Picking Up the Pieces:
Transitional Shelters for Disaster Relief in the Northern Mountainous Regions of Pakistan

by

Weifeng Victoria Lee

Submitted to the Department of Architecture in Partial Fulfillment of the Requirements for the
Degree of
Bachelor of Science in Art and Design

at the

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Signature of Author..............................................................

Department of Architecture
May 25, 2006

Certified by ........................................................................

Jan Wampler
Professor of Architecture
Thesis Supervisor

Accepted by ........................................................................

Jan Wampler
Director, Undergraduate Architecture Program
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ABSTRACT  
This thesis seeks to tackle a complex problem – disaster housing relief – from the angle of architecture design discipline and attempts to find a logical approach to solve such a problem via an in depth examination of a specific topic – transitional shelter. The project addresses three main issues in the field of shelter design:  
1) the need of transitional shelters in a particular disaster situation (the October 8, 2005 Pakistan earthquake),  
2) the design criteria for the shelters in this specific setting and a systematic way of evaluating shelter designs, and  
3) a specific transitional shelter design that is produced using the established methodology  

Thesis Supervisor: Jan Wampler  
Title: Professor of Architecture
It’s in the shelter of each other that the people live.
“In everyone’s life, at some time, our inner fire goes out. It is then burst into flame by an encounter with another human being.” – Albert Schweitzer

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Picking Up the Pieces:

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Picking Up the Pieces

The title of my thesis has multiple meanings. The first, and obvious, meaning refers to the reconstruction of home and normal life one is forced to face after disasters. The second meaning refers to the design of the transitional shelters (which are in pieces) addressed in this thesis. The third, and perhaps the least apparent, meaning is the personal association to this thesis.

Four years ago I entered MIT dreaming of becoming a doctor. Almost two years later I recognized the fact that I was merely in love with the humanitarian motivation underlying medicine, rather than medicine itself. Amid confusion, frustration, and disappointment with myself, I did the only thing I, at that time, knew how: following my instinct. I switched my major from biology to architecture, something I’ve always admired as a luxurious hobby but not a profession that can most directly help the needy. For a short while I sat in my studio, enjoying the designing experience, but was secretly in pain for giving up my aspiration to lend a hand in today’s most urgent global crisis. But along the way, I’ve discovered that architecture and the built environment are just as deeply rooted in humanity as does medicine.

So, this thesis not only serves as a conclusion to my undergraduate education, but also as a closure to my doubts and reservations in being an architecture, instead of a pre-medical student. I won’t be finding a cure for cancer or a remedy for AIDS in this lifetime. But I’m okay with that. Doing this thesis project is picking up the pieces for myself; I have come to terms with what I enjoy doing and what I think I should be doing. And lastly, doing this project is just my way of, in Vincent van Gogh’s words, “expressing a sincere human feeling.”
The Pieces

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Piece No.1_Context
Recent catastrophes, both natural and man-made, have made millions of people homeless. While the disasters themselves are traumatic, the most distressing experiences often take place during the time-consuming reconstruction period after the unfortunate events. From Bam’s earthquake to South Asia’s Tsunami, from Hurricane Katrina to the tremor in Pakistan, survivors have not only lost their homes, but have also been uprooted from their society and in many cases, their regional culture. While reconstruction of permanent housing can take up to several years to complete, full restoration of lost towns and cities can take even longer. When the events are no longer news and the media stops reporting, the rest of the world tends to forget about the people left behind the wreckage. Yet in the meanwhile, these survivors are confronted with chaos. The bare necessities, such as shelters, come to be of paramount importance.

Phases of Disaster Housing Relief

Disaster remediation and rescue operations are largely planning issues. Over the years, numerous guidelines and development standards have been developed; some examples are The Sphere Project’s Humanitarian Charter and Minimum Standards in Disaster Response, UNHCR’s (United Nations High commissioner for Refugees) Handbook for Emergencies, UNDP’s Emergency Relief Items – Compendium of Generic Specifications. More recently there is Transitional Settlement: Displaced Populations developed as part of the University of Cambridge shelterproject. These guidelines focus on sheltering as a process rather than on specific shelter designs. Although sheltering should be considered rightly as a process and “not as an object,” the specific physical product of a shelter “may form a part of the process.” Much energy and interest have been devoted to the process of sheltering and interest in the physical forms of shelters has been slowly on the rise. This thesis project is an example that addresses such an interest.

According to Tents: A guide to the use and logistics of family tents in
humanitarian relief developed by the Office for the Coordination of Humanitarian Affairs (OCHA) of United Nations, a “shelter is a habitable, covered living space”.

But as indicated by the title of the guide, the word “shelter” in disaster remediation largely means tents, which is the single least expensive, most portable, most easily assembled and distributed coverings one could provide in a post-disaster situation where large populations are displaced. Their prevalent usage is well founded; however, they do not always provide the best possible shelters given the particular stage in a disaster remediation process.

This thesis design project does not intend to develop a structure that will substitute tent, but rather as a structure that will supplement tents in advancing the sheltering progress where tents prove to be inadequate or inappropriate. Stages of different housing needs must be clearly defined in order to better determine the requirements and criteria for transitional shelter. Several organizations of the housing need in disaster remediation have been mentioned in literature, two are explained as followed.

One is suggested by Dr. Fred Krimgold as mentioned in Ian Davis’ book Shelter After Disaster. In this approach, the disaster is considered as an agent that causes interruption, or “gap” to continuous occupation of “normal housing”. There could be three scenarios after the disaster occurs (fig.1):

1. the normal housing is not damaged and therefore no “gap” is created
2. normal housing is damaged, and the “gap” is filled by temporary housing
3. normal housing is damaged, and the “gap” is filled by speedy reconstruction of normal housing.

In David Joseph Kinel’s Master of Architecture 1973 thesis, he pointed out that “the post-disaster period is not a single period at all, but rather three consecutive periods.” The three periods are: (1) life-sustaining, (2) situation stabilization, and (3) recovery. Housing relief during the three periods is also different.

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*all diagrams, photos, and images by the author unless otherwise noted in the caption; for complete credit refers to bibliography using keyword provided in parenthesis.
Programs, a study done in 1972 by the Special Advisory Committee on Disaster, part of National Academy of Sciences, defines the three housing periods as followed:

“(1) emergency housing, defined as immediate shelter, providing minimal comfort, convenience, and privacy to help dislocated persons through the immediate post-disaster period; (2) temporary housing, defined as shelter providing minimal comfort and convenience and assuming the semi-family living conditions (sleeping/sitting/privacy) needed to stabilize the family unit during the intermediate post-disaster periods; and (3) semi-permanent housing, defined as housing providing sufficient comfort and convenience to help restore the well-being of the family unit for the balance of the first year following the disaster.”

The above different periods can be better understood in terms of phases (fig.2). There is the immediate response, first phase, that should sustain life in the critical hours after the event strikes. The shelters required in this phase should be ready for occupancy within 48 hours and should continue to provide protection for up to three weeks, depending on the circumstances. The “shelters” in this very first stage often means tents, as demonstrated by recent as well as historical disaster remediation operations.

The second phase is the transitional phase, during which remediation operations, such as searching for survivors and clearing roadblocks, carry over from the first phase and happen simultaneously with the reconstruction of permanent shelters. This phase can last anywhere between six weeks to five years, and in some cases, even longer. In the unfortunate event of slow reconstruction progress, this second phase is further broken down into two separate stages: transitional and semi-permanent. Nevertheless, the time it requires to erect permanent or even semi-permanent shelters largely depends on the availability and accessibility of the building materials and tools, survivors' technical knowledge and physical prowess to undertake the constructions, and perhaps most importantly, the nature of the disaster and the degree of damage it caused. The season is likely to change during this lengthy period and tents that are usually deployed in the first phase simply do
not suffice. Yet today they almost always double as transitional housing, providing meager protection and security for the survivors.

The **final phase** is recovery, during which most survivors have either moved into permanent shelters or are near completion with the reconstruction of their homes. Public buildings are expected to take longer to rebuild, but civic activities should slowly return to normal during this stage.\(^6,^9\)

This organization of housing relief process is very general and therefore should not be read as applicable in every case of disaster remediation. Every disaster is different regardless of similarities in culture, geography, demographics, climate, or nature of the disaster. As a result, every and any categorization intended to be general standards must be adapted to meet the situation of individual disaster incidents. The length of each phase is also variable depending on the situation.

Housing in both the first and the final phases described above has been well researched, and numerous improvements to tents and alternatives to traditional construction techniques have been proposed and even effectively implemented. Today there are heavyweight winterized tents that perform at a much more acceptable level than typical tents in cold weather. There are also many innovative methods for rebuilding houses after disaster involving new fabrication methods and new building materials.

Progress on the transitional shelters for the second phase, however, has been slow. This is due to a lack of understanding, or rather a clear definition, of what transitional housing is. It is all too easy to inadequately simplify housing situations in a post-disaster situation: those who lost their homes should be given “emergency housing” while “permanent housing” is being constructed or repaired. However, there is considerable ambiguity regarding how long the emergency housing should last and when emergency housing ceases to be “emergency” and crosses over to become semi-permanent or even permanent housing. The recognition of the existence of “transitional housing,” such that the period passed between emergency housing and permanent housing can be distinctly different from either, is important.
The terms “temporary” and “transitional” are often used interchangeably. However, the term “transitional” should be used to indicate the “gap” as referred to by Krimgold, or the “second period” of the post-disaster period mentioned above. The reason is that “transitional housing” accurately characterizes the middle period. Because the time to reconstruct or repair permanent housing varies depending on the degree of damage and nature of the disaster, sometimes emergency housing (mostly tents) will suffice and no transitional housing is needed. But most major disasters cause damage on a scale so large that usually requires a long period of time to repair. During this long period of time, tents inevitably become inadequate. The premise of this thesis project assumes this latter condition, where a transitional state of remediation, and therefore transitional housing, is needed.

8:50:40 AM, Saturday, October 8, 2005

Just as different phases in disaster remediation require different types of shelter relief, different climates demand different shelter design strategies. The current project focuses on the cold climate zone. In light of a recent major natural disaster, the October 8, 2005 earthquake in Asia, the northern mountainous regions of Pakistan (fig.3) is chosen as the general site for this project.

The 7.6 magnitude earthquake occurred in the northern region of the country, around the Pakistan-administered Kashmir area. The earthquake had an epicenter in the Muzaffarabad region, where it caused the heaviest damages and villages were destroyed in entirety (fig.4 & 5). The earthquake, the biggest since the country’s independence in 1947, killed at least 86,000 people, injured over 130,000, destroyed more than 200,000 buildings and severely damaged another 200,000, leaving more than 3.5 million homeless. The tremor was so sever that it was felt 200 miles away from the epicenter in both India and Afghanistan (fig.6). Unfortunately, the northern region of Pakistan lies within a zone of high seismic activity. (fig.7) As a result, the October 8th tremor would not be the last time the earth shakes around the
Figure 3. northern mountainous regions of Pakistan (source: Karakoram, p 49)

Figure 4. northern Pakistan earthquake, epicenter at Muzaffarabad (source: USGS)

Figure 5. devastation in urban areas of Muzaffarabad (source: Reuters)

Figure 6. October 8 earthquake intensity map (source: USGS)
region. Numerous aftershocks occurred on the same day and more than 1500 were recorded in the following three months. The subsequent rockfalls and landslides induced by rain claimed more lives and further exacerbated the grim situation.

More than two months after the disaster, the majority of the survivors were still dispossessed or living in inadequate shelters made from rubble, cloth, and wood sticks (fig. 8). The winter temperature of the region can plummet rapidly to a freezing minus 30 Celsius (-22 Fahrenheit), the tents that were housing those fortunate enough to receive them simply would not suffice, and many were unable to receive any aid due to their highland locations and inaccessible roads. Helicopters were enlisted to help the relief effort but the larger models that can carry the most items are not able to land in the mountains because of the lack of flat terrain. Many agencies ended up having to rely on smaller helicopters provided by the Pakistani military and more numerous trips that delayed the relief effort and increased cost. The downpour following the earthquake further hindered the relief effort via air to the highland areas. The situation was desperate based on strong evidence in virtually any article written on the subject in the newspaper since the earthquake occurred.

