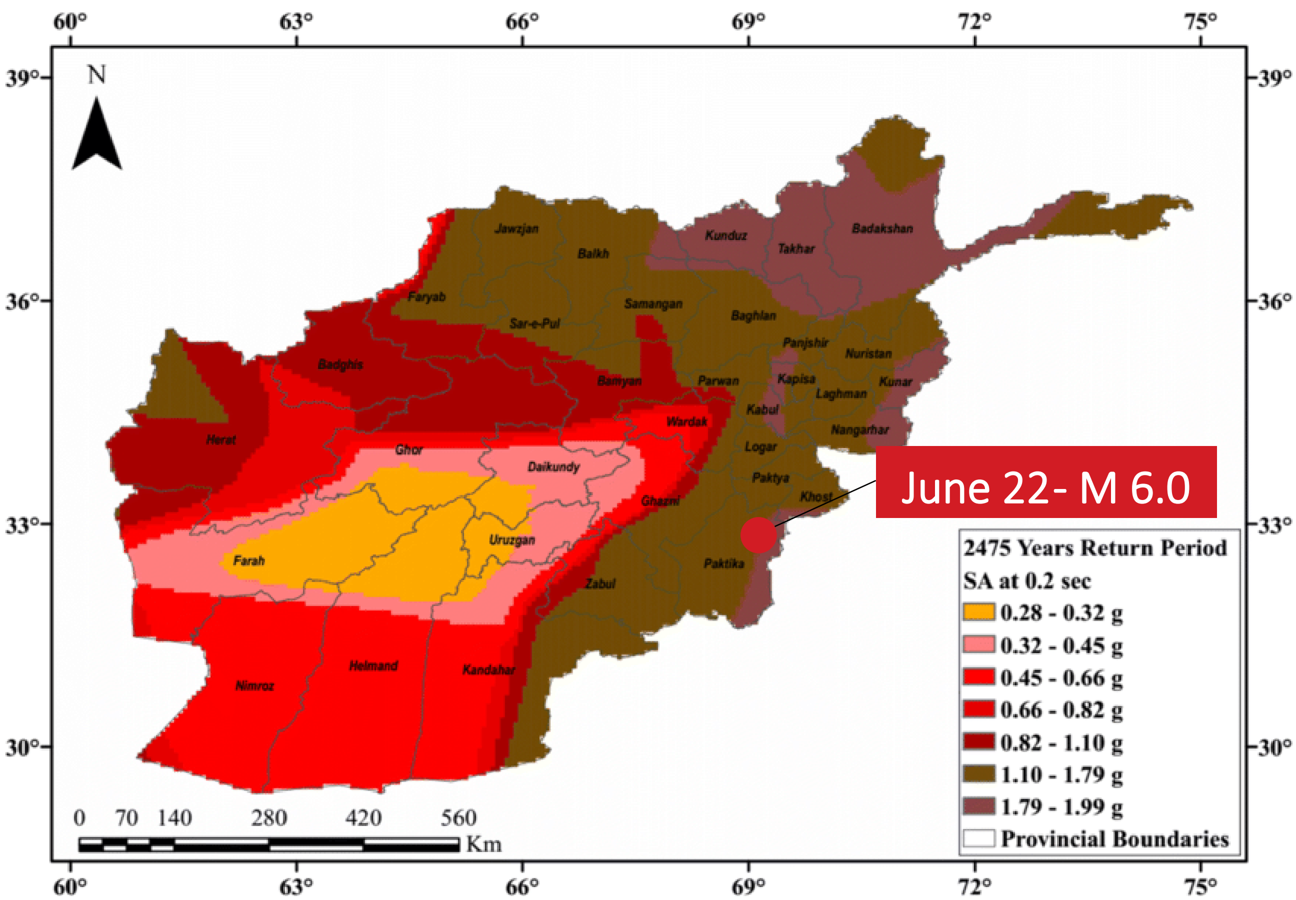

Figure 1-3. Seismicity of Afghanistan

1.4 Objectives of Earthquake Engineering

Structural engineering, for most loading cases, is based on prescriptive loading, wherein the building structure is designed to resist in the linear range over service level loading. This means that the structural elements resist the loading and there is no permanent (non-linear) deformation that results.

Earthquake engineering utilizes non-linear behavior to resist the seismic loading on the structure. The basis of design for typical occupancies, such as houses or commercial, is life safety. The life safety performance objective means that building structural damage is anticipated during major seismic events and the intention of design is to reduce the risk of serious bodily injury and/or death of the occupants.

2. Field Assessment

Miyamoto engineers and shelter experts conducted a field assessment mission to the earthquake impacted areas of Paktika, Khost, and Paktya to survey buildings' structural damage, typologies, and systems, as well as social systems and shelter considerations.

To facilitate information gathering, a rapid field survey was conducted to collect pertinent information to facilitate understanding of:

- Building typologies/systems
- Damage typologies
- Habitability assessment
- Shelter considerations

As part of the field mission, the assessment team visited selected areas around the three humanitarian hubs located in Barmal, Giyan, and Spera. **Figure 2-1** illustrates the epicenter, Modified Mercalli Intensity (MMI), and humanitarian camps.

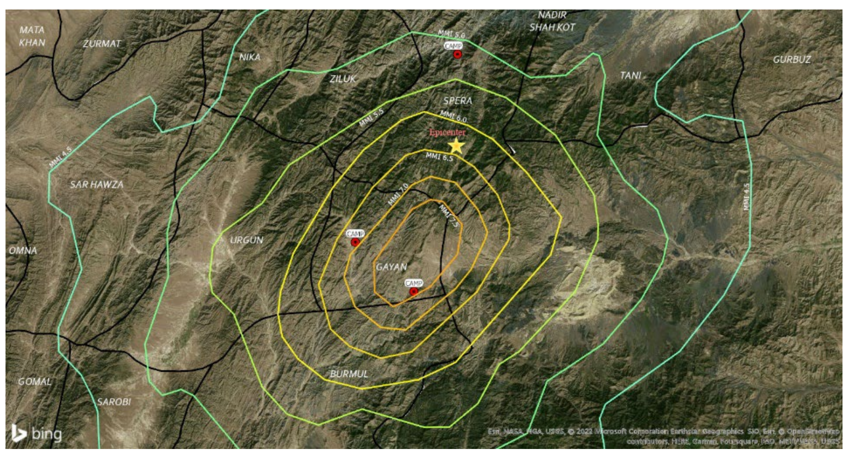

Figure 2-1 Humanitarian camp locations overlayed with earthquake epicenter information.

2.1 Field Survey

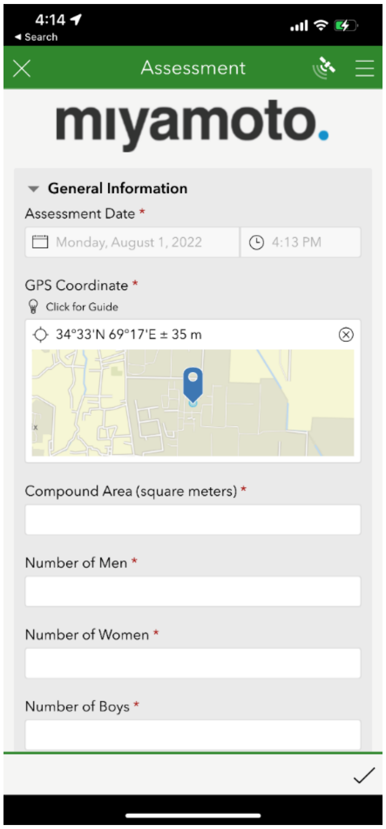

Figure 2-2. Survey123 sample page.

The field survey was developed utilizing an ArcGIS application, Survey123, that allows for standardized surveys. The surveys can be collected on or offline with either Apple or Android devices based on a configured format. **Figure 2-2** illustrates the survey interface and first section of questions. For Afghanistan, the survey is developed around the compound rather than the house or family. This data collection is targeted to align with typical living situations in Afghanistan.