Now more than six months after the earthquake, as the time this document is being written, the situation remains dire, although the reason has taken a different turn (fig. 9). The winter, which was feared to kill a majority of those that were dispossessed, turned out to be not as severe as predicted. The survivors who were able to seek shelters in the scores of tent villages erected by numerous humanitarian aid agencies managed to endure perhaps their hardest season at the mercy of Mother Nature, but with the arrival of spring and better climatic conditions, the earthquake survivors are faced with homelessness again because many tent villages are beginning to close because aid agencies do not want people to develop dependency.

While the fate of those living in high mountains or locations inaccessible due to obstructed roads were unclear to begin with, now those who were able to be temporarily sheltered will join them to face the problem of rebuilding their homes. For clarity, I have categorized the earthquake survivors into two groups: (1) those...
who relocated to lower altitudes per the aid agencies’ recommendations, and (2) those who remain on or near their properties in the remote areas above snowlines in the mountains. The project addressed in this thesis was done to target the second group. However, the design of the shelter is also suitable for the first group as there was severe shortage of tents and with the arrival of spring this first group now is again facing with homelessness.

**Amid the Mountains**

The Islamic Republic of Pakistan is located in South Asia (fig.10). It is flanked by India on the east side, Afghanistan and Iran on the west, China at the north tip amid the Himalayas, and the Arabian Sea on the south. Pakistan has the sixth largest population in the world and is the second largest Muslim country. The nation is divided into 4 provinces (Baluchistan, Sind, Punjab, and North-West Frontier), two territories, Azad Kashmir and Northern Areas (with capital letters)(fig.11).19

The geography of the northern and southern part of Pakistan is very different. While the northern and western areas of the country are mountainous, the southern parts are much flatter. The northern part of Azad Kashmir and Northern Areas (fig.12) are especially hilly with colder and moister climate conditions as opposed to the warmer and desert-plateau climate in the south part of the country.20 (fig.13)

The northern Azad Kashmir region, where the October 8th earthquake occurred, is mostly rural with an urban to rural ratio of 12:87 and a population density of 252 persons per square kilometer, although the irrigated lands are mostly separated from populated lands, making this survey density not a very representative number. The livelihood in this region is primarily agriculture although tourism is on the steady rise and silk and carpet weaving is also a popular way of earning a living.21 The terraced fields and orchards feature wheat, barley, potatoes, apricots, apples, and mulberries. Rice, corn, and oilseeds are among the other principal crops.22 Irrigable lands are not exactly in scarcity but also not in abundance, therefore people tend to save
Figure 11. provinces of Pakistan (source: Mumtaz, inside cover)

Figure 12. the northern mountainous regions of Pakistan

Figure 13. topography of Pakistan
terraced farm lands in the mountains (source: Karakoram, p 53, 57)

Figure 14 & 15. The region is divided into two divisions: Muzaffarabad (north) and Mirpur (south). The divisions are further divided into seven districts and 18 sub-divisions. There are a total of about 1646 villages with a wide spectrum of populations in each. Some villages are not even known or marked on the maps due to their remote locations. Some villages are made up of members of the extended families, while others consist of many different families. Most families have around 7 members and typically also have some livestock such as buffalo, cattle, sheep, goat, and poultry.

Many residents in the most mountainous areas are also among the poorest population in Pakistan. Incidentally, they are also probably the most traditional population as well. Some of the families have lived in the same place for generations therefore have much sentimental attachment to the land. As a result, when their homes were destroyed in the earthquake, many chose to remain in the mountains near their properties instead of temporarily relocate to lower altitudes for the winter. One man was quoted as saying, “This is the only home I have ever known...if I am going to die, whether from an earthquake or from the cold, it should be here, in this place.” While many wealthier survivors moved in with their relatives or rented a place to stay for the winter in the cities, most mountain residents have no financial capabilities to move into the cities and no relatives to stay with. When it comes to choosing to stay on their land and moving to tent villages, many opted to stay. Furthermore, there is much debate of proprietary issues of land especially in the rural regions. An estimate of probably only half of the residents has physical documents validating their ownership of the land. Oftentimes ownership is substantiated by living on it. As a result, another reason that the survivors refuse to relocate to lower altitude is the fear to lose their land. Having to leave their livestock, one very important source of wealth and livelihood, also contributed to people’s reluctance to leave their homes in the mountains. According to a quick
survey done by the Pattan Development Organization approximately two weeks after the earthquake in Balakot, a town to the west of Muzaffarabad, 93% of the interviewees indicated that their own village is their preferred place of living during winters (fig.16).  

Figure 16. Survey of earthquake survivor's preferred living place in winter (source: Pattan Development Organization)
Piece No.2_Problem
As discussed in the previous section, transitional housing is not always necessary in every disaster mitigation operation. In the case of the Pakistan earthquake, however, the circumstance proves that alternative shelter options that fare better than tents are needed.

Tents are, inarguably, the best option out there for immediate distribution and deployment when the disaster first strikes. The advantages of tents are as follows:

1) **economical**: the tents are cheap to produce. A typical tent that houses around 5 people can cost as low as $40 and a larger winterized tent, as manufactured by a Lahore factory and distributed by Oxfam, cost only $140.

2) **transportable**: because the tents are largely made out of collapsible material, they can easily be shipped in large quantities by any land vehicles; where the areas are not reachable by land traffic, tents can sometimes be airlifted, although most airlift operations consist of food, water, and medicine.

3) **easy assembly**: tents are very easy to put together; at camps put up by disaster agencies hundreds of tents can be put up over the course of one day, provided that the tents themselves have arrived already.

These advantages make tent a formidable choice in terms of emergency shelter, when the need of housing relief is longer than a few weeks, as in the case of Pakistan earthquake, tents prove to be inadequate, not to mention that even at the emergency phase of disaster remediation, there were not enough tents to go around. By the end of the year 2005, more than two months after the disaster, estimated 480,000 tents have been distributed, 85-90% of the tents failed or proved lacking under inclement weather. It is unimaginable how people managed to survive the several long weeks without even the meager protection of tents.

In some extreme cases, the disaster victims would be better off without the tents altogether. One such case is in the extreme high altitudes in Pakistan. Some residents were given tents which were insufficient to combat the fierce winter. Because the
residents were given tents, they felt more strongly and confident about staying up in the mountains instead of heeding the recommendations of aid agencies to relocate to lower altitudes for the coldest period of winter. As a result, mortalities and illnesses occurred, which could have been prevented.\textsuperscript{43} But in addition, long term occupancy in an emergency shelter such as a tent that is meant for short term occupancy can pose the following problems:

1) \textbf{Safety:} The majority of the tents were put up in camps tended by aid agencies and governments. The people who occupy these tents are the displaced populations because oftentimes they have to leave their properties and live in close proximity with thousands of others (fig. 17 \& 18). Although guidelines and regulations have strongly recommend against “mega-camps” that house more than 5,000 people and suggest that “camps should be as close as possible to people’s own home locations, enabling clans to stay together and pre-existing social support networks to function”, in the case of Pakistan earthquake, this description is almost too ideal. While most people live in the mountains, most camps are at the feet of the mountains, in order to move into camps the earthquake victims are indirectly forced to relocate and become “displaced” and joint many other whom they do not know.\textsuperscript{44} In such circumstances, women and girls are at increased risk (fig.19). In the presence of chaos and large number of strangers, rapes and sexual violence can go unnoticed, and theft and other crimes are also not uncommon.\textsuperscript{45} The risk increased especially for unaccompanied women. A simple trip to the latrine could easily become tragedy as other displaced people with ill intentions can easily use the lack of lighting and overcrowded conditions of the camps to their advantage. It was also suspected that sex traffickers in the region also took advantage of the chaos and were responsible for missing female survivors.\textsuperscript{46} Without solid enclosures that not only present a figurative sense of security but also provide a literal sense of refuge, the disaster survivors are exposed to both natural and man-made elements. In emergency situations
where no other alternative is available, two weeks living in such condition may be bearable; but long term living in such condition is unacceptable.

2) Privacy: this is another issue that affects mostly women and girls; at tent camps, water sources, latrines, and sometimes cooking facilities are communal (fig.20) and a walking distance is required, in many cases this not only proves inconvenient but also makes the women and girls extremely uncomfortable to have to pass many other tents in order to use the latrine, wash clothes, or other daily tasks. It should be understood that this discomfort may not be imaginable to most westerners because these women and girls come from a "culture where they have never in their lives come in front of strange men." It is suspected that because of the exposure, some families wanted to marry their daughters off even when they are relatively young.\(^{47}\)

3) Weather: because the Pakistan earthquake happened at the onset of winter, the inappropriateness of long term use of tent is magnified. In addition to the fact that most of the tents are not winterized (fig.21), in early January after heavy snow fall and rain, some tents even collapsed. Those that survived have become wet due to the heavy rain, as evidenced in one survivor’s complaint, “Everything is wet. This is very difficult for me and my children. We can’t survive in this tent.”\(^{48}\) Tents collapsed because stakes were loosened as the earth become sodden with rain. It was reported that after their tents collapsed refugees had to seek even cruder shelter made from rubble.\(^{49}\) Furthermore, in cold climate disaster zones, such as the Pakistan earthquake, the majority of the tents are not winterized and they are heated solely through fuel. In order to keep the inside temperature within reasonable comfort, the heater has to be constantly on. In the long run this may pose a high cost. As a result, as stated by UNHCR, “tents are not suitable as cold climate shelters.”\(^{50}\)

4) Sanitation: in addition to more organized tent camps tended by aid agencies,
there are many "spontaneous camps", formed by survivors with tents, on land wherever it is available. Although the organized tents are in better condition than the spontaneous camps, both types of camps face sanitation issues as there is no formal sewage system installed for the camps. The high density of population exacerbates the situation. Although most residents of high altitudes also do not have formal sewage system, the fact that the population density is much lower, people live more spread out, makes sanitation less of an issue. Furthermore, because people live in the mountains, most of the time they utilized gravity to help take care of the sewage problem.

5) Cultural & Psychological Security: Although appearance in the case of emergency shelter seems to have minimal significance, the formal qualities of the design should, nevertheless, not be overlooked. One of the most overlooked faults of tents is the culture shock and post-traumatic stress they can induce. Tents do not assume vernacular architectural forms and, with their flimsy nature, hardly provide a safe or comfortable setting for victims to recuperate (in addition to the real danger explained previously). As explained by Dr. Unnikrishnan, Action Aid coordinator for quake response in Bangalore, “psychosocial and disability care are two issues that are neglected by a lot of agencies on the ground who may say they are not [about] life-saving so let’s do them later...there is no contradiction between psychosocial care and saving lives – they are not competing agendas.” In addition to counseling, the remediation effort should strive to make the environment as familiar to the survivors as possible, although this is understandably very difficult. Disaster survivors have just experienced a traumatic ordeal and the last thing they need is to be further uprooted from their typical way of life. As a result, it is advantageous to design shelters in coherence to the local style in order to restore a sense of stability and to better facilitate mental, and thereby physical, recovery.
These five issues show that tents, although an adequate short term solution, fall short when the disaster survivors need a shelter that will accommodate them for more than a few weeks as they rebuild their permanent homes. In the case of the Pakistan earthquake, there is a clear need of transitional housing, a niche that cannot be satisfied by tents. Currently there are several options available. These will be discussed in another section, but it is important to point out here that there are also problems attached to transitional shelters, especially when they are not designed or constructed properly. One such problem is that the transitional shelters tend to become permanent housings with ineffective or even dangerous “add-ons” by the residents themselves when the design of the shelter itself does not warrant these additions. Overtime, the buildings would prove insufficient and unsafe, living quality is not improved, and the projects for permanent housing become harder to complete.
Piece No.3_Precedents
The concept of transitional shelter is not a novel idea. Many shelters meant to be used for the transitional phase of disaster remediation have been suggested, some more suitable than others. Below is a detailed discussion of each of these precedents, their desirable qualities and shortcomings. It should be noted that the discussion is purely an educational one and is not meant to discredit any relief effort. It should also be noted that the list of different transitional shelters here is not an exhaustive list, but simply a sample of the different options out there.

Some of these precedents are meant to be permanent, not transitional, housing. However, because of the novel way of construction or material utilization, these examples can shed light on how a transitional shelter can be built and therefore are included here as well.

Shelter Homes

Developed by Muslim Hands, a UK registered international NGO, these shelters are built out of “reclaimed timber,” stones, and bricks salvaged from rubbles. Each house has 3 rooms and dimensions at around 30 ft x 10 ft (fig.24). The walls are made mostly out of stones and mud (fig.25). Each home costs 150 pounds or about $280 and can be built by people without construction expertise. The house also utilized other salvageable materials, such as door and windows (fig.26). This shelter model is not expensive to build and makes good use of recyclable material, although that very requirement may also hinder the construction process. Insulation is also another issue that might raise a concern. While both mud and stones are good thermal mass, they are poor insulators, especially stones. It is also unclear how well this model will hold up to seismic activities. But because it is local material, it does not deviate from the language of vernacular architecture and is very much culturally appropriate. For the same reason, this model is perhaps better suited as a permanent housing rather than a transitional shelter.54
This shelter model is developed by Pattan, an NGO that works specifically with the vulnerable population in the Punjab Province in Pakistan. The tip of Punjab province, like the northern regions, is deeply affected by the October 8th earthquake. The walls of this model are made of wood and cotton sticks bound by ropes and plastic sheets (fig.27). The roof is made of corrugated metal sheets for roof (fig.28). The structure can be erected in 2 hours by 4-5 people and requires no special skills and only minim tools such as spade, hammer, saw, and knife. The materials are easy to transport and the cost of such a shelter is also low, about $200. Architecturally it is acceptable in terms of resembling local form. However, there is serious doubt about the insulating qualities of this shelter, despite the fact that it can withstand typical snow and rain load.55

Habitat for Humanity & UN Habitat A-frame semi-permanent Houses

This model uses sand bags for walls and timber for roof frame that is covered by up to 16 galvanized iron sheets (fig.29). The shelter boasts 430-540 sq ft and has insulation in the form of straw-stuffed rice sacks held by strings underneath the roof panels (fig.30). The house is designed for at least one year of occupancy and is for both people and livestock. This model, unlike the others, takes care of the insulation issue. However, the form does not conform to those of the local architecture and is unclear how long it will take to construct one such shelter or how many people it would take to complete the job. The shelter material would be transported from a nearby Habitat resource but it is possible some sort of vehicular transportation would be required, especially to move the galvanized iron panels.56 Cal-Earth Institute, working from a design by architect Nader Khalili, is also building shelters using sandbags.57 Many of these beehive-looking shelters are already popping out on the map (fig.31). Construction time for these shelters are fairly short and the cost low.
However, the form and the fact that large amount of earth is required as well as special instruction, this technique is probably unsuitable for mountainous regions.

**Transitional Shelter Kits**

Concern, a humanitarian aid agency, provides a "transitional shelter kit" that includes CGI (corrugated galvanized iron) sheets, tools and cash. UNDP (United Nations Development Program) also provides similar kits to residents in the mountains. These kits have no specific layout for the transitional shelter. It is meant to be used such that each individual family can fashion some sort of enclosure with the sheets provided along with the rubble that they can move easily. The main concern for this kind of highly "indeterminate" shelter kit is again insulation (fig.32). The kit provided by USAID (United States Agency for International Development) is better in that it provides insulation and bedrolls in addition to CGI sheets and tools (fig.33). Relief International, an American charity organization, also provides a similar kit that costs around $425 to the villages in the mountains. However, because the kit still mainly consists of raw material, personnel with expertise are required to show the residents how to utilize the materials. Although this might slow down the process, especially in the case of far-apart villages and isolated residents who would not benefit from the rapid learning process that can take place in larger villages where people can build following others’ example.

**Barrel-vaulted winterized transitional shelter**

Designed by Catholic Relief Services (CRS), this model is made out of cloth-lined plastic sheet stretching over plastic tubes, basically an arched-shape tent that is intended to be used for one year (fig.34 & 35). These shelters cost around $400 and can be erected in about 2 hours. The materials are transported either via truck or helicopter delivery or by mules or on foot. The strategy is such that one model shelter would be erected by a CRS team and the earthquake survivors can follow the
construction method using the materials distributed by the organization. Although the shelter is sealed at the bottom and has double lining (cloth on plastic), the insulation quality of this combination is probably not sufficient to battle the cold brought by the alpine winter. However, plastic sheeting allows penetration of light during the day and also allows easy repair should the sheeting is damaged.62

**Framed transitional shelter**

Also designed by CRS, this model relied on a wood or steel frame with walls made of stone and brick. Metal sheeting forms the roof. This shelter also costs about $400 but will require an individual family two days to erect. The problem with this model is again the insulation. Stones and bricks are not insulators and can pose danger should they topple during aftershocks.63 Although this model is intended to be used for more than one year, unless it is further reinforced, it should not be occupied for a prolong period of time. CRS’s partner in aid, North American Jewish Community, are also helping to build this model to serve as a “core house” that can later be extended into a full permanent home.64

**Sheet Metal Transitional Shelter**

Greg Zaller, a builder from Northern California, initiated a transitional shelter building process in collaboration with Relief international and was able to finish around 100 homes in northern Pakistan. His houses measure 12’ x 12’ and include a small kitchen and bathroom. The shelter is made out of 6-foot wood framed panels that are milled locally as well as salvaged building materials. The walls themselves are made out of CGI sheets (fig.36). The roof is pitched and is mud-insulated. The shelter costs around $425 and can be erected in a few days with trained help (fig.37 & 38).65 Although this model doesn’t appear akin to traditional houses, it seems to be a better option than many other models mentioned previously because it does not resort to stone and rocks as building material, which poses serious seismic hazards. However, it is unclear how the walls are insulated. The CGI sheets alone would not be sufficient
to combat the cold climate in the mountains. Nevertheless, using CGI sheets as walls proves to be a popular way of constructing transitional shelters. Kashmir International Relief Fund (KIRF) is also building similar shelters above the snowline.\textsuperscript{66}

**Straw Bale Transitional Shelter**

More recently Zaller returned to Pakistan to construct straw bale houses, a hot topic itself in the States. These shelters are meant to be permanent houses rather than transitional shelters. Because the straw bale houses require a few more steps in construction, it takes longer to finish an individual home. However, the house only costs around $50. In addition to its extremely low cost, the shelter provides good insulation qualities.\textsuperscript{67} However, the problem here again is assembly; trained help is a requirement in order to finish the house, which is a potential setback to quickly erecting houses in different location simultaneously. It is also unclear if there will be enough straw around to construct houses for every family in any particular location.

**Foam Shelters**

A technique first tested by H.H. Haddock, a builder in Alaska, foam shelter takes advantage of the insulating qualities of expanded polystyrene (EPS), sandwiching the foam with sheets of cement board to produce regular size (4’x8’) wall panels that are structure and insulation all in one. This technique was perfected by the researchers at the Federation of American Scientists by reinforcing the panels with wire mesh and metal trusses (fig.39). Houses made out of such panels have already been built in Afghanistan, where winters are cold and wood supplies are hard to be found, situations that are a lot similar to that of northern Pakistan. The resultant house is earthquake resistant, costs about the same as building a permanent adobe house (traditional houses in Afghanistan) and can be erected in a third of the time.
it takes to build the traditional house (fig.40). Green Sandwich Technologies, a U.S. based building company, has also used similar technique to build houses in Pakistan in collaboration with Relief International (fig.41). These permanent shelters take 3-5 days to put together by trained personnel and cost around $1500. Besides the advantage of economical and rapid construction, this shelter model is fully and appropriately insulated and resembles local architecture. It is very possible that these permanent shelters can be put up very quickly therefore eliminating the need of transitional shelters altogether. The only problem is that because this building technique is targeted towards a complete and permanent house, there are construction details that need to be tended to by trained workers. Although the skills are not hard to master, the fact that a non-resident has to be present in order to demonstrate the construction and educate the locals adds to the time it requires to have these houses quickly and simultaneously erected. In addition, the panels, because they are sandwiched by cement or dense fiber boards, weight up to 150 pounds per 4’x8’ panel. This is on the heavy side of the allowable carrying load for two people transporting goods on foot. Most likely the material for building a foam home need to be trucked in. In case of impassable roads and precipitous high altitude locations, it would be difficult to deliver materials to destination. The issues of transportation and assembly can potentially prolong the time it requires to erect a single house. As a result, although the foam home is an excellent solution to building permanent housing, it is not quite ideal as a transitional shelter.

"Building in a Bag"

Two British engineers, Peter Brewin and William Crawford came up with a completely different approach to erect a transitional shelter – concrete canvas. The concrete building comes in a bag that weight about 500lb. After the bag is filled with water and inflated, a process that takes about 40 minutes, the building starts to take shape. After 12 hours of curing, the $2100 shelter, which boasts 172 sq ft, is ready to use for 10 years. This shelter was envisioned with a wide range of uses in mind, therefore
it is not particularly suitable for use in the northern mountainous region in Pakistan. The fact that it is made out of concrete and is of an egg-shell shape (fig.42) also makes it a less desirable candidate for cultural sensitive region. Nonetheless, this is such an ingenious idea that it should be included in any discussion of transitional shelter.

**Unifold Shelters**

This model developed by a company based in the U.S. is already widely used in many volunteer camps in New Orleans post Katrina. The shelter is made out of corrugated plastic panels that can be flattened when shipped. Upon arrive it can be folded out like an accordion. The corrugation the shelter is self-supporting and no elaborate assembly is required (fig.43). The individual units have holes cut out where AC and heaters can be inserted. This design clearly is not for the alpine climate. But like the Concrete Canvas, because of its merit – fast and easy deployment, albeit its geometry render vehicular transportation a must and the shelter has stability issue due to its ultra lightweight – this design should be included in discussion of transitional shelters.

**Paper Log Houses**

Designed by renowned architect, Shigeru Ban, these transitional shelters give about 200 sq ft of living space and cost around $2000(fig.44). The foundations of the shelter are either made out of rubble or sand bag filled beer crates. The walls are made out of thick paper tubes filled with sponges, wastepaper, cardboards, or plastic sheets. A Tarp usually makes up the roof. The original paper log houses were design to shelter the displaced population in Kobe after the earthquake. An improved design was used in Turkey and in India. With each iteration the design becomes more elaborate and incline toward permanent housing (fig.45).
"Recycled" shelter

Another novel design uses used phone books to build shelters. Developed by architecture students from Dalhousie University, a one-room shelter was built using 7,000 used phone books (fig.46). Although environmentally conscious, it is not clear how durable the phone books would be against cold mountainous conditions. The same team also utilizes donated billboards as tent coverings, (fig.47) idea that has also been done at MIT.

Global Village Shelters

This is a very well designed transitional shelter made out of triple corrugated laminate by a private company called Global Village Shelters. The shelter allows 67 sq ft of living space and has a pitched roof that is about 5 feet at the lowest point and 7.5 feet at the highest (fig.48). The total weight of the shelter is 170 lb and comes in individual pieces that are easy to assemble (can be done by 2 people in less than half an hour). The design takes into considerations of expandability, such that two shelters can be joined together. However, this shelter design is only suitable for tropical climates as there is no insulation material. Furthermore, because the form is rather foreign, it is perhaps not the best suited alternative in a more traditional environment such as in the mountains of Pakistan. Nonetheless, this design looks into many important aspects of transitional shelter, such as issues of transportation, assembly, and flexibility. Therefore it is a valuable precedent that can aid in future shelter design.
Piece No.4 Approach
Designing a shelter is a multidisciplinary task. Because a disaster relief shelter brings out the most primitive function of architecture – to protect occupants from natural elements, and because it is driven more strictly by structural feasibility, economical practicality, and material availability among many other things, the designing process of a shelter, in the barest of the word’s meaning, is quite different from designing, say, a museum. Nonetheless, much methodology used in the “typical” architectural design tasks can still be applied to shelter design process.