Following assessment, data is collated in ArcGIS which can be rapidly analyzed and sorted through the ArcGIS dashboard. **Figure 2-3** below is an example of the dashboard. A full copy of the survey questionnaire has been included in Appendix A. At the time of drafting, assessments were still ongoing with over 170 compounds already assessed. This included just under 4,000 people from 823 families, with a total assessed indoor living space (including still habitable, damaged, and repairable or destroyed spaces) of about 39,000m^2, an average of 230m^2 of covered living space per compound prior to the earthquake. The assessment found an average of 4.8 families per compound, with an average family size of 4.8 people, which works out to a little over 10m^2 of undercover living space per individual, or just under 50m^2 per family prior to the earthquake.

The assessment found that post earthquake about 10% of indoor living spaces (rooms) were still habitable with little to no damage, 57% were repairable (most rapidly repairable, within 2-3 weeks), with the remaining 33% destroyed beyond reasonable repair.

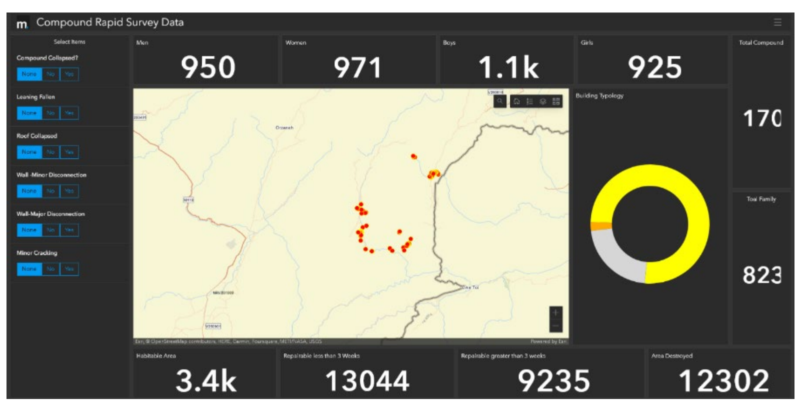

Figure 2-3. ArcGIS dashboard.

2.2 Comparability with other assessments

While the percentage of repairable space found by the Miyamoto assessment was slightly higher than the number of repairable 'households' found in the recent Earthquake Damage Assessment conducted by REACH[5] (50%), this difference is however well within the confidence margin of both studies. The differences are likely due to differences in methodologies, such as one measuring households and the other undercover living space and one using engineers specifically training to assess repairability in the local vernacular construction.

The findings of both the Miyamoto and REACH assessments were however notably different to that of the initial joint Multi Sector Rapid Emergency needs assessment (MSRAF) conducted by cluster partners which found almost all households damaged beyond repair. This difference in findings is also understandable, as the rapid initial assessment was focused on multisectoral emergency needs, such as immediately habitable space, while Miyamoto's assessment specifically looked at repairability using engineers trained in understanding the unusual vernacular building system in the area.

To ensure this discrepancy was in fact due to differences in methodology and not due to some form of selection bias the Miyamoto team conducted a second smaller more comparable assessment. In coordination with IOMs cluster Information Management team, three representative villages were randomly selected from the MSRAF dataset and then a whole of village, house to house damage and repairability assessment was conducted in each village. to provide an indicative proportional cross comparison of findings.

The three villages selected for the comparative assessment where Khan Mohammad in Gayan district, Aye Jan in Barmal district and Afghan Dubai/Pasa Mela in Spera. The MSRAF did not identify any repairable households in these villages noting only that 27%, 2% and 85% of households (respectively) were destroyed. The detailed data from each assessment was again not directly comparable, as Miyamoto's methodology focused on habitability and repairability of undercover living space within compounds, without assessing how each space may be used, or allocated amongst households.

Overall, the second 3 village, whole of village assessment found a similar pattern of damage to the main assessment with 9% of undercover living space still habitable 57% repairable and 34% destroyed. This finding indicates the findings of the initial study can be extrapolated with some confidence across the affected area, to provide overall guidance on average damage and repairability.

[5] REACH, Earthquake Damage Assessment Khost, Paktika and Paktya Provinces Afghanistan July 2022

2.3 Building Typologies

During the field mission there were three (3) primary typologies of wall construction noted including:

- *Pakhsa*
- Mud brick
- Rock/stone wall

The observed wall construction typologies generally shared consistent foundation and roof systems.

Foundations consisted of rock masonry construction to the width of the walls, reportedly 5-700mm deep below ground and generally rising above maximum potential water level where applicable. Foundations were seen to step up slopes, with a minimum of 100mm commonly visible above natural ground level at low points. The rock construction for these elements, where observable, was constructed consistent with the rock/stone wall construction.

The roof system consists of roof joists supporting transverse (perpendicular to joist span) lath or flat wood to support the mud roofing system. The mud roof system provides water protection, thermal stability, and slope for drainage.

Evolved Vernacular Versus Modern Prescriptive Building Codes

Throughout the world differing vernacular housing typologies have evolved in response to local conditions. Usually this includes local, cultural, climatic, environmental and resource availability considerations along with consideration of local hazards and risks. Commonly, this evolution is driven by experience garnered over generations of what has proven to be comfortable, safe, and affordable. When asked, vernacular construction experts often can't explain the reasons why they do particular things, other than to say that it's what their parents and grandparents taught them, and that they know it's important. At times religious or spiritual explanations are provided, such as the snakes that provide spiritual protection to Nepalese houses and serve as seismic banding. At other times, cultural norms may be cited, such as the intricate carving of stone foundations in Indonesia, which also provide protection from termites.

Modern prescriptive building code-based solutions are defined through a process of western scientific analysis with a focus on potential hazards and risks. Both methodologies can and regularly do arrive at construction solutions that are adequate for the risks they face when well built. In both cases, poor construction is equally likely to result in fatal catastrophe when disaster strikes, as can also be the case when these two very different approaches are mixed without extensive research.

Construction practitioners trained in a modern building code often face difficulty in assessing or evaluating the ways that vernacular houses perform. This is true for the non-engineered social aspects of the built environment, such as the social role and functions or importance of courtyards, terraces, and other spaces. Yet these components can play critical roles in the functioning of the buildings.

Deeper analysis by Miyamoto of the characteristics and limitations of seismic performance of the *Pakhsa* based compound construction is ongoing, but an initial analysis is outlined below in **Section 2.3** of this report.

The earthquake-affected area of southeast Afghanistan offers a unique example of traditional vernacular housing that is both culturally, climatically, and environmentally appropriate, as well as appropriate to risk. Most of the affected area is extremely remote with limited access to outside building materials or training in how to use them. While high value items, such as solar cells and cars, were apparent throughout the area, lower value construction items such as cut lumber, fasteners, fired bricks, steel, or cement were rarely observed.

Figure 2-4. Views across remote valleys in the region with few signs of introduced modern building materials.

Throughout the affected area, examples can be found of vernacular buildings that have survived unscathed or at least performed well within the criteria of the modern building codes "to reduce the risk of grave bodily injury and or death". Poor material selection, poor quality of construction and occasionally poor site selection appear to be the predominant reasons that most structures failed. As such, there appears to be no reason to alter the existing vernacular construction.

Pakhsa

Pakhsa is a vernacular construction practice that combines regionally available clay soils with small aggregates to form monolithic wall elements. Clay soils are hydrated with water and the batch is worked (mixed) to ensure mixing of the components that are then formed into lifts (layers) of approximately 50cm high. Hydration and batching processes vary based on local cultural practice and potentially related to variations in material quality. New layers are built upon the foundations or underlying supporting course (layer) and later trimmed. These wall systems are most commonly used for perimeter walls, as well as for courtyard-facing exterior room walls, and some interior partition walls. The typical wall height observed for perimeter walls was 3m to 5m (perimeter walls) with interior partition and courtyard facing room walls of 2m to 3m.