The overall methodology of designing the transitional shelters addressed in this thesis project is as followed:

1) define problem
2) define criteria
3) establish concept
4) define assumptions
5) categorize design components but develop each components simultaneously as each component is interdependent on the others
6) refine and improve designs

This section focuses on step two, defining criteria.

Define Problem

The problem, as discussed previously, is a pressing need for transitional shelter that will succeed tents and not only continue and better the service that tents have already delivered (such as fast and easy assembly), but also at the same time provide cultural familiarity, satisfy human needs, and more importantly, respect and respond readily to the often challenging environment.
Define Criteria

Because we all have a preconceived notion of what a tent looks like, we tend to think that disaster relief houses share a universal look. While the problem at hand does not have one single solution, the notion of a set of “universal solutions” is equally invalid. Ian Davis pointed out that universal solutions “have ignored the cultural issue altogether, or else assumed that people’s living pattern are more or less identical throughout the world.” Because people around the world do have distinctively different lifestyles, people should not be expected to be sheltered in the same way. Yet of course when time is the essence and there is no choice, a universal solution, such as tents, can help buy time until more appropriate shelter solutions arrives. It is these “more appropriate shelter solutions” that this thesis seeks to address.

To design shelters catered to a specific population requires identifying and refining a set of criteria that will finesse the “universal solutions” into “appropriate solutions”. The criteria generated for the transitional shelters addressed in this thesis are generated by a reiterative process in which a core set of shelter requisites established by trusted sources is qualified by more specific sets of requirements either found in published materials or collected from interviews with Pakistani in America or experts in the field of architecture who have worked in Pakistan. In addition, the precedents discussed in the previous section were revisited and their desirable qualities as well as shortcomings were considered in making the final set of criteria. In other words, the final design criteria for the transitional shelters in this thesis are a synthesis of multiple sets of guidelines that each caters to a specific condition applicable to the context of this project.

The Core Criteria
(degree criteria for ALL shelters, as specified by the UNHCR Emergency Handbook Notes on Shelter, edited for relevance)

1) shelter must provide protection from the elements, space to live (sleeping,
washing, and dressing) and store belongings, privacy and emotional security; blankets and clothing must be provided if necessary
2) the type of housing, material, and construction considerations will and should vary significantly in each disaster situations
3) housing (include shelter design, access to water and sanitary facilities) should be cultural and socially appropriate and familiar. Suitable local materials are best, if available
4) shelter must be suitable for the different seasons
5) wherever possible, people should build their own housing, with the necessary organizational and material support; this ensures that the housing will meet their particular needs, reduce their sense of dependence, and cut costs
6) an individual family should always be sheltered together as opposed to communal accommodations as it provides the necessary privacy, psychological comfort, emotional safety and a territorial claim for future security. It provides safety and security for people and possessions and helps to preserve or rebuild family unity
7) only if adequate quantities cannot be quickly obtained locally should emergency shelter material be brought into the country (should limit usage of prefabricated components)
8) The simplest structures are to be preferred. Materials should be environmentally benign or gathered in a sustainable manner
9) The design of shelter should if possible provide for modification by the occupants to suite their individual needs

A. The Climate-Specific Criteria
(design criteria for shelters in COLD CLIMATES, as specified by the UNHCR Emergency Handbook Notes on Shelter, The Sphere Project Handbook (an international collaboration of humanitarian NGOs and the Red Cross and the Red Crescent), p.219-224, and Transitional Settlement: Displaced Populations published by Oxfam Great Britain in
association with University of Cambridge Shelterproject, p.239-240, and Disaster Assistance Manual Volume I: Transition Housing for Victims of Disasters prepared by David Oakley for the Agency for International Development (AID) p.59, and Studies into Appropriate Clustered Housing for Karimabad, Northern Areas, Pakistan by Esa Khan, Masood Khan, John Myer, and Leslie Norford, edited for relevance)

1) shelters which are sufficient to withstand cold conditions have to be of a high standard and are complex and expensive to build
2) walls, roofs, doors, and windows should have wind protection, should be designed to retain as much heat as possible (comfortable interior temperature is 15-19°C)
3) should have insulated enclosed space and heating stoves
4) should have structural stability to withstand snow and wind loads
5) cooking and sanitary facilities should be protected
6) must protect human body from loss of heat especially during sleep
7) should have limited living space and no cold air leakage or draughts
8) minimum space of 4.5 m² to 5.5 m² per person including the kitchen and bathing facilities
9) lower floor to ceiling height is preferred to minimize the internal heated space
10) shelters should provide space for eating and cooking as in cold climates these activities cannot take place outdoors
11) proper ventilation for smoke generated from cooking and heating to maintain sanitary/healthy internal environment
12) the floor should be insulated (by using mats, mattresses or raised platforms) to minimize loss of body heat while sleeping on floor
13) the roof should also be insulated as heat can most readily leave from the roof
14) when possible a “thermal buffer zone” (fig 46) should be implemented and interior spaces should be divided into several smaller spaces
15) in mountainous/cold regions, there is a short swing between seasonal
temperatures and day-night temperatures; design is often influenced mostly by the extreme that lasts the longest in the year

16) height of shelter can be kept low (6’8”) to reduce heating requirement

17) efficient surface-to-volume ratio structure (Eskimo igloos are the most efficient but are not architecturally appropriate in most cases)

18) thermal resistance in all surfaces of the shelter should be about equal to prevent thermal leak

B. The Disaster-Specific Criteria


1) build on site that is as flat as possible
2) the plan should be as square as possible (length < 3x width)
3) should take on symmetrical geometry to minimize torsion effect (fig.47)
4) minimize large inertial stress by keeping buildings to minimal number of stories
5) keep the height of the room as low as possible
6) use light building materials, particularly in the roof
7) shelter should be designed for safe collapse and recovery of material
8) the building should be strongly secured to its foundation
9) anchor walls to foundation to prevent uplift
10) roof should be strongly tied down to prevent uplift
11) vertical supports (columns) should be similar height
12) strong connections should be made where walls meet, especially at corners
13) lateral load should be effectively transferred to the ground
   a. design should provide ample shear walls in both directions
   b. openings in walls should be kept to a maximum of 30% of the total area of wall
   c. unrestrained walls should be avoided
14) minimize wall degradation by loading wall axially and making walls thick enough and not too tall so as to prevent buckling
15) provide for some allowance in degradation in wall: judicious use of tensile material (wood or steel) in horizontal courses to build an alternative load path
16) complete earthquake resistance is nearly impossible to obtain in practice

C. The Cultural and Social-Specific Criteria
(Design criteria for shelters in the NORTHERN MOUNTAINOUS REGIONS OF PAKISTAN are derived from data gathered through interviews with Bushra Muhamood, Margaret H Myer, LICSW, Disaster Assistance Manual Volume I: Transition Housing for Victims of Disasters p.33, Architecture in Pakistan by Kamil Khan Mumtaz p.132-134, Karimabad Notebook: Studies into Appropriate Clustered Housing for Karimabad, Northern Areas, Pakistan, The Women and Children of Karimabad by Margaret H Myer, LICSW, World Housing Encyclopedia Report published by Earthquake Engineering Research Institute)

This group of criteria is difficult to define due to the fact that I was not able to personally collect field data. As a result, the criteria are defined through interviews with researchers who have been to the northern mountainous regions in Pakistan and published materials on vernacular architecture in Pakistan. The first part of this group of criteria is a description of the typical Pakistan homes in the northern mountainous regions and the typical household activities and customs.
The rural houses in Pakistan are said to possess “a powerful rustic simplicity.” The traditional homes in northern mountainous regions of Pakistan are generally small in size, Figure 48 shows typical variations of traditional houses. The houses ranging between 20'x20' to 30'x40' and typically accommodates one family with usually more than 6 members. There are typically less than five occupants in the house during the day, as male members leave the house to work, leaving the house to be occupied by only females and children. But at night the house can easily be occupied by 5 to 10 people. Figure 49 lists the average sizes of the typical spaces in a mountainous Pakistani home. Most of these spaces overlap one another, for example, a Ha is often used as the kitchen, eating, and sleeping space.

Each house typically has 1 bath/latrine facility. Those families who do not have a bathroom find it extremely inconvenient because they have to find cover, such as shrubs or large rocks, in order to relieve themselves. For a culture in which privacy, and especially a female’s privacy, is extremely important, not having a private bathroom presents a real problem.

### Construction

The houses are built out of stones with sparse wood framings and wood cribbing at the corners (fig. 50, 51, & 52). Because of their composition, the walls can be as thick as 3 feet (fig.53). However, because the main material for walls is stones and rocks, despite the thickness the walls provide very little insulation. Whatever thermal qualities the wall merit lie in the mud plaster that people often put on the interior and exterior of their homes.

Roofs are put together using long branches serving as beams and thatched with available dry vegetations and mud (fig 54). The roofs are also

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**Table:**

<table>
<thead>
<tr>
<th>Space</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ha (~ family room)</td>
<td>square, 18’x18’ or 19’x19’</td>
</tr>
<tr>
<td>Vestibule</td>
<td>5’x5’ or 4’x6’</td>
</tr>
<tr>
<td>Kitchen/eating/sleeping</td>
<td>10’x12’ or 10’x14’</td>
</tr>
<tr>
<td>Bath</td>
<td>5’x7’</td>
</tr>
</tbody>
</table>
Figure 50, 51, 52. traditionally constructed houses (source: Karakoram, p 193 & 131, and Jan Wampler)

Figure 53. vernacular house showing depth of wall (source: Karakoram, p 212)

Figure 54. traditional roof construction (source: Karakoram, p 262)

Figure 55 & 56. traditional roof use (source: Jan Wampler Karakoram, p 271)

Figure 57. typical use of Ha (source: Karakoram, 181)
very thick, typically 15-20 inches. This thickness, along with materials of better insulating qualities, made the roofs much more thermally acceptable than the walls when they are built properly and also sturdy enough for the family to use as an outdoor cooking and living space during warmer months. It is very common for people to dry apricots, a principal stable, on the roofs (fig.55 and fig.56). Even family livestock sometimes occupy the roof. The roofs are flat with a very slight, almost undetectable slope molded with mud to allow easy drainage of rain water. Apricot juice is used as a water sealant. The roof typically overhangs creating eaves all around the house.

Architectural Details and Family Activities

All homes center around the Ha, an equivalent to a western family room, where the majority of family activities take place (fig.57). The typical Ha usually has platforms around it for sleeping that rise about 8” high (fig.58). The floor is usually dirt covered by carpets. A family sleeps around the Ha in an organized fashion; the parents sleep on one side and the children sleep on the other. The Ha usually has a skylight through which people can access the roof via a ladder (fig.59). The opening can be covered with tarp or cloth when the weather is inclement (fig.60). The opening also serves as a ventilation outlet through which the smoke from cooking and heating can exit.

Because the cold winter seasons are generally long, the hearth becomes a crucial component of the house. It is considered, as noted by Mumtaz, “more than a necessity, it plays an almost ritual function in every peasant home.” The form of the hearth varies from the bare minimum shallow recess (fig.61) on the floor to highly decorative designs. Oftentimes people also have a clay molded tripod consisting of three columns that can serve as the support for pots (fig.62).

Traditionally a woman is not allowed to inherit land. Dealings with land,
such as irrigation and field making, are considered to be a man’s job alone and only he has the ability to manage such tasks. However, the matriarch of the family, usually the mother, or the grandmother if living with extended families, called *ruli gus*, because of her role as the principal caretaker of the family, has equal power in the family as the men. Her principal working space, the cooking space, should therefore remain in the central of the house to signify her position in the family. If the cooking space is cast aside to one corner, her position in the family is likely to become depreciated as well. The *Ha* is therefore the most important place in the house for women in the mountainous region, where there is no separate kitchen in the house and preparing, cooking, and rationing of food all happen around the *Ha* (fig.63 & fig.64).

One prominent feature of the houses in the mountains is the thick wooden door and window frames (fig.65). Although most of the time the rural houses are simple and sometimes even borderline bare, on some houses carving and decorative relief can be found on the frames (fig.66). Whether it is decorated or left bare, the frames introduce strong lines in the simple dwelling and are an architectural vocabulary in the vernacular houses in this particular region of Pakistan that should not be easily dismissed. Also note that the door height is relatively low, as shown in figure 67, and the threshold, or doorsill, is elevated such that one has to step across the door to enter the house instead of simply walk in (fig.68).

**Latrine**

The bathroom is usually in the courtyard and is considered to be an extremely private space. Anyone inside would be completely hidden and the access to the bathroom area should not be easily observed or even noticed. The lavatory system typically consists of a very deep dug hole surrounded by
stones. Families use both water and sand to “flush” the excrements. A stash of clean sand is usually kept in the bathroom.

The bathrooms are sometimes separate from the house, or are entered from outside the house to prevent the smell from permeating the living areas. However, the lavatory areas are usually placed on the slope so that to use gravity as a natural drainage. After a long time, if the depth of the hole has reached a certain level a new hole is dug.

Although some bathrooms are reported to be uncovered, most latrine accommodations should be enclosed as the harsh and long winters would prevent use of outdoor facilities.

Amenities

Precipitation is not a daily phenomenon in the northern region of the mountain, although downpours and heavy snowfalls are not atypical in the coldest months of the winter season. In fact, if there were no glacial springs (fig.69) serving as water source, the entire northern mountainous regions would be arid. The fact that many parts of the mountainous regions seem to be thriving with vegetation and crops (fig.70 and fig.71) in terraces is due to extensive, but rudimentary, irrigation systems established by the residents in the mountains. People dug channels to guide the glacial runoff into their terraced farmed lands and use large rocks to alternative water routes and share the resource. The same water is used for drinking, washing, cleaning, and cooking throughout the entire year. Families usually have their own reservoirs, where they store the water they drew from public channels, near their homes. Drinking water is kept in pouches and can be stored inside the house. In many places people collect water in jars and use the jars as a refrigerator because of the low temperature of the water.

Electricity is available in the more populated villages in the mountains;
Figure 68. raised threshold (source: Karakoram, p 101)

Figure 69. glacial spring in the mountains (source: Karakoram, p 59)

Figure 70. vegetations in the mountains (source: Karakoram, p 57)

Figure 71. terraced farmland in the mountains (source: Karakoram, p 53)

Figure 72. isolated village (source: Jan Wampler)
some even have satellite receptions. More sparse settlements and isolated residents in higher altitudes (fig.72), however, likely do not have access to electricity. In the slow and difficult progress of reconstruction, both aqueducts and electricity lines are likely to remain interrupted for a long time. Sanitation and clean drinking water were and still are major issues. In addition to broken aqueducts and conduits, the rivers are polluted due to landslides.78

Whatever wood supply people have in the mountains is used primarily as fuel. Occasionally they also use animal droppings or vegetative chaff. Residents who make trips to suburbs or cities to buy supplies and provisions may also purchase gas cylinders to use as fuel.

There is almost no transportation system to speak of. Roads are not paved and are typically narrow and precipitous. Most of the roads are for traveling on foot or with animals like donkeys that are used to transport goods (fig.73). Roads that are meant for vehicular traffic are usually poorly maintained and dangerous (fig.74 and fig.75). After the earthquake they become entirely unserviceable.

**Socioeconomic Status**

Families usually keep small herds of goats, sheep and cows to provide for milk and wool. The animals are usually housed in a *bier*, a structural that resembles a small barn. In the post-disaster situation where shelters for human are scarce, shelters for animals are even harder to come by. However, it should be noted that for the self-sufficient residents of mountainous regions in Pakistan, the animals are as important as humans. Without the food and clothing material provided by the animals it would be extremely difficult for human to survive. After the October 8th earthquake, many mountainous residents were forced to slaughter their animals as they cannot keep them as they relocate to the tent camps put organized by aid agencies. For these
residents, it is a tremendous loss of property that will pose great threat to the self-sufficiency of the families after the aid from humanitarians groups ceases.

Finally, the residents in the mountainous regions of Pakistan are among the poorest populations in Pakistan. They are also among those who still lead a very traditional way of life. Some families also lead very primitive lives, without electricity and running water or connection with the outside world. As a result, it might not be easy to introduce dwellings not built using traditional methods to these people. In any case, the exterior appearance of the finished transitional shelter should be carefully considered to emulate existing architecture.

Based on the above information, the cultural and social-specific criteria are as followed:

1) the shelter design should be such that the space where cooking and eating spaces will be central and women's domain should be reinforced
2) the design should accommodate bath/latrine facility
3) the entrance to latrine facility should be carefully considered in relation to front entrance of the shelter
4) the finished shelter should have similar appearance to existing houses in both forms and function
5) openings (windows, skylights, doors) should have proportion and location resembling those of existing houses
6) people should have tenure over the land they are planning to spend a significant amount of time on, otherwise people will be hesitant to contribute time or money to the reconstruction effort
D. The Logistical and Miscellaneous Criteria

(Design criteria for PRODUCTION IMPLEMENTATION, DISTRIBUTION, TRANSPORTATION, ADAPTABILITY, and LIFE CYCLE of the shelter, based on interviews, and inference from previous information)

1) individual shelter pieces are easily transportable by people on foot or by means of animals (such as donkeys); the pieces should be under 55 pounds if to be carried by one person, and 150 pounds if to be carried by two people; in either case, the pieces should be of a geometry that’s easy to carry by hand, on shoulders, or be strapped onto the back (references to Inca Trail porters regulations)

2) the shelter pieces should have a pre-life and an after-life, meaning that each shelter component should be able to be used as something else to reduce cost and material waste

3) the pieces should be able to be assembled with relative ease and/or rudimentary tools and equipment aid (e.g. ladder) by a single household in one day, this makes transporting and erecting the shelter within the time frame of two days; a single household of about 5-7 people (with perhaps only 3-5 able bodies) can obtain and put together the shelter within 2-3 days

4) the assembly sequence is easy enough that could be understood through simple graphic means or is self explanatory; the key is that the shelter kit can be put together without construction knowledge or expertise so an aid relief worker is not required to help guide the people in their shelter construction
Final Design Criteria

Taking considerations of all five sets of criteria each targeting a different aspect of transitional shelter, from deployment, design, to end use, as well as the five major problems about using tent as a long term shelter solution discussed in the previous section, a final set of design criteria is identified and listed by categories in the following pages. The criteria are organized in a check list fashion against which each stage of the transitional shelter design in this thesis is evaluated. Some criteria overlap criteria in another category because the nature of the requirement fits both. The criteria themselves are listed as a series of questions; this format will facilitate the evaluation of the designs. For each criterion, there is a range of how well the design satisfies that particular criterion: poorly (P), moderately (M), and successfully (S).
<table>
<thead>
<tr>
<th>Criteria Category</th>
<th>Criterion/Question</th>
<th>Degree of Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Climate-Specific</strong>&lt;br&gt;(cold mountainous, alpine steppe)</td>
<td>1. Does the shelter contain enclosed space for sleeping, eating, as well as bathing and cooking? (activities that need to take place indoors)</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>2. Is the shelter insulated against alpine temperature, and able to maintain a comfortable interior temperature (15-19°C), especially the roof?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>3. Does the shelter protect occupants from losing body heat during sleep? Is the floor insulated?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>4. Is the insulation material adjustable? Renewable?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>5. Is the insulation material part of the shelter? Or can the insulation material be obtained locally? For what cost?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>6. Does the shelter allow indoor heating/cooking?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>7. Does the shelter provide proper ventilations for smokes from cooking and heating to exit (without bringing in too much cold air)?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>8. Does the shelter prevent cold air leakage or draughts?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>9. Is the thermal resistance in all surfaces of the shelter about equal to prevent thermal leak?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>10. Is the floor to ceiling height minimized to reduce internal heated space?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>11. Is a thermal buffer zone present/possible to be added?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>12. Does the shelter have efficient surface-to-volume ratio?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>13. Can the shelter withstand snow loads of the alpine climate?</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>14. Does the shelter provide a minimum space of 4.5 m² to 5.5 m² per person including the kitchen and bathing facilities?</td>
<td>P</td>
</tr>
<tr>
<td>B. Disaster-Specific (earthquake)</td>
<td>1. Is the shelter of a symmetrical geometry to minimize torsion effect?</td>
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<td>2. Is the length of the shelter plan less than 3 times the width?</td>
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<td>3. Is the shelter made of light building materials, especially the roof?</td>
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<td>4. Are the walls light enough that if they fall no fatal damage would be done?</td>
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<td>5. Is the roof light enough that if it falls no fatal damage would be done?</td>
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<td>6. In summary, if the shelter collapses, will the occupants have a high chance of survival?</td>
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<td>7. If the shelter collapses, will the material be salvageable?</td>
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<td>8. Does the shelter have appropriate system against lateral load (earthquake)?</td>
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<td>9. Does the shelter have appropriate system to support snow load and its own weight?</td>
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<td>10. Is the roof securely fastened to the walls?</td>
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<td>11. Is the shelter secured to the ground?</td>
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<td>12. Are all vertical supports of similar height?</td>
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<td>13. Are there strong connections where the walls meet?</td>
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<td>14. Are the openings (windows and doors) in the walls less than 30% of the total area of wall?</td>
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<td>15. Is the shelter as a whole durable enough such that the walls won’t be easily broken, chipped, or otherwise damaged during the transitional period for up to 5 years?</td>
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<td>16. Are the walls loaded axially and thick enough and short enough to prevent buckling?</td>
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<td>17. Does the structure of the shelter include tensile material in the horizontal direction to build an alternative load path?</td>
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<td>C. Cultural &amp; Social Specific (border poverty line, self-sufficient farmers, traditional mountain dwellers in Pakistan)</td>
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<tr>
<td>1. Are the spaces arranged such that the women's quarter (cooking and rationing food) is a central part of the shelter?</td>
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<td>2. Does the inside space of the shelter serve similar functions to those of vernacular dwellings?</td>
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<td>3. Does the shelter include a bathroom?</td>
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<td>4. Is the entrance to the bathroom private?</td>
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<td>5. Do openings of the shelter (windows and doors) have similar proportion and location as those of vernacular dwellings?</td>
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<td>6. Does the overall exterior appearance resemble vernacular dwellings?</td>
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<td>7. Are architectural details (such as eaves, window and door frames, level change, etc) similar to those of vernacular houses?</td>
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<td>8. Does the shelter incorporate local and traditional materials?</td>
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<td>9. Or can the shelter be easily finished with traditional material (such as earth/mud) to obtain the appropriate appearance?</td>
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<td>10. Does the shelter allow people to build on top of land which they have tenure and allow individual family to stay together?</td>
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<td>11. Is the roof sturdy enough to be walked on? If not, will it at least be sturdy enough for storage and fruit drying?</td>
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<td>12. Does the design allow the shelter to be built by individual family alone without outside help and only minimal help from neighbors?</td>
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<tr>
<td>13. Does the shelter design allow modification by the occupants according to culture-specific, person-specific, and location-specific needs?</td>
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<table>
<thead>
<tr>
<th>D. Logistics and Miscellaneous</th>
<th>1. Can the shelter (either in whole or in components) be easily transported by a typical family of 6 or 7 on foot or by means of animals (such as mules or donkeys) within one or two days?</th>
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<tr>
<td></td>
<td>2. If the shelter is in components, are individual pieces under 55 lb if to be carried by one person, and 150 lb if to be carried by 2 people?</td>
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<td>3. Does the shelter require assembly? If so, can it be easily assembled by a typical family of 6 or 7, with perhaps only 3-4 adult able bodies and children who are old enough to help, without construction expertise?</td>
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<td>4. Does the assembly require tools? If so, are the tools the residents probably already have or can easily and economically obtained? Or do the required tools come with the shelter?</td>
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<td>5. Does the shelter include instructions on how to assemble and/or is the process self-explanatory and clear?</td>
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<td>6. If the shelter comes with written instructions, are the instructions represented in graphical forms, as can be understood universally?</td>
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<td>7. If the shelter comes in components, does each component have a pre-life such that the components are functional even in transit?</td>
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<td>8. Can the shelter be converted into a permanent house using economical materials or traditional building materials?</td>
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<td>9. If prefabricated can the shelter be manufactured in Pakistan? Near the mountainous region (such as at the foot of the mountains)?</td>
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<td>10. How does the cost of one shelter compare to the cost of a tent and other currently available options?</td>
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<td>11. Is the shelter material recyclable and environmentally responsible?</td>
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Piece No.5 Concept
The established criteria not only provide a set of parameters against which any transitional shelters for the northern mountainous regions of Pakistan can be evaluated, but also serve as the conceptual foundation and co-determinant of the form of the design. There are three principal concepts that dictate the design of the transitional shelters in this project:

1) modularity
2) versatility
3) sustainability

Modularity

The shelter should not be considered as an object in entirety, but rather as a kit of parts that can give rise to a number of different end products. Lego, the popular toy, is a perfect example of a kit-of-parts building system. The toy set comes with bricks of different sizes that one can make many different variations of walls, windows and doors to be placed anywhere in the wall, and roof components that one can choose among gable, hip, and other forms. Like the Lego pieces, the shelter pieces, or more accurately, modules, should be simple and easy enough for people to recognize their proposed function and to put together, while allowing them to assert some very fundamental architectural decisions, such as determining the size and orientation of the windows and doors, and even the size of the shelter itself, within certain limits.