Figure 2-5. Example of a large Pakhsa compound wall (5-6m high).

Figure 2-6. Example of Pakhsa used for inner compound room wall construction

The process of hydrating, mixing, and compacting the *Pakhsa* is critical to the performance of the system. Mixing and compaction of the mix is achieved by either machine (tractor) or manually, most commonly by ox or another large animal. Adequate hydration, mixing, and compaction is critical to facilitate the natural bonds of the clay to other components of the material matrix.

In addition to material preparation, material protection from erosion/exposure to water is important to system performance. This is achieved through the use of natural fiber reinforced plaster and/or a capping structure consisting of a sacrificial rounded (or sloped) layer of Paskha over a slate or other material that protrudes from the wall providing a drip line beyond the wall surface. The capping system is easily observed at the top of walls in **Figure 2-5 and 2-6**.

Mud Brick

Mud brick is a vernacular construction practice that combines regionally available clay soils with small aggregate to form regular rectangular block elements. The size of the blocks varies by location as does the composition of the block elements. Like *Pakhsa*, clay soils are hydrated with water and the batch is worked (mixed) to ensure consistency and then formed into the block elements. The bricks are then assembled in courses with differing thicknesses and used to support the roof system. **Figure 2-7** illustrates typical mud brick construction.

Figure 2-7 Example of mud brick construction.

Rock/Stone Construction

Rock/stone construction is a vernacular construction practice that utilizes local rock stacked as a dry-stone construction or interlocked with mortar (clay based). The rock typology and shape vary regionally, and wall systems of varying thicknesses were used to support the roof system.

Figure 2-8 illustrates typical rock wall construction, in this case built with an interlocking clay-based mortar.

Figure 2-8. Example of rock wall construction to the rear with collapsed mud brick rubble in front.

2.4 Seismic performance of *Pakhsa* walls

Pakhsa walls, from a structural point of view, are bidimensional elements with length that is prevalent to the other dimensions (see **Figure 2-9**). The ratio length/height is probably up to 10 times more than a usual ratio in common unreinforced masonry (URM) buildings.

Figure 2-9 Length to height ratio of Pakhsa walls

Commonly in URM buildings the distance between orthogonal walls and the presence of the floor/roof connection makes the structure work as a box like element, when exposed to a seismic event. In those cases, band beams are necessary to connect the floors to the walls and orthogonal walls.

The shape factor in the *Pakhsa* compound walls produces a different behavior of the wall in the central part and close to the corners. In these last positions the cracks disconnect the two orthogonal walls that displace independently as illustrated in **Figures 2-10 and 2-11.**

Figure 2-11 Example of commonly observed partial corner detachment.

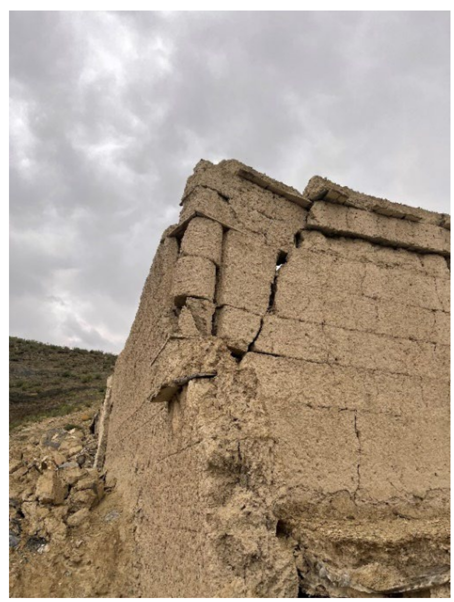

Figure 2-10 Example 2 of corner detachment

The evidence of rocking behavior during earthquakes is the probable reason behind commonly observed detachments at wall corners as seen above. ***In this case a strip band especially of rigid concrete or steel elements may significantly alter this structural behavior increasing the probability of structural instability and potential building failure***.

The long walls behave like a free-standing wall subject to seismic actions. These walls rock in out of plane at the bottom of the wall. In many instances horizontal cracks were observed at the base of walls where this had occurred. In some instances, horizontal cracks or horizontal displacement were visible higher up, where lower parts of the wall had been overly constrained. This rocking behavior provides a stable mechanism for absorbing seismic energy. The out-of-plane behavior is the only possible resisting mechanism that these walls can have. This video filmed in the field further describes this rocking mechanism.

The seismic performance of *Pakhsa* walls also appears to be linked to a friction dampening effect caused by rafters sliding in and out through the much shorter and more stable interior courtyard walls as described in this video. Further research is needed to determine the seismic limitations of this unique mechanisms, which is also likely to be related to the frequency of seismic waves, material selection, construction technique, and height ratio of the walls. Hence the recommendation to follow local vernacular best practice rather than altering or stiffening components of this unique system.

2.5 Structural Defects and Mitigation Strategies by Typology

One of the primary objectives of the field mission was to identify damage/failure modes by typology. Failure modes provide engineers with insights into the behavior of the structural system and interaction between elements. The subsequent sections include discussion on a construction typology basis.

Within each construction typology, good performance was observed when construction had been implemented in accordance with best practices.

Pakhsa

The seismic resilience of this building typology is based on the inherent flexibility and compatibility of deflection capacity between building elements. Overly stiffening or weaking of any one element may lead to structural failure. Field observations revealed some common causes of structural failures when not constructed in accordance with traditional methods, including

- Insufficient roof system bearing support

Figure 2-12 Example of Pakhsa wall construction

- Excessive roof loading, thick mud
- Insufficient material (clay) preparation–poor compaction, oversized rock elements
- Aspect ratio
- Retaining condition
- Construction defects

Insufficient Roof System Bearing Support

This failure mode was frequently observed and resulted in many fatalities due to the roof joists or timbers lacking adequate anchorage/support by the wall systems. Two failure modes resulted from this including out-of-plane wall failure: reference **Figure 2-12** above. **Figure 2-12** also shows the embedment of the roof system was approximately 10 to 15cm and a portion of the wall has failed out of plane. The second failure mode was the collapse of the roof system that often included the wall being pushed over (or partially), by the roof supports.

Excessive Roof Loading

Roofs are commonly repaired prior to winter with additional layers of mud added to ensure adequate waterproofing and improve thermal comfort. Proper maintenance of the roofing systems should include regular removal of excessive mud and replacement of mud/timber where needed to ensure structural quality and adequate water protection. Many cases were observed where multiple layers of mud had accumulated over the years, resulting in excessive roof thickness and potentially unnoticed pest or rot damage to timbers. The weight of the mud roof system, particularly where multiple layers have been allowed to accumulate, contributes significantly to the seismic mass of these structures and is associated with reduced performance. Reference **Figure 2-13.**

Figure 2-13. Failed section of multilayered roof.

Insufficient Material Preparation

One of the critical components of the *Pakhsa* construction system is the adequate composition (discussion in the following section), compaction and activation of the clay materials. Once activated and compacted (worked by equipment or manually), the clay particles bond with the matrix and act as a rigid body. When the lifts (layers) lack adequate compaction, they are not able to accommodate the rocking behavior and are prone to premature failure. **Figure 2-14** illustrates an example of poorly compacted *Pakhsa* that includes oversized rocks. Oversized rocks within the wall element create stress concentrations and failure planes.

Aspect Ratio and taper

The aspect ratio of a wall is the ratio of the height to width, for example, if a wall is 5m high and 50cm wide, the aspect ratio is 10:1. As the aspect ratio increases, the wall becomes increasingly slender. The structural behavior of these walls is compression-based (no tension capacity) and utilizes a rocking mechanism where the centered mass restores the wall. When the wall is too slender, it becomes prone to failure. **Figure 2-14** also illustrates a slender wall with an aspect ratio closer to 14:1. Some walls were seen to taper but the critical factor appears to be the aspect ratio at base to height.