The advantage behind a modular approach to design transitional shelters is that it allows rooms for user intervention and future modification and adaptation. The very essence of the design for transitional shelter is that it must be thought of in relations to what comes before and after the transitional state of disaster housing relief in order to effectively transition disaster survivors from states of chaos into
stabilized situations. Having the survivors take an active role in building their own shelters can facilitate the stabilizing and therefore the recovering process.

The transitional shelters in this project are based on a 5-part system: floor, corner, wall, frame (as in window and door frames), and roof (fig. 76). The individual pieces are connected via joint mechanisms and the entire shelter can be erected without typical construction hardware, such as screws or nails, or tools. The shelter is literally like a giant Lego model that is composed of interlocking components.

**Versatility**

The notion of shelter automatically places emphasis on practical issues such as manufacturing, distribution, assembly, and cost. All of these considerations call for multiple uses of the transitional shelter. The concept that the shelter, either in its entirety or in pieces should not only have more than one end use but also interim uses, is an important one in designing transitional shelters. Most shelters, emergency or transitional, are considered to be objects that have only one destined use - to shelter. In terms of material and transportation, approaching shelters as a single-function product is not very economical or efficient. The use of the shelter and its components can be multiplied if it is designed to be used in a variety of different ways. Although most current shelter solutions do not have such versatility, some of the materials used to make up these shelters are beginning to take up some of this property. Consider tarp that is used extensively in tents. The tarp acts as the wall, roof, and floor in a tent, but it can also act as a weather-proofing material in a damaged, but still habitable house. By bringing the tarp to remote regions, two solutions are being delivered: those who lost their house can use the tarp to make shelters while those who just need to repair their houses can use the tarp to fix their roofs. In short, the modules of the transitional shelter should be able to be used in more than one way. While the shelter in its entirety might serve a single purpose, its individual pieces should each be one object that delivers multiple services.

The transitional shelters in this project have components that can be used in 5
different ways: as shipping containers, as provisional walls (for transitional shelter),
as permanent walls, as insulation (for existing permanent walls), and as platforms
that can be used in the ha for sitting and sleeping (fig.77). The stages and scenarios
where these different functions of the shelter will materialize will be discussed in the
next section of this book.

**Sustainability**

This third concept is directly related to the previous one. By having versatile
uses, the shelter, either in entirety or in individual pieces, becomes more sustainable
in the sense that once the initial service of the shelter is no longer required, the
shelter can still be useful because it will simply be utilized in another way. This notion
of multiple functions in different stages is not limited to after the shelter has been
used as a protective covering; there can be a pre-life to the individual components of
the shelter such that the shelter is used from the moment it is manufactured. More
specifically, the shelter should be able to deliver service in transit; this is especially
important when non-indigenous materials need to be transported to disaster-affected
locations. If the shelter or its components are considered to be objects with a single
end use, it would be highly inefficient and uneconomical to transport it, which is a
serious concern regarding prefabricated shelters (discussed below). However, if the
shelter or its components can be used during transportation, it will cease to be a
dormant object whose function can only be activated once the object reaches its
destination; instead it can be continuously serviceable throughout its life cycle.

As mentioned previously, the modules of the transitional shelter in this project
can be used as shipping containers. Because the shelter delivers service in transit,
it can be manufactured virtually anywhere. Ideally transportation will no longer be
a strong limiting factor that drives up the cost and resources. By delivering service
in transit, the shelter (in pieces) is set up to have a wider circulation or distribution
chain and can involve participants beyond aid agencies (fig.78). For example, the
Figure 78. Map of service in transit
shelter module (as shipping containers) can be manufactured in North America and be used for a commercial business as packaging materials for medical supplies. An aid agency in North America buys the medical supplies from this business and reorganizes relief packages containing both the medical supplies and food. This aid agency then sends the packages, again in the shipping containers, to a major city in Pakistan such as Karachi, to be received by the aid agency there. Once received, this national aid agency can further reorganize and send off relief packages to regional and local aid agencies to be distributed to the disaster-affected areas. Every time the shelter modules will be used as shipping containers. Before the modules finally reach the affected population, they can again be used as shipping containers for aid agencies to distribute relief items to individual families. Essentially when each family walks away with a container of relief items, they also walk away with a piece of the transitional shelter. Once the family has all the required pieces together, they are ready to assemble a transitional shelter that they can call home while slowly reconstructing their permanent house. After the transitional phase has passed, the families have a choice to continue using the shelter, reinforcing it and making it into a permanent house, or disassembling it and utilizing the individual pieces for other purposes, or they can return the shelters to aid agencies to be used in future disaster relief situations.

Chronology

The three major concepts for the transitional shelters for the northern mountainous regions of Pakistan allow the shelter to transcend its state as a deliverable good with a single destined use to be an evolving piece whose utility changes as the location and circumstances change. The nature of such a shelter system calls for a closer look at how exactly the individual shelter or shelter modules will be used. Figure 79 is a flow chart that describes exactly how the transitional shelter is expected to be used in each scenario of the disaster housing relief. Figure 80 is a graphical summary of the chronology.
Figure 79. chronology (detailed version)
month 6- year 10

rubble on top of property is cleared / desire to incorporate shelter material into house reconstruction

rebuild original house with traditional/ salvageable material only using transitional shelter as a core/ habitable room

rebuild original house with traditional/ salvageable material only/ vacated transitional shelters can be coupled together and turned into a community structure

vacated transitional shelters are collected by aid agencies to be used in other disaster relief situations
Figure 80. chronology (graphical summary)
Prefab or Not Prefab?

So far the transitional shelter in this project has been envisioned as a prefabricated modular system. There is a huge question regarding prefabricated shelters in the field of disaster housing relief. Most guidelines recommend against using prefabs. In Disaster Assistance Manual Volume I: Transition Housing for Victims of Disasters prepared by David Oakley for the Agency for International Development (AID), a list of disadvantages of prefabricated shelters are noted by disaster victims who have been given such a shelter:"

1) not as economical as other forms of houses and at times more expensive than traditional houses
2) if built in mass may sport the danger of being uniform architecture
3) resale market is very restricted resulting in high number of abandoned houses after their services have passed
4) transportation cost, especially in rural regions, can be very high
5) occupants have no input and may be unsatisfied with the design

The reason that the transitional shelter addressed in this project remains a prefabricated system is because the shelters are designed specifically to mitigate, if not remedy, these problems. The fact that the transitional shelters in this project is imagined to deliver service in transit, address cultural sensitivity, encourage occupant participation, and allow flexible utilization before, during, and after the target transitional period, counteracts the disadvantages of prefabs. In fact, because the transitional shelter is imagined as a prefabricated system, it allows these concepts and criteria to be incorporated into the design of the shelter. As a result, prefabrication is the appropriate choice for the transitional shelter addressed in this project.
Piece No.6_Development
The design concepts established in the previous section, together with the criteria, set up the grand scheme of the design for the transitional shelter. The actual design itself, however, requires simultaneous development and investigations of 5 distinct but interdependent areas.

The 5 areas are:

1) cultural
2) joinery
3) material
4) thermal
5) structural

As stated in Disaster Assistance Manual: Transition Housing for Victims of Disasters, "in design work decisions, all are drawn on at one and the same time. A cultural attitude can influence building orientation or the choice of walling material. A structural choice for a core house may determine whether or not a family can safely extend using traditional materials they have readily on hand." Each section also includes the assumptions made for this project pertaining to that particular area where appropriate.

**Cultural**

Cultural aspect of the transitional shelter addressed here is a key distinction of this project. Most shelters do not pay much emphasis on cultural issues. Figures 81 and 82 show examples of transitional shelters provided by Oxfam in Pakistan, 1974, and by West German Red Cross at Nicaragua, respectively. These are failed attempts due to "cultural unacceptability of alien forms of housing." The design of the transitional shelters address in this thesis takes on a formal similarity to the vernacular architecture found in northern mountainous regions of Pakistan. As shown by the photographs presented in the Approach section, most traditional...
houses are rectilinear in shape and small in size. Because of the modular system of the transitional shelter, there are several possible configurations. For clarity, a typical configuration is used for most of the discussion to follow. Figure 83 shows a perspective rendering of the typical configuration. It should be noted that only the geometry is precise, the different colors are merely used to distinguish the different systems of modules (floor, corner, wall, frame, and roof). The dimensions of such a configuration are shown in figures 84 and 85 via plans and sections, which also illustrate the size and locations of the openings, as well as the partition. This configuration allows approximately 100 square feet of habitable space for a typical family in the region. Although this is severely under the recommended habitable space per person discussed in the Approach section, the existing permanent houses do not boast much bigger square footage, either. Therefore, the floor space of the transitional shelter here is considered to be an acceptable one.

The modular system of the shelter allows partitions of the space inside the shelter. Since the ha (equivalent to the family room) and the bathroom are considered to be the most important program in the traditional houses, the typical configuration has a larger space that serves as the ha, and a smaller space that serves as the lavatory. However, because the modular system of the shelter allows certain pieces to be interchanged, the shelter can be reconfigured to have spaces that serve different purposes and to have windows of two different sizes. Figure 86 shows how, by removing different pieces of wall (thereby creating openings for doors), the bathroom can be transformed into a vestibule. This flexibility made possible by the modular system is important as it allows the transitional shelter to be transformed into part of a permanent house later. For example, the smaller space can serve as the bathroom while the shelter remains a transitional house but can be changed into a vestibule when the occupants reconstruct their permanent house around the transitional shelter. Under the material segment of this section more details are provided regarding transforming the transitional shelter into a permanent house.

Because of the religion and customs, privacy is a very important issue. Where
Figure 85. sections

Figure 86. sample configurations showing different placement of doors and windows and space use
people enter the house, and especially the bathroom, is therefore not a trivial concern. Ideally the entrance to the bathroom should be strategically placed such that no one will catch plain sight of the person about to use the lavatory. The modularity of the transitional shelter allows the occupants to reposition the doors as they see fit. Figure 87 shows an initial design that configures the bathroom to be connected to the main habitable space at the corner and 2 possible layouts of entrances into the main space and the bathroom. This layout of bathroom and main habitable space is later altered to the current design, shown in figures 84 because the new layout conserves material better by having the bathroom and the main habitable space sharing a common wall. This is also more efficient from a thermal point of view. However, this change is at the expense of a more concealed entrance into the bathroom.