Figure 2-14. Failed section of Pakhsa wall

Retaining Conditions

Retaining walls are used to support earth and allow a sloping site to be leveled. Retaining walls are commonly exposed to high water loads and changing hydrological pressure, which unstabilized clay structures are unable to withstand. As such, *Pakhsa* walls are inappropriate for this application and rock walls should be used with a mass retaining approach. *Pakhsa* walls can then be supported on top, ensuring the *Pakhsa* system itself has adequate drainage and does not bare any retaining load.

Construction Defects

Construction defects (in addition to preparation discussed in the section above) are a concern in all building typologies from modern to ancient construction. Some common construction defects noted included

- Poor drainage away from the base of walls
- Out-of-plumb construction
- Poor water protection

These defects were noted to adversely impact structural performance.

Mud Brick

Similar to the *Pakhsa* typology, mud brick is a flexible structural system; however, some unique structural failures were noted

- Wall coursing and unit dimensions
- Mortar joints
- Water intrusion/deterioration
- Aspect ratio
- Construction defects

Retaining conditions were not noted with this system. Mud brick should not be used for retaining.

Wall Coursing and Unit Dimensions

Masonry systems generally utilize unitized rectangular units that are laid in a pattern to form a wall. The way the masonry units are laid is commonly referred to as the bond. The coursing or bond pattern utilized varies in type and size of the masonry unit, wall dimensions and other project factors. The most commonly used pattern is a Stretcher or Running Bond where bricks are laid longitudinally overlapping midway between courses. Best observed practice used double layered walls with alternating courses of Stretcher and Bond courses known as an English Bond. In some cases, a Stacked Bond pattern (aligning of the blocks vertically) was observed, which unless otherwise reinforced, is associated with reduced performance. In addition, poor quality or missing mortar (additional discussion in the following section) contributed to weak wall structures. **Figure 2-16** illustrates an example of poor course work.

Figure 2-15. Examples of Stretcher, Stacked and English Bond coursework. Source: spruce.com

The geometry of individual clay bricks is a critical component of system performance, the aspect ratios of length, width, and height must be rectilinear and not square, and compatible (increments of each other) to allow for proper coursing. In multiple conditions, this was noted to be inconsistent and therefore associated with reduced performance.

Mortar Joints

In addition to incorrect coursing, **Figure 2-16** illustrates poor mortar joints including incomplete head and bed joints. The head (sometimes referred to as perpendicular joints) refers to the vertical joint between adjacent masonry units. The head joints maintain space between the masonry units and help make the wall act as one. When the head joints are incomplete, it allows masonry units to shift and can lead to an incomplete gravity load path resulting in failure, reference **Figure 2-17**.

Figure 2-16. Example of insufficient coursing.

Figure 2-17 Example of poor mortar joints, poor rain protection and poor course work.

Water Intrusion/Deterioration

Due to the small unit nature of the mud brick system, erosion and water protection were noted as critical to performance. When the mud brick system isn't protected from water, the units and mortar were noted to deteriorate with significant structural implications. The traditional solution for this is the application of a mud-based plaster that provides protection. Wall systems with maintained plaster were observed to perform better than those lacking plaster. **Figure 2-18** illustrates plaster wall protection.

Figure 2-18. Example of plaster protecting mortar.

Aspect Ratio

Wall coursing and mortar (discussed above) engage the masonry units to act as a wall rather than individual blocks. Once the units are acting as a wall, the aspect ratio of a wall is critical to performance, like the *Pakhsa* system.

Construction Defects

Construction defects (in addition to preparation discussed in the section above) are a concern in all building typologies from modern to ancient construction. Some common construction defects noted to adversely impact structural performance included

- Poor brick unit composition and preparation
- Poor aggregate (rock) size control.

Rock/Stone Wall

Rock/stone wall systems were the least commonly observed during this field survey though this is a common typology of wall systems globally. Rock wall systems utilize locally available materials that can be assembled into a building structure. This field survey revealed the following deficiencies

- Shape/form
- Mortar between rocks
- Wall aspect ratio
- Construction defects.

Rock/stone walls are most favored for retaining conditions, aspect ratio, soil conditions, and drainage should be evaluated when utilizing this system for soil retaining.

Rock Shape/Form

Rock walls utilize locally available rocks and the shape/form of these varies regionally. In some cases, they are round river rocks while in other locations they are flatter and angular. In general, wall systems with angular rocks assembled to provide a cohesive wall and bound by mortar have better performance. **Figure 2-19** illustrates an example of angular rock construction.

Figure 2-19. Example of angular rock wall construction.

Mortar Between Rocks

Similar to other masonry systems, mortar is commonly used in rock construction to fill gaps and help engage adjacent elements, and to make the system act as a unified wall. Failure to provide adequate or appropriate mortar, or conversely, use of excessive mortar can be associated with reduced performance and should be avoided. High quality dry-stone construction avoids the need for mortar by careful placement or additional shaping and facing of angular rocks to ensure an interlocking structure. In locations with regular water, especially moving water, clay mortar is inappropriate and therefore higher quality dry stone construction or further stabilized water-resistant mortar is required.

Wall Aspect Ratio

Similar to the prior wall systems, slender walls are associated with reduced structural performance (both in and out-of-plane) and should be avoided. Globally, stone walls are commonly constructed with a tapered form with a 1:6 to 1:10 bater. Tapering of stone walls was not observed by the assessment teams; this is an area that requires further investigation. Maintaining lower aspect ratios is generally recommended; with aspect ratio limit states yet to be determined.

Construction Defects

Construction defects (in addition to preparation discussed in the section above) are a concern in all building typologies from modern to vernacular construction. A common construction defect that was noted was walls that had been constructed out-of-plumb prior to the earthquake.

Any common construction defects may adversely impact structural performance.

3. Factors Affecting Needs and Assistance Options

This section details the factors that affect the needs of the affected population and options for assistance. The following section (**Section 4**) includes specific shelter recommendations for consideration by the Afghanistan Shelter and Non-Food Items (NFI) Cluster, implementing partners, and donors.

3.1 Damage Levels

Damage levels varied greatly across the affected area, frequently related to the quality of construction. Levels of damage, however, directly affect assistance needs. Households that have faced total devastation may be much more greatly traumatized and may also have lost members of the household. These households may require considerably more psychosocial support and may also require additional labor inputs to make up for the loss of family members who previously generated income. Vernacular repairs may no longer be possible and whole room and compound wall reconstruction may be required. Higher levels of damage are predominantly associated with poorer quality of materials and construction, and as such, highly damaged households may also require additional levels of training or financial assistance. These factors should be considered on a case-by-case basis.

3.2 Hazards and Risk Level

As noted, the entire affected area is characterized by a high level of seismic risk. While in general the current vernacular construction is well suited for general seismic risk, when built well there are some areas where specific local hazards are beyond the capacity of the local technology. Examples of this include

- **Houses built in flood zones:** Lime stabilization of base walls, or adequately high stone foundations may suffice, however, heavily denuded landscapes indicate a high likelihood of flash flooding that may mean some sites are beyond the scope for this approach.
- **Houses built on steep, loose slopes:** Heavy earth walls may have increased risk on steep or poorly compacted slopes without significant improvement to foundations. Overly stepped sites may require movement joints at steps to allow the wall system to rock and dissipate energy according to their differing heights.
- **Houses constructed below falling rock hazards:** Some of the locations visited during the rapid technical assessment were constructed below steep fragile cliffs where loose boulders pose a significant hazard to those living below. Construction in these situations would require specific assessments and potentially unaffordable engineering investment to be considered safe.
- **Houses built in areas prone to uniquely high seismicity[6]:** Localized conditions such as hill effects amongst other factors may result in increased localized seismic movement.

Although examples were observed of houses constructed in higher risk areas, it did not appear to be particularly common and therefore may be expected to comprise a small segment of households in need of assistance. The choice to relocate or live with and accept the risk must be the right of individual families. Relocation or mitigation assistance may be appropriate.