The flat roof of the transitional shelter features an opening in direct reference to the skylight found in almost every rural traditional house (fig.88). The significance of the skylight is two fold: ventilation and security of family structure. Because of the climatic condition in northern mountainous regions in Pakistan, people mostly cook inside. The smoke from cooking and heating needs an exit, and usually the small windows are not enough for this purpose. For this reason, directly below the skylight is usually where the cooking and heating occur. The fact that cooking and distributing food are the women’s principal jobs, by having the skylight in the center of the room, and therefore the cooking area in the center of the shelter, will help secure a woman’s place in her family, ensuring that her position remains a crucial one. By having the heating source in the middle of the room also helps to evenly warm the space and make the most out of the fuel.

In terms of architectural details, the transitional shelter also shares some similarities with the vernacular houses. The shelter has thick window and door frames which make up part of the architectural language found in the traditional homes. Because the walls are very thick, wide ledges around the windows are common in traditional homes. The frames of the transitional shelter are not only wide but also deep. In the final design the frame components slip over the window openings,
widening the window boundary and thereby creating a spacious ledge (fig.89). The roof of the shelter overhangs and creates an eave on all four sides, which is yet another feature found in the traditional homes. Although these eaves are typically much deeper than those on the transitional shelter.

In terms of coverings for the openings, a piece of cloth or tarp will be sufficient in the case of transitional shelter. Even in the traditional houses, many doors are “closed” by draping over a piece of cloth and the skylights are covered with a piece of tarp. The same can be done in the transitional shelter.

It is assumed that inhabitants of the mountainous regions do not have heavy reliance on electricity. In a post-disaster situation, it is assumed that no electricity is available in the transitional shelter. There is also no running water available in the shelter; inhabitants will draw water from glacial springs for daily use. In the case of water pollution from landslide, the survivors will have to rely on water provided by aid agencies. Because it is assumed that the electricity and water are either not prevalent in the targeted regions of this project and/or not available after a disaster, the design of the shelter did not take into consideration of where and how cables, ducts, and pipes will be incorporated.

From research and interviews, it is also assumed that no modern lavatory facilities are available or prevalent in the interested regions. Bathroom will therefore consist of an enclosed space and a hole in the floor/ground. This allows for a flexible dimension of bathroom as no fixture, such as toilet or bathtubs, is used.

**Joinery**

As mentioned earlier, the transitional shelter is a 5-part modular system. There are five different types of pieces that make up the shelter system: floor, corner, wall, frame, and roof. In the initial design, the shelter is made out of four elements (fig.90). The wall pieces were square in shape. The intention is to keep the pieces non-orientation specific such that a mere three different wall elements can compose
Figure 90. 4 elements that make up the wall system in the initial design

Figure 91. In the initial design, 5 different wall variations can be made from 3 different elements (a square, a rectangle, an L-shape); A: solid wall, B: wall with big horizontal window, C: wall with big vertical window (a door opening), D: wall with small horizontal window, and E: wall with small vertical window

Figure 92. Coupling of individual shelters in the initial design

Figure 93. (left) Final design consists of 3 wall modules between corner modules (right) initial design consists of 3 wall modules between corner modules

Figure 94. 2 window options in the final design: coupling of two wall modules gives one big window
different configurations of walls - solid walls, walls with windows, and walls with doors (fig.91). This initial design does present many problems, such that it breaks the shelter into too many pieces and the issue of joinery was not considered. It was unclear how the floor and the roof will be attached to the wall. However, this initial design does have the advantage of variety. Using the same four elements (three different wall pieces and one corner piece), one can construct shelters of different sizes with bathrooms, and allow families to share a common wall (fig.92).

In the final design, each wall is reduced to be made out of only three, instead of nine, pieces (fig.93). Although the rectangular, instead of square, geometry loses some adirectionality, the two sides (interior and exterior) of the pieces are still identical therefore interchangeable. The advantage of having a modular system is the variation of configurations it allows. Because the pieces in each system are identical or very similar, there is a lot of freedom to where the pieces can fit together. For example, there are two wall pieces with openings in them. They can be coupled together to give a big window, or they can be placed separately to create two smaller windows (fig.94). The door is basically the absence of one wall piece so its location can be decided by the occupants, allowing them to reconfigure the entrances as discussed in the previous section. This flexibility allows the expansion of the shelter at a later date. Because the modules of the shelter are “fit” together instead of permanently attached to one another, the configuration can be altered even after the shelter has been erected. The shelters can also be coupled such that two shelters share one common wall (fig.95). However, in order to do so, two special (non-standard) roof and floor modules would be required to “link” the two shelters together. This scenario is only necessary in the situation where the adjacent land to the destructed house is not available for survivors to erect the transitional shelter. (see diagram under chronology in the previous section) As a result, the survivors have to temporarily relocate to the outskirts of the village where space may be limited and must be conserved.

The modules in each system are connected via a universal joint mechanism.
- slide dovetail joint (fig.96). The joint is designed such that the pieces have to be put together by sliding up and down and pass one another. This ensures that the pieces are locked laterally and the freedom of movement is limited to one direction (a total of three directions of movement is possible). It should be noted that structural failure is not limited to this direction only. The structural aspect of the shelter design is discussed later in this section.

While the slide dovetail joint is the primary joint mechanism, there is a secondary joint mechanism – lock and key – to connect the individual pieces within the floor system and to tie the systems together. The roof and wall pieces are connected entirely via the slide dovetail joint. The wall pieces are also connected to the corner pieces via the same mechanism. The corner pieces essentially serve as posts with pieces of walls already attached to it. While the load of the transitional shelter is transferred through load-bearing walls, not a frame system, the corner pieces are erected before the wall pieces, setting up a skeleton to be filled subsequently by the wall pieces. The floor pieces, however, require the secondary joint mechanism to be put together. The main reason for this departure from a streamline universal joint mechanism is that the floor pieces are large in size, comparing to the wall pieces. The dimension of the floor pieces may hinder on foot or animal transportation through the precipitous mountain roads, therefore each floor piece is further broken into two pieces that are joined together via the secondary joint mechanism (fig.97). The roof pieces have the same dimension as the floor pieces in length and width and are 33% deeper. However, due to the structural nature of the roof, the roof pieces are not broken into two pieces joined via lock and key. Although this may create a transportation problem, the decision to keep the roof pieces intact allows a viable roof structure. The roof system and the floor system are connected to the wall system in the same way – through a channel/groove that snugly fits over the wall system, locking the walls in place and preventing them from moving in the horizontal direction (fig.98).

The overall joinery system sets up a specific sequence that must be followed
in order to put the shelter together with all parts securely interlocked with one another. Figure 99 shows the sequence of the assembly of a typical configuration of the transitional shelter. The assembly is clear enough such that the instruction can be conveyed through drawings alone, which is a valuable asset as literacy and lingual communication can be a potential barrier in the northern mountainous regions of Pakistan.

It is assumed that people build on terraces of flat lands in the mountains, therefore avoiding issues related to building on a slope. This is not an extreme assumption, as terraced lands in the mountains are very typical and are the principal ground where farming occurs. There is reasonable doubt that most people also live on terraced flat lands in the mountains.

**Material**

The transitional shelter is primarily designed to be portable by people on foot or by animals such as mules or donkeys. It is known that routes up into the mountains are narrow and at times quite precipitous and not passable via vehicular means, especially in post disaster situation. This restriction of transportation places a limit on the material the transitional shelter can be made of. Wood, although not an abundant natural resource in Pakistan, is overall an excellent building material in terms of strength and sustainability. However, wood is not a light material. Most other typical building materials, such as concrete, steel, and brick, are all not suitable for the construction of transitional shelter. Two materials have been considered for the transitional shelter in this project: plastic and expanded polystyrene (insulation foam). Their pros and cons are discussed below.

**Plastic**

There are many types of plastic. The specific kind, polycarbonate resin thermoplastic, more commonly known as Lexan, is especially suitable for the purposes
Figure 99. Assembly sequence of a typical configuration transitional shelter.
and intents of the transitional shelter. Lexan is the plastic that makes up the exterior of iPod and the popular water bottle Nalgene. Because it is easily moldable, it can be fabricated to take on the shape of the modules with the joint mechanism. Lexan specifically is a very durable and rigid material. It can withstand heat up to 150 °C without deformation and has high modulus of elasticity and tensile strength (compared to the other plastics). Because plastic is weather proof, easily maintained, and can be made into any color to imitate the color and texture of traditional buildings, it is a suitable material for the transitional shelter discussed in this project. Furthermore, as each individual piece of shelter module is also a container, rigid plastic like Lexan seems to be a reasonable choice. However, the downside of Lexan is the cost. A very rough calculation concludes that a transitional shelter of the typical configuration will cost about $3000. Although cost analysis is not the central part of this thesis, as this project is more of an intellectual exercise and exploration, it can be easily foreseen that although the material quality of rigid plastic makes Lexan a fairly good choice of material, it is not a realistic option. Another issue for plastic is weight. If the wall modules are made out of Lexan that is 1/8” thick, each individual wall module will weigh at least 50 lb. Although this is still an acceptable load to be carried on foot or via animals, it is at the upper limit.

Expanded Polystyrene (EPS)

Another possible candidate for material is expanded polystyrene, or EPS for short. EPS is the material that the foam house (see section Precedents) is made out of. Although in the case of foam house, developed and tested by Federation of American Scientist, the EPS is part of a sandwiched panel for a permanent house. There are several reasons why EPS has been considered to be a building material while plastic has not. EPS is an excellent insulation material. It is low-cost, moldable, and easily processed, as well as resistant to moisture. Furthermore, EPS is recyclable. Because of these properties, EPS is widely used as a packaging material, an application that will serve the container use of the shelter modules well. A rough calculation concludes
that a transitional shelter of the typical configuration will cost about $600. This is a significant drop of cost when compared to the same shelter made out of plastic. In addition, the same module that would weigh 50 lb in plastic would weigh only about 15-30 lb if made out of EPS, depending on the density of the foam.

Although EPS alone (without the sandwiching component of cement boards, as in the case of foam house) is not very strong, as a transitional shelter material it is an acceptable choice. In addition to cost and weight, there is another advantage of EPS that makes foam a slightly better choice – a transitional shelter made out of foam can be easily reinforced to become a permanent house. While the foam by itself may not last for years without breaking here and there, it can be easily reinforced with chicken wire and coated with plaster and mud to make a permanent wall. The insulating property of foam also allows the transitional shelter material to be recycled, sliced, and used as additive insulation inside traditional house, where stones are the primary material that offers meager insulating quality. Furthermore, because foam can be easily sculpted with a regular knife, a shelter floor made out foam can be easily cut away to create a hole for hearth or lavatory uses. However, it should be noted that anything made out of EPS should be coated with fire-retardant as the material is flammable. With most of the cooking taking place indoors, fire hazard is a major concern. Nevertheless, the versatility of foam, together with its low cost, makes it a slightly better choice of material for the transitional shelter design addressed in this project.

Strictly speaking, neither foam nor plastic is the ideal material as both have high embodied energy and use fossil fuel, an increasingly limiting resource, as the primary material. However, because of their moldability, weight, weather resistance, and the fact that the shelter modules have multiple uses, they were both considered to be acceptable candidate of prefabricated transitional housing material.
The orientation of the transitional shelter is important from a thermal point of view. The shelter should be south facing and the modular system allows reconfiguration of the shelter to accommodate sites that face any direction.

The main insulation material for the transitional shelter would be agricultural wastes such as wheat chaff (fig. 100). Although it is unclear how much wheat is produced in this region of Pakistan, and how much wheat chaff is saved and available for direct use upon arrivals of the shelter kit, it is assumed that there is enough wheat chaff or other agricultural wastes available to insulate the shelter modules for each needy family. This is not an exaggerated assumption as Pakistan is the 10th largest wheat straw producing country, generating 22,376,064 metric tons per year, and 13th largest rice straw producing country, generating 6,883,348 metric tons per year. There are also spring and winter wheat, which allows the supply of wheat to be available continuously. Although it is unknown if winter wheat is available in the northern mountainous regions of Pakistan, it is very possible that wheat chaff and other agricultural by-products will be available to be used as insulation. In addition, other vegetations, such as grass, can also be used as insulation. Currently in several self-help built schools in the northern regions of Pakistan, the roofs are already insulated with local grass. Both wheat chaff and grass can be obtained for free or very little charge. The cost of straw is also low, about 4 Rupees per kilogram.