3.3 Compound Living

The predominant housing form encountered during the field assessment was that of a series of rooms contained within a larger family compound. Commonly, these compounds were owned by a senior male member of an extended family group with his sons and their families occupying rooms within the compound. Some compounds also housed more distant relatives, and many also included rooms for guests either inside or outside the compound walls. Although some freestanding houses were observed, these did not appear to be as common[7], though this did vary from region to region and certainly appeared more common in denser more urban environments.

[6] Miyamoto International has been requested to undertake a geo-seismic study of the affected area that should provide further insight into areas of increased risk.
[7] Miyamoto is currently conducting a whole of village assessment of three randomly chosen villages that will assess damage levels of all houses, recording amongst other factors what percentage of houses are part of a compound and what percentage are freestanding.

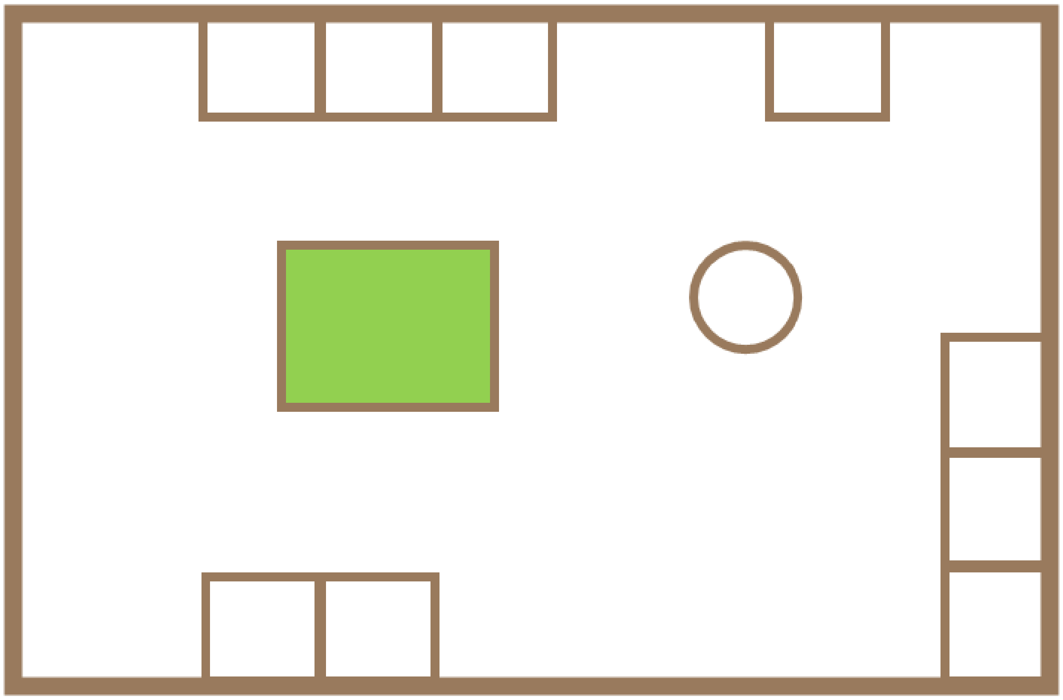

Figure 3-1. Example of the typical layout of a compound.

Compounds challenge many of the common precepts used by shelter practitioners. On one hand, the compound wall could be seen as nothing more than a garden wall enclosing a common outside space. In other ways though the compound wall performs more like the outer wall of a family house, providing essential privacy and security for family members to carry out the daily activities of life, as women and children are free to roam within the compound.

Figure 3-2. Four compounds as seen from the air. Note the construction of rooms along the perimeter wall with open spaces in the middle. Photo courtesy of Jago Boase, IOM.

While in some ways the compound is the primary housing unit, it also usually contains multiple families, occupying rooms that compromise their individual home within the extended family compound. The exact relationship between numbers of rooms and households within a compound is not fixed. Each of the compounds shown in **Figure 3-2** may house only one or possibly four or more families.

3.4 Undercover living space: How much is adequate in a compound?

The majority of compounds visited during the field assessment contained a number of rooms that were either habitable at the time of assessment, rapidly repairable, or totally destroyed and in need of replacement. While the Miyamoto assessment noted that 57% of undercover living space was in need of repair, not all of this will need to be repaired to provide adequate shelter for the coming winter. Standard 3 of the Shelter and Settlements section of the 2018 Sphere Handbook[8] provides an indicator of 4.5-5.5m^2 per person or 22.5m^2 per family of five for winter, which is approximately 50% of what the assessment found as the average under cover living space per person prior to the earthquake. Less than 17% of compounds had inadequate repairable space for the average number of residents per compound. Determining exactly how much space and how many rooms need to be repaired or replaced in order to provide adequate shelter for the number of individuals and family units will require individual compound assessments to better understand family living arrangements and how spaces within the compound are used and allocated amongst families[9].

The very nature of compound living means that much of the daily activities of life may be carried out communally rather than individually. Assessed compounds contained a range of habitable spaces; some covered but unenclosed often between rooms that were used for a range of household activities and appeared to perform an important function as airlocks during winter. Families also spoke of using their flat roofed areas for sleeping in summer and drying foods. Structures for shade, cooking and other purposes were also observed.

To further understanding the role of the compound as part of the house, Cluster partners may find it useful to refer to the Key Actions listed in the Living Space section of the 2018 Sphere Handbook:

- *Ensure that each affected household has adequate living space to perform basic domestic activities*.
- *Provide living space that accommodates the diverse needs of members of the household for sleeping, food preparation and eating, respecting local culture and lifestyles*.
- *Provide a basic roof and walls for occupants and their household assets, offering physical security, dignity, privacy and protection from weather*.
- *Provide optimal lighting conditions, ventilation and thermal comfort*.
- *Ensure that the space immediately surrounding the living space supports safe access to fundamental activities*.
- *Include appropriate cooking, toilets, laundry, bathing, livelihoods activities, socializing and play areas*.
- *Promote the use of shelter solutions, construction techniques and materials that are culturally and socially acceptable and environmentally sustainable*

[8] https://handbook.spherestandards.org/en/sphere/#ch008 Shelter and Settlements Standard 3: Living Space

[9] The Miyamoto rapid assessment did not count numbers of rooms, their sizes or uses, nor how they were distributed across the families within the compound

3.5 Prioritizing Reconstruction of Compound Walls

Reconstruction of compound walls is a key protection issue for women in the compound. Without the compound wall, women are not free to move around outside where they could be seen and must remain in tents or small rooms for extended periods. Allocating funds both for temporary emergency privacy screening, and more specifically for repairs to compound walls, may have a significant impact on the lives of women.

Figure 3-3. View inside a compound, note the repairable rooms to the top right and that women are confined to the tents visible top left.

Other aspects of compound life, such as the layout of water, sanitation, and hygiene (WASH) facilities, cooking spaces, and terraces may also be of particular significance to women. It is essential that further detailed consultations are urgently conducted with both women and children to better understand the specific shelter needs, as these groups make up around 75% of the inhabitants in compounds.

3.5 Differing Pathways to Recovery

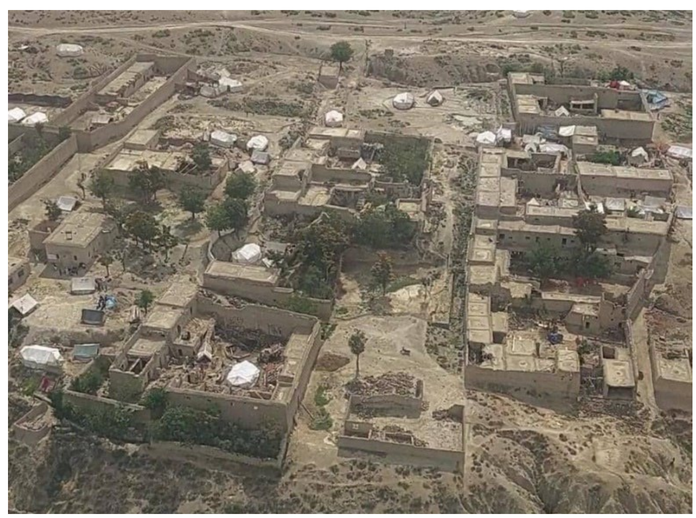

Figure 3-4. Additional example of compound configurations as seen from the air. Note the limited number of non-compound housing. Photo courtesy of Jago Boase, IOM.