Ideally the insulation materials should be insect and rodent resistant. The fact that the insulations are contained will ensure that rodents have no access. Furthermore, the pocket system allows the insulation to be taken out and therefore could be renewed on a periodic basis. Figure 101 shows a typical panel with pockets for insulation.

Because the shelter modules are already made out of an insulating material, expanded polystyrene, the insulating qualities of the shelter will be quite satisfactory. Figure 102 shows a table of the r-values of the different shelter modules when empty and when filled with wheat chaff. Although the total r-values of the different
**R-values (ft²Fh/BTU-in)**

- **EPS Modules alone: (2pcf type)**
  - Walls: 10-15
  - Roof: 15-20
  - Floor: 10-15

- **With wheat chaff insulation: (~0.8 R-value/inch)**
  - Walls: 13-18 (recommended 20-25)
  - Roof: 18-23 (recommended 40-50)
  - Floor: 13-18 (recommended 25)

**Figure 102.** R-values of shelter modules empty and with insulation compared to recommended values (source: http://www.eere.energy.gov/consumer/tips/insulation.html)

**Structural**

Because of its simple geometry, the transitional shelter is quite stable in terms of structure. The major and most important structural concern is whether the proposed design is able to take the lateral load caused by an earthquake. The earthquake load is determined to be 1/2 of the shelter weight.\(^7\) For a shelter of typical configuration, the total weight is about 4000 to 5000 lb. This weight estimate includes all shelter modules as well as the insulation material, but excludes occupants (which can add up to about 800 lb, depending on the number of occupants). Because the shelter is of a rectangular shape (not a square), there are therefore a strong and a weak axis. The weak axis is along the shorter side of the shelter. Because it is less in length it provides less resistance to the lateral force. The structural analysis, therefore, is done in reference to the weak axis. Figure 103 shows a perspective diagram of the respective forces. The lateral force is simplified into two point loads, around 1250 lb (an upper estimate to be safe) at each end. The result of this force leads to a moment of roughly 10,000 lb-ft, which breaks down to a tension force on one side and a compression force on the other side, each amount to about 1070 lb. The tension force is less of a concern as it just goes into the ground. However, the compression force will cause the walls to be lifted off and cause the shelter to collapse. The only other force that can counter it is the self weight of the shelter, which at this end amounts to about 750 lb. This is clearly not enough to balance the components of the shelter are still not high enough to meet the recommended values, the insulating quality is considered to be quite satisfactory for a transitional shelter and should prove to be adequate for the climatic demand. It should be noted that an average indoor temperature of 15-19 °C is considered appropriate for temporary housings such as the transitional shelter discussed here (see Approach section). Occupants can always wear multiple layers of clothing to keep warm. However, since the goal of the transitional shelter addressed here is to create a living environment as close to a permanent home as possible, a warmer indoor temperature is preferred.

**Figure 103.** Diagram of structural analysis showing the major forces.
upturning force. A solution to this problem is a mechanical joint system (in addition to the system previously described.) Figure 104 shows that by using a dowel (can be a twig found locally) inserted through both the corners (which is locked to the wall modules) and the floor and roof modules, the entire shelter is securely fastened. In addition, each floor module is staked down to the ground. However, in the face of lateral load, there are multiple ways this joint system can fail, for example through shear such that the dowel just slices through the floor or roof panels and fails to keep the floor, roof, and wall system together. To ensure this does not happen, the dowel should be inserted at least 3 inches from either edge of the floor and roof modules. However, the dowel itself need not be big. If using a twig, which has a high modulus of elasticity, the cross section of the dowel can be as small as just 1/4 square inch. Needless to say, this structural analysis is based on a myriad of assumptions and simplifications of the shelter. The actually structural performance would need to be evaluated via testing and simulations.

Figure 104. section view showing the dowels tying the wall system to the roof and floor systems
Piece No.7_Conclusion
Transitional shelter, despite the very essence of the term indicates that it is a much simpler entity than is a permanent building, is just as complex to design as any lasting structure. Because a shelter has the most pressing purpose to protect and shield its occupants from the outside elements than any other architectural entity, its practical aspect is equally important as, if not more important than, its architectural and aesthetic aspects. This thesis explored just exactly what a shelter, a transitional shelter in particular, needs to be. Although the original goal of the thesis was to produce a functional prototype of a transitional shelter, the project ended up being an investigation and a rigorous qualification of what an appropriate transitional shelter is in a particular context. It is in the process of trying to propose a specific transitional shelter for a specific situation that the need for a systematic way of designing and evaluating shelter is recognized. The end product is a set of design criteria that is catered to the particular context of this thesis, the October 8, 2005 Pakistan earthquake.

A design of transitional shelter is made based on this set of criteria and established methodology. The design, by all means, is not the solution, but is a possible solution. Below is the evaluation of this design against the criteria.
<table>
<thead>
<tr>
<th>Criteria Category</th>
<th>Criterion/Question</th>
<th>Degree of Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Climate-Specific</strong></td>
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<tr>
<td>(cold mountainous, alpine steppe)</td>
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<td></td>
</tr>
<tr>
<td>1.</td>
<td>Does the shelter contain enclosed space for sleeping, eating, as well as bathing and cooking? (activities that need to take place indoors)</td>
<td>x</td>
</tr>
<tr>
<td>2.</td>
<td>Is the shelter insulated against alpine temperature and able to maintain a comfortable interior temperature (15-19°C), especially the roof?</td>
<td>x</td>
</tr>
<tr>
<td>3.</td>
<td>Does the shelter protect occupants from losing body heat during sleep? Is the floor insulated?</td>
<td>x</td>
</tr>
<tr>
<td>4.</td>
<td>Is the insulation material adjustable? Renewable?</td>
<td>x</td>
</tr>
<tr>
<td>5.</td>
<td>Is the insulation material part of the shelter? Or can the insulation material be obtained locally? For what cost?</td>
<td>x</td>
</tr>
<tr>
<td>6.</td>
<td>Does the shelter allow indoor heating/cooking?</td>
<td>x</td>
</tr>
<tr>
<td>7.</td>
<td>Does the shelter provide proper ventilations for smoke from cooking and heating to exit (without bringing in too much cold air)?</td>
<td>x</td>
</tr>
<tr>
<td>8.</td>
<td>Does the shelter prevent cold air leakage or draughts?</td>
<td>x</td>
</tr>
<tr>
<td>9.</td>
<td>Is the thermal resistance in all surfaces of the shelter about equal to prevent thermal leak?</td>
<td>x</td>
</tr>
<tr>
<td>10.</td>
<td>Is the floor to ceiling height minimized to reduce internal heated space?</td>
<td>x</td>
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<tr>
<td>11.</td>
<td>Is a thermal buffer zone present/possible to be added?</td>
<td>x</td>
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<tr>
<td>12.</td>
<td>Does the shelter have efficient surface-to-volume ratio?</td>
<td>x</td>
</tr>
<tr>
<td>13.</td>
<td>Can the shelter withstand snow loads of the alpine climate?</td>
<td>x</td>
</tr>
<tr>
<td>14.</td>
<td>Does the shelter provide a minimum space of 4.5 m² to 5.5 m² per person including the kitchen and bathing facilities?</td>
<td>x</td>
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</table>
| B. Disaster-Specific  
(earthquake) |
<table>
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<tbody>
<tr>
<td>1. Is the shelter of a symmetrical geometry to minimize torsion effect?</td>
</tr>
<tr>
<td>2. Is the length of the shelter plan less than 3 times the width?</td>
</tr>
<tr>
<td>3. Is the shelter made of light building materials, especially the roof?</td>
</tr>
<tr>
<td>4. Are the walls light enough that if they fail no fatal damage would be done?</td>
</tr>
<tr>
<td>5. Is the roof light enough that if it fails no fatal damage would be done?</td>
</tr>
<tr>
<td>6. In summary, if the shelter collapses, will the occupants have a high chance of survival?</td>
</tr>
<tr>
<td>7. If the shelter collapses, will the material be salvageable?</td>
</tr>
<tr>
<td>8. Does the shelter have appropriate system against lateral load (earthquake)?</td>
</tr>
<tr>
<td>9. Does the shelter have appropriate system to support snow load and its own weight?</td>
</tr>
<tr>
<td>10. Is the roof securely fastened to the walls?</td>
</tr>
<tr>
<td>11. Is the shelter secured to the ground?</td>
</tr>
<tr>
<td>12. Are all vertical supports of similar height?</td>
</tr>
<tr>
<td>13. Are there strong connections where the walls meet?</td>
</tr>
<tr>
<td>14. Are the openings (windows and doors) in the walls less than 30% of the total area of wall?</td>
</tr>
<tr>
<td>15. Is the shelter as a whole durable enough such that the walls won't be easily broken, chipped, or otherwise damaged during the transitional period for up to 5 years?</td>
</tr>
<tr>
<td>16. Are the walls loaded axially and thick enough and short enough to prevent buckling?</td>
</tr>
<tr>
<td>17. Does the structure of the shelter include tensile material in the horizontal direction to build an alternative load path?</td>
</tr>
<tr>
<td>C. Cultural &amp; Social Specific (border poverty line, self-sufficient farmers, traditional mountain dwellers in Pakistan)</td>
</tr>
<tr>
<td>2. Does the inside space of the shelter serve similar functions to those of vernacular dwellings?</td>
</tr>
<tr>
<td>3. Does the shelter include a bathroom?</td>
</tr>
<tr>
<td>4. Is the entrance to the bathroom private?</td>
</tr>
<tr>
<td>5. Do openings of the shelter (windows and doors) have similar proportion and location as those of vernacular dwellings?</td>
</tr>
<tr>
<td>6. Does the overall exterior appearance resemble vernacular dwellings?</td>
</tr>
<tr>
<td>7. Are architectural details (such as eaves, window and door frames, level change, etc) similar to those of vernacular houses?</td>
</tr>
<tr>
<td>8. Does the shelter incorporate local and traditional materials?</td>
</tr>
<tr>
<td>9. Or can the shelter be easily finished with traditional material (such as earth/mud) to obtain the appropriate appearance?</td>
</tr>
<tr>
<td>10. Does the shelter allow people to build on top of land which they have tenure and allow individual family to stay together?</td>
</tr>
<tr>
<td>11. Is the roof sturdy enough to be walked on? If not, will it at least be sturdy enough for storage and fruit drying?</td>
</tr>
<tr>
<td>12. Does the design allow the shelter to be built by individual family alone without outside help and only minimal help from neighbors?</td>
</tr>
<tr>
<td>13. Does the shelter design allow modification by the occupants according to culture-specific, person-specific, and location-specific needs?</td>
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<tr>
<td><strong>D. Logistics and Miscellaneous</strong></td>
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Overall, the transitional shelter design meets most of the criteria quite well. However, this evaluation is only an estimated assessment as the shelter has not been produced and tested in the fields. There remains many issues, such as manufacture and fabrication, which were not explored or discussed at length in this thesis. Question such as “how are the shelter modules produced?” will have a significant impact on the success or failure of the design and is a problem that does not thwart the exploration and investigation of the current project but propels the groundwork established by this thesis to the next level.

Because shelter design is a complex problem not only in architecture, but also in material, structure, and planning, one cannot expect a huge leap of progress over the course of several months. In fact, the problem is an important one that deserves a lifetime investigation. This thesis has established one important preliminary tool to undertake such a task – a systematic set of design criteria, and has made an infant step to future transitional shelter investigations by using an established methodology that can be concretely evaluated and analytically improved.

With the increased frequency of large scale disasters, one can only expect the demand for viable shelter designs to rise. Every day is a potential fight with Nature and the disaster survivors are in a race against time. This thesis is only the beginning of a quest to improve people’s built environment in the face of the most formidable challenges.
Piece No.8_EndNote
Notes

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11 Kozyrev, 55.
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