As with any disaster, families affected by the 2022 earthquake are on a range of housing pathways and will inevitably take different approaches to recovery. While some live in free standing houses, for others life is based around a compound. Some are urban dwellers whose homes may include a shop front or cater to other urban livelihood functions, while others are rural dwellers whose homes must cater to housing livestock and other agricultural functions. More and more, thought leaders across the housing and shelter sectors are recognizing the need to provide more diverse and flexible shelter assistance options to ensure the assistance provided by humanitarian agencies not only matches peoples' immediate needs, but also assists in their autonomy to return to their individualize life and housing pathways.[10]

[10] Pathways Home, 2022, self-recovery.org

4. Shelter Assistance Recommendations

The diverse range of circumstances, hazards, housing typologies, building materials and damage outlined in this document will require a range of assistance solutions and implementation modalities. Different agencies have different mandates and strengths and may be better suited to assist in various capacities. What remains important is that assistance is tailored to beneficiary needs, adheres to common standards, and remains well-coordinated to minimize gaps and overlapping.

4.1 Common Shelter Standards

While individual assistance packages may vary, a range of common principles should apply. This includes acknowledging

- The importance of compound walls as a key component of housing for much of the affected population, and the particular importance for women and children.
- The unique earthquake-resistant mechanisms in traditional construction to minimize disruption to these practices.
- The introduction of shelter solutions based on materials that are not locally available locally is unlikely to be replicated due to remoteness, poor access, poverty, and other factors. Therefore, current assistance should support and encourage ongoing reconstruction with best practices that utilize locally available materials. It should be noted that in some heavily destroyed households, roofing timbers may have been damaged to the point where additional timbers may be required. In other households, stones or mud within close proximity may be low quality, and therefore materials may require transportation to the site.
- To ensure speed and transition, emergency shelter assistance should prioritize repairs and retrofits rather than new building or provision of external emergency/transitional shelters.
- Much of the reconstruction effort will involve unskilled or low skilled labor that families may be able to carry out themselves. However, this will not be the case for all families as key breadwinners focus on other critical livelihoods activities, or simply where the household does not have the required physical capacity. In these cases, additional labor support may be needed.
- Limited available funds means that shelter assistance should focus on "emergency only" shelter to ensure maximum reach. This may mean agreeing on an emergency repairs and reconstruction assistance package of 4.5-5.5m^2 undercover space per person or 22-25m^2 family. Exact determination will require further understanding of compound living.
- Ideally, minimum standards should also be agreed upon amongst cluster partners for such issues as ventilation, drainage, lighting, access to WASH facilities, privacy for women and other key issues.

4.2 Implementation Modalities

Globally, much like other sectors, the shelter sector has seen a rapid drive to provide cash assistance. Provision of cash-based assistance can provide families with more freedom of choice and improved dignity, while injecting funds to recover the local economy. The shelter sector faces a number of challenges with cash-based assistance, including a) whether local markets can supply the volume of materials needed quickly enough; and b) how to ensure adequate adherence to technical standards that ensure structural safety.

The June 2022 earthquake occurred in an extremely remote area with limited transportation access or shops. Most of the materials used in construction are either gathered on or nearby the site. The field assessment teams saw very little evidence of construction materials brought in from the external sources other than the occasional steel beam, windows, or doors. While direct cash assistance remains the preferred assistance modality, additional assistance may be required. The following considerations are critical

Figure 4-1. Example of local tractor/trailers used to transport building materials.

- **The increased movement of materials.** Most construction materials can be found on or near the homes and most of the mud and stone from destroyed building is salvageable, reducing the need to buy materials. However, some families in valleys may lack appropriate angular stones, while communities higher up may lack access to quality mud.
- **Training of additional skilled construction labor.** Additional training will be needed, especially for *Pakhsa*, dry stone, and mud brick construction workers.
- **Training of skilled engineers.** While Afghanistan has no shortage of engineers, many will need additional training to better understand the vernacular architecture and to determine what can be repaired versus what needs to be reconstructed.
- **Importing of additional timber**. While nearly all sites visited had sufficient timber for the construction of emergency shelters, in some cases this used a significant proportion of the household's salvaged materials, potentially impeding future recovery plans. Supply of some timber may help address this concern and reduce pressure on local deforestation.

Figure 4-2. A high volume of salvageable timber at an assessed site.

4.3 Increased Potential Vulnerability, Prioritization Tool

The capacity of different households to respond to and recover from disasters varies greatly across the world. Some indicators of reduced capacity or increased vulnerability are fairly universal such as levels of poverty, loss of key breadwinners through injury or death, households with high numbers of elderly, the very young, individuals living with disabilities, etc. Local factors may also increase vulnerability, such as altitude increasing the risk of extreme cold. Damage levels due to poor construction may also be a proxy indicator of many factors such as education and poverty, etc. Prioritizing heavily destroyed compounds will ensure **ALL** families have at least some undercover living space prior to winter, while prioritizing rapid repairs will ensure the **MOST** possible will have adequate cover.

Designing and agreeing on a common Vulnerability Prioritization Tool may significantly improve humanitarian outcomes by ensuring those most vulnerable are the first to be assisted. Agreeing on a method to prioritize those most urgently in need of assistance should not be confused with a targeting tool used to limit the total number of households assisted. It is likely that in such an isolated area most families may be in need of some form of assistance, and a prioritization tool simply aims to ensure those most in need receive assistance quickly. Community engagement and communication will be essential to ensure the effectiveness of such a tool to ensure communities understand and agree with the process of allocation of assistance.

4.4 Matching Shelter Assistance to Needs

In many disasters across the world, shelter clusters coordinate a range of shelter assistance packages designed to match the differing geographical, impact, or social situations of the affected population and better harness the various capacities of participating organizations. One critical factor in determining appropriate assistance packages in this response is the two predominant forms of housing: compound versus non compound. A second variable is the level of damage and desired building performance to better address varying households' risk exposure. Although some risks, like that of future earthquakes or aftershocks, apply generally across the entire affected area, other risks may be more site specific so increased performance or self-relocation may be deemed appropriate.

Figure 4-4 provides an example of a potential Shelter Assistance Matrix for the current response.

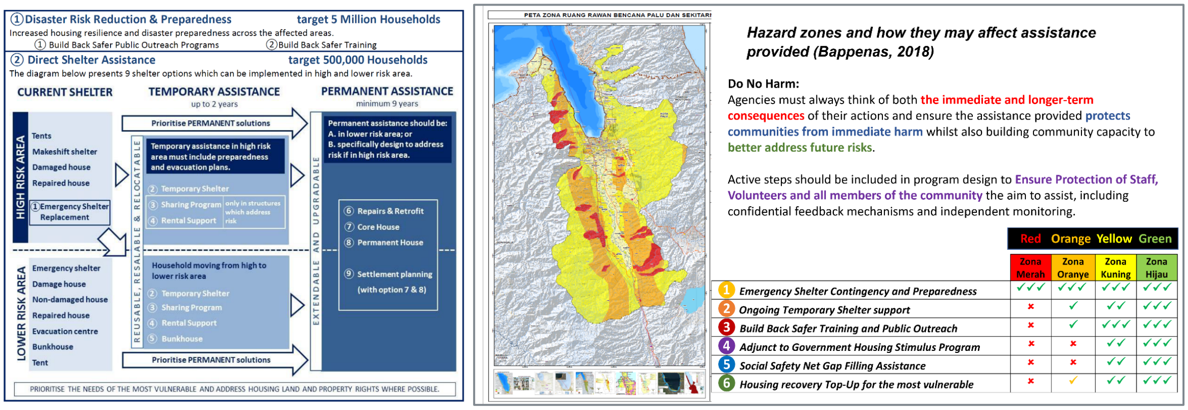

Figure 4-3. Examples of Shelter Assistance Matrix from: 2013 Typhoon Haiyan Response, 2018 Central Sulawesi Response

All Areas	Housing Type		Performance Level	Mild Damage	Heavy Damage	Total destruction
1 Public Outreach on Key Message 2 Winterisation Assistance	**Compound** Predominant Housing form, Est 90%+	3 Privacy Screening 4 Compound Wall Repairs	**Average** This performance level is adequate for an estimated 90%+ of all rooms	5 Vernacular Room Repairs	5 Vernacular Room Repairs OR 6 Vernacular New Rooms	6 Vernacular New Rooms
			High (Low percentage)	5 Vernacular Room Repairs	5 Vernacular Room Repairs OR 6 Vernacular New Rooms + 7 Vernacular seismic upgrades	6 Vernacular New Rooms + 7 Vernacular Seismic upgrades OR 9 Site Specific HLP Support
	Non Compound Secondary housing form. 5-10% (TBC)	3 Possible need for some Privacy Screening	**Average** (Low percentage)	5 Vernacular Room Repairs	5 Vernacular Room Repairs OR 6 Vernacular New Rooms	6 Vernacular New Rooms
			High (Lowest percentage)	5 Vernacular Room Repairs	6 Vernacular New Rooms + 8 Seismic upgrades	6 Vernacular New Rooms + 8 Seismic upgrades OR 9 Site Specific HLP Support

Figure 4-4. Potential Shelter Assistance Matrix for 2022 Afghanistan Earthquake Response

4.4 Potential Shelter Assistance Packages

The following outlines recommendations for the range of potential Shelter Assistance Packages (SAPs) shown in the Shelter Matrix proposed above.

Shelter Assistance for all Areas

1 Public Outreach for Key Messages

Public outreach for key messages will be needed across the entire affected area. While some households remain immobilized by fear or hope for external assistance, many others are already commencing reconstruction. It is essential that households are aware of the key features that will make their home safer, regardless of whether they receive assistance.

It is also important to note that the entire area faces significant risk from future aftershocks and earthquakes. The epicenter of any future shocks will almost certainly create different patterns of seismic impact and result in damage to different houses. Broad, timely public outreach campaigns may also assist the broader community, not just those currently affected, to reduce their risk in future events.

While the development of key messages is a critical step in uniting agencies under a common vision of what needs to be done, they are rarely developed in a format that is easily accessible by the public. Different agencies may have various levels of skills and experience in communicating key messages. Ideally, a technical working group (TWiG) should be formed among implementing agencies to discuss and decide on the most appropriate outreach methods. In past disasters, this has included distribution of information via word of mouth by religious organizations, through schools, over radio, TV or internet, or through posters, banners or flyers. In some cases, information has been conveyed through creative methods such as cartoons, dancing groups, etc. Ideally, a Communicating with Communities (CwC) strategy should be developed that identifies key actors in the reconstruction process, their roles, information needed, and how best to target each beneficiary group.

Managing Expectations

Public outreach for key messages should include clarity on the scale, limitations and variations of aid and peoples' right to receive it. The Miyamoto team encountered high expectations for assistance in the field. While communities may hope for assistance with the full reconstruction of their homes and villages, the assistance is likely to be limited. Managing these expectations is critical to ensuring security and safety. Managing expectations and knowledge about assistance rights will also further empower self-recovery, reducing any tendencies for households to delay their own recovery out of fear that it may reduce their entitlement to assistance.

Global best practices related to CwC often includes anonymous complaints or advice hotlines to ensure accountability to affected communities. The development and dissemination of such mechanisms could also be included in public outreach programs.

2 Winterization Assistance — Cost Estimate: To Be Agreed

There can be no doubt that the coming of winter is a key concern for most of the affected population. Life in tents is likely to prove harsh. Poverty and a lack of access to alternatives may drive communities to burn reusable construction timbers or increase deforestation for warmth. Rapid repairs to vernacular housing based on thick masonry walls for thermal stabilization should be the priority for winterization. The reality that not all may achieve this within the limited time frame needs to be addressed urgently.

The Afghanistan Shelter Cluster has already agreed upon common standards for winterization assistance packages that appear appropriate for the risks faced by the community.

Specific Shelter Assistance for Compounds

3 Emergency Compound Privacy Screening, Cost Estimate: To Be Agreed

Provision of temporary screening materials should be considered for compounds with partially or totally damaged walls. A wide variety of materials could be used, from cloth fencing to plastic sheeting. Exact material choice should be discussed with the affected community, with a preference for materials that are either biodegradable or have a high-value secondary use once walls are constructed. Assistance should include materials suitable for temporary posts, sheets, and appropriate fasteners.

Privacy screening may also be appropriate for some free-standing houses awaiting assistance for repairs

4 Compound Wall Repairs, Cost Estimate: To Be Agreed

Assistance to repair compound walls should be considered for all compounds where walls are either damaged, collapsed or in need of partial deconstruction and reconstruction. Compound sizes vary greatly as does damage, so the funds needed to repair walls will also vary. The suggested figure of $500-800 should be adequate to build corner walls or attach new rooms even in situations where the compound has been heavily damaged or destroyed. Compounds where damage is much milder may not require all these funds.

Compound wall repairs should include

- Technical inspection and advice on what can be repaired or needs to be demolished
- Cash assistance to procure higher quality clay and stones for base walls, if needed
- Cash assistance to pay for both skilled and unskilled labor
- Training on best practices in compound wall construction.

Where possible, the use of *Pakhsa* should be encouraged for compound walls as walls constructed in this manner appear to have survived better than others.

Key features of a successful boundary wall for all compound wall repairs include

- No more than a 10:1 height-to-width ratio (to be confirmed)
- Base foundation walls of stone to protect the base from moisture
- Stepped foundations to level out changes in slope
- Quality mud construction
- Rain proof capping.

Shelter Assistance for Vernacular Repair and Reconstruction of Rooms

The emergency shelter needs of the affected population have largely been addressed through the rapid provision of tents and plastic sheeting. Families have also sought refuge with other families in less damaged houses or constructed their own emergency shelters. As winter now rapidly approaches, the communities are looking to the humanitarian community for assistance with more durable transitional solutions that will both assist them along their pathway to recovery and better address their shelter needs over winter. The two most obvious and appropriate solutions for durable transitional shelter are

- The repair of easily repairable rooms in compounds and free-standing houses
- The construction of new habitable rooms where rooms can no longer be repaired.

In line with recommendations throughout this document, repairs or reconstruction of rooms should use best practice in vernacular construction to the extent possible.

The number of rooms repaired should be adequate to ensure that each household has undercover living space to carry on the normal functions of daily life.

Repairs and reconstructions provide an opportunity to train and improve the knowledge of households and the broader community in safe vernacular housing.

Vernacular room repairs or reconstruction should include

- Technical inspection and advice on what can be repaired or needs to be demolished
- Cash assistance to procure higher quality clay and or stones for base walls, if needed
- Cash assistance to pay for both skilled and unskilled labor
- Training on best practice in compound wall construction.

5 Vernacular Room Repairs, Cost Estimate: To Be Agreed

Repairs to rooms as durable shelters will vary according to damage. In many cases, rooms may simply require minor repairs to walls followed by replacement of timber roof elements and clay roof coating, along with application of wall plaster. In some cases, repairs may require the reconstruction or repair of some walls. Households should be encouraged to salvage and reuse timbers and building materials to speed up reconstruction,

6 Vernacular New Room Construction, Cost Estimate: To Be Agreed

Wherever possible, reconstruction of new rooms as durable shelters should be undertaken using best practice techniques in traditional housing construction. Within compounds, new rooms should be tied directly to compound walls with the compound wall itself providing one of the four walls of the rooms. Outside compounds, new rooms may be built as additions to damaged but repairable houses, or as free-standing units.

Shelter Assistance for Higher Performance Locations

The entire affected area is at risk for future earthquakes and while this report notes that the current vernacular housing system is adequate for risk, there may be circumstances where damage is particularly extensive and individual agencies or households feel that seismic upgrades are warranted in that specific location. Note that the authors see this as the exception rather than the rule, and that ensuring quality of construction in the existing vernacular system is adequate for risk.

The low probability of mass reconstruction funds beyond the humanitarian stage of the response, along with a lack of available or affordable alternative materials in the area, makes it highly likely that most families will continue novel reconstruction unassisted after agencies leave, instead using local materials and the same vernacular construction system that they used prior to the earthquake. This makes it essential that any seismic upgrades that are applied do not alter the unique seismic response of the current vernacular system. While stiffening, increased bracing or flexibility of components of the existing vernacular, may be seen to reduce risk in what agencies construct, it may then increase longer term risk as families extend or renovate with insufficient funds, knowledge, or desire to incorporate new techniques. This is particularly true in repairs or new rooms provided to families who chose to live in an extended family compound. Exact specifications for seismic upgrades will require deeper investigation than can be provided through this initial assessment.

Given the two dominant housing forms across the affected area, different seismic upgrade options may be appropriate.

7 Vernacular Seismic Upgrade **Cost Estimate: To Be Agreed**

Durable shelter solutions for households in compounds with extensive damage may benefit from minor vernacular seismic upgrades. This may include support beams at junctions where rafters meet compound walls, or stones placed below rafters in inner courtyard room walls to improve freedom of movement in friction joints. It is critical to ensure that any seismic upgrades to rooms in compounds do not alter the flexibility and seismic response of compound walls. *Exact details to be determined*.

8 Seismic Upgrades **Cost Estimate: To Be Agreed**

Durable shelter solutions for households that are not inside compounds and are in higher risk areas with extensive damage may also benefit from seismic upgrade. Although this circumstance applies to only a small proportion of those impacted, appropriate solutions need to be explored. In these cases, upgrades must still be designed to support future expansion plans of the household. *Exact details to be determined*.

9 Site Specific HLP Support **Cost Estimate: To Be Agreed**

A limited number of specific sites may face hazards beyond the performance capacity of the current vernacular construction system even with suitable upgrades. These sites may be considered too hazardous for safe reconstruction. The most probable examples of this are steep sites on fragile soils facing a high probability of slope collapse, landslides, land slippage or rock fall from above, sites with a high risk of flash flooding, or sites with specific increased seismic risk. In such cases, HLP support to identify and move to a more suitable site should be considered as an assistance option. Exact details of such a support package will require consultation with communities and discussion amongst agencies that specialize in providing HLP assistance.

4.8 Key Messages

Key messages on safe reconstruction in vernacular housing should be designed and agreed upon amongst the cluster partners. The unique nature of the vernacular housing of the earthquake affected area means that key messages developed for stone and mud housing in areas such as Nepal are not appropriate in this context. Below is a summary of the key messages that could be considered and further explored by the Cluster's Technical Working Group.

It should be noted that the "process" of jointly defining key messages is important for uniting agencies in a common understanding of the problem and the most applicable solutions. Reaching agreement on key messages between agencies is however only the first step in the process. Once agreed upon, appropriate public outreach strategies will need to be developed along with appropriate training materials targeting particular groups in the reconstruction process. While key messages may remain consistent, the learning styles of masons, engineers or householders may vary greatly and therefore need to be considered.

<table>
<tr><th>1) Safe site</th><th>2) Foundations</th></tr>
<tr><td>Some sites are more dangerous than others, and may require extra strengthening
Some sites are too dangerous, and people should consider moving
Steep loose slopes
Loose rocks above
Flood areas</td><td>Stone bases prevent rising dampness, 50cm?
Stepped to match the slope
Ensure main walls are built on level surfaces
Good dry stone foundation construction, select good stones
Not round river stones, but square stone
Choose or cut stones to fill gaps
Ensure overlapping
Ensure adequate drainage
Sufficient fall for water away from foundations</td></tr>
<tr><th>3) Compound walls</th><th>4) Internal compound walls</th></tr>
<tr><td>Preferably Pakhsa
Material selection
Good clay content
Small aggregate not big
Material preparation
Working the clay to make it sticky
Height vs. width ration
Rain protection
Base wall of stone
Capping
Plaster</td><td>Preferably Pakhsa
Same as for external walls
Mud brick
Quality of mortar joint
Importance of plaster and maintenance
Importance of staggered placement
Length vs. width
Stone
Good stone selection
Not round but square
Good dry-stone construction
Minimal gaps
Overlapping</td></tr>
<tr><th>5) Roofing</th><th>6) Retrofit</th></tr>
<tr><td>Roof thickness
Regular maintenance to reduce thickness
Use of plastic layer
Rafter material selection</td><td>If your house is not well built, you can strengthen it
Consider posts below beams
Consider timbers in corners
Improve drainage away from foundations
Wall capping</td></tr>
</table>

○ Not too large not to small ○ Termite resistant timbers • Rafter connections to walls ○ Connection to Compound wall ○ Connection to internal wall • Adequate drainage	
7) Maintenance	**8) Have a plan**
• Staying safe needs maintenance • Maintain plaster ○ Use straw and maintain regular coating for water proofing • Trim roofs ○ Don't let them get too thick • Check timbers ○ Check for rot and termite damage • Replace if needed	• Aftershocks will happen but will reduce • But… earthquakes may happen again • Be prepared to get outside ○ Run away from big walls and heavy roofs • Keep some emergency shelter/ plastic sheeting

Appendix A. Site Visit Summary Sheets

Compound Rapid Survey

Submitted by: MiyamotoBIM

Submitted time: Jul 27, 2022, 11:51:16 AM

General Information

Assessment Date

Jul 26, 2022, 11:17:00 AM

GPS Coordinate

Lat: 32.93564 Lon: 69.452135

Compound Area (square meters)

600

Number of Men

1

Number of Women

2

Number of Boys

1

Number of Girls

1

Number of families

1

Building typology

Compact Earth

Compund is totally Collapsed?

No

Habitable area (sq meters)

0

Building area repairable in less than 3 weeks. (sq meters)

20

Building area repairable + 3 weeks (sq meters)

0

Area destroyed (sq meters)

24

Wall leaning or fallen

Yes

Wall corner disconnection Minor (6 mm)

Yes

Wall disconnection Major(+6 mm)

Yes

Minor cracking

Yes

Major cracking

Yes

Roof collapse

Yes

For Picture

Photo 1

Photo1-20220726-102355.jpg

photo 2

Photo2-20220726-102405.jpg

Photo 3

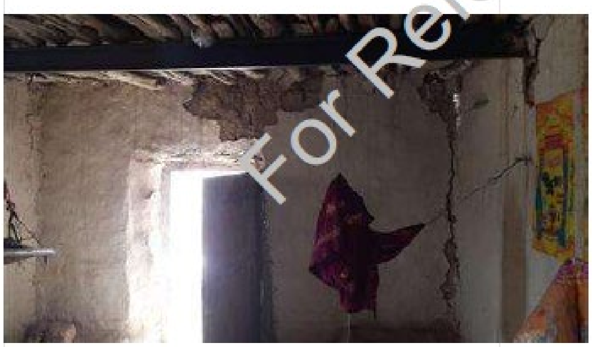

Photo3-20220726-102440.jpg

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miyamoto.

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Las Vegas | Phoenix | Washington, D.C. | Puerto Rico | Mexico | Costa Rica | Colombia | Haiti | Italy | Ukraine | Turkey
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