



RESEARCH PAPER

**Rummage for a Sustainable Earthquake Resistant Structure
“Construction Techniques and Technologies” in Northern Areas of
Pakistan**

Mir Wali Shah ¹ Iftikhar Ali*² Ishtiaq Ahmad ³

1. Assistant Professor, Department of Architecture, Hazara University, KPK, Pakistan
2. Assistant Professor, Department of Architecture, Hazara University, KPK, Pakistan
3. Deputy Manager Architecture, Velosi, Integrity and safety, Islamabad, Pakistan

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***Corresponding
Author**
iashah54@gmail.
com

The research focus on comparative Analysis on the determination of emerging construction technology verses new improved form of indigenous construction techniques-technology. To rebuild confidence among the people it relies on traditions-culture by restoring pride in a new improved form of indigenous construction, using traditional techniques and materials, built-in safety factors that would result in safer buildings. Improved vernacular construction was explored to yield seismic resistant structures through survey, emphasis on the revitalization of the cultural identity of the community. Most techniques are modified or more developed forms of indigenous construction techniques and are already in practice. Paper describes practical solutions for new construction of buildings in the affected area after the earthquake October 8th, 2005 in Northern KP, Pakistan to make the sustainable building structures, resistant to the earthquake by using traditional techniques, local resources, and technologies which is environmentally friendly, socially adaptable for the communities and suggested guidelines for the buildings to be adopted in future.

Introduction

8th October 2005 earthquake has resulted in havoc, devastating entire infrastructure in northern, KPK-Pakistan at a magnitude of 7.6 & around 3.5 million people was displaced as well as approximately 400,153 houses were destroyed & damaged. Disasters directly strike human shelters which are the only protection for them against calamities. Rehabilitation and rebuilding these shelters in very limited time becomes one of the greatest challenges during these situations (Daly, 2016).

Different kinds of emergency shelters are introduced to the affected areas by the various public as well as private sector helping agencies without paying due attention to the specific climatic conditions of the region, socio-cultural norms of the inhabitants, and historically evolved architectural vocabulary of the context. Though most of these shelters are temporary, yet these last for a considerable period and leave long-lasting imprints on the directory of regions' architectural elements (Barenstein, 2015).

Northern areas Khyber Pakhtoon Khwa Pakistan possess a very strong architectural heritage adorned with both rich design patterns and effective building techniques. But, insane ethicist rehabilitative interventions resulting as aftermaths of a series of natural calamities frequently occurring after October 2005, have practically swallowed several rings from the evolving chain of the built environment. A wide range of indigenous construction materials is gradually being replaced with monotonous concrete blocks, context responsive organic building forms are substituted with typical cubic modules and climate-responsive roofing and fenestration systems are being dominated with standardized metal objects (Figure 1& 2).



Figure-1: Village in Siren Valley after Disaster



Figure-2: Village Hairpain before Disaster

Literature Review

The transformation of architectural structures in the affected areas is not the only depiction of a single type of architecture, but it is also the combination of mind percepts from different parts of the world being implemented according to the desired needs of that particular place, not necessarily conforming with the overall demands of the target society and its culture as well as heritage identity (Dudek, 2010). Human desire is one of the most important consideration factors before the design of a building which has relation with the past and present eras of available architectural vocabulary and paves a way towards the transformation of a new form of architecture amalgamated with many clues induced from one place to another to build a single unit. Such uncontrolled rapid transformations in the regional

architecture create a big gap between the lifestyle of inhabitants and the space where they live on one hand, and on the other hand, it also gives rise to socio-cultural and economic disparities within a single region.

The need for re-constructing and re-habilitating these affected communities as per their lifestyle based on cultural norms and traditions always remains a challenge for not only the local authorities but also for other international NGOs. Most of the time, such areas become experimental labs for testing fast construction technology that ranges from prefabricated structures or improved indigenous technology. Experiments have been done in providing emergency and permanent shelters of different materials with different construction techniques, which unfortunately over rid and vanished the lifestyle of the affected community {Davis, 2008 #6}. Architects, Engineers, and philanthropists across the country have tried to introduce an improved form of construction technology that offers resistance to natural calamities like earthquake, fire, and flood, structurally sound and thermally comfortable with different quality and specifications, using available techniques, at least in some cases, as per desires of the material provided or the donor organizations and belong to the personal inclinations and regional architecture of that very country from where the donor came.

Material and Methods

The objective of this analysis is to explore the most appropriate and practical solutions for the architectural design of buildings to assist the communities in the affected area. The investigation is primarily qualitative.

Population and Sample

Five villages were chosen for this study because of their unique character during the earthquake in 2008 (Table.1) and were reconstructed and built by donor organizations.

Instrumentation

Physical surveys, documenting of various technical components of building design, and on-site observation was chosen as study instruments for comparing the various approaches to house reconstruction.

Collection and Analysis of Data

The data was collected by visiting the five villages that were chosen. In the field, keeping track of the relevant technical details and documenting the data. The rest of the analysis is presented in tabular form in the findings and discussion sections, as can be seen here.

Results and Discussion

Villages for the Study

Table1
Selected Villages for the Study

No.	Village	Status
1	Kandi	Densely populated and heavily constructed village in the Valley
2	Kodar	Least populated in the Valley
3	Sacha(n) Kalan	Averagely populated village in the Valley
4	Jabbar	Has strong cultural influence and construction techniques
5	Hair Paina	Unaffected/ least affected village in the Valley

Most of the structures were built by the various donor organizations after the earthquake and it was difficult to cover each type of buildings in the limited period of this research. The research majorly focuses on the study of the residential units in the affected communities of the selected villages in Siren Valley. Different structures of houses were built by the national and international organizations most of which were constructed without considering the social values – one of the most important points to be considered – as the situation demanded to meet the required number of houses to protect inhabitants from the harsh climate.

Most of the people adopted the proposed design and technique of ERRA because it was a free-of-cost house yet not appropriate enough to protect people from the cold environment of the Valley. Some introduced effective insulating techniques of these structures but it was expensive. A traditional method of the Siren Valley was Dajjhii entirely ignored by the ERRA presenting a program to present permanent rehabilitation program for the affected communities. A typical two-room with a front veranda was the core design which could not cover the needs of the family structure and social values of the locality. Traditionally, two construction techniques were being used in the area, which had proved to be earthquake resistant. One was the *KotDhijji* method, and the other was *BahitterTarz-e-Tameer*(Figure 4).



Figure 4:(Left) Construction process of *KotDhijji* method using wooden diagonal bracings. (Right) *BahitterTarz-e-Tameer* with horizontal wooden elements

Table 2
Data from Selected Villages

Village	No of Houses	Houses Built by ERRA	Houses Built by NGO,S	Self-Built Houses	Most adopted structure
Kodar	73	20	30	23	Self-Built
Sacha-Kalan	100	65	25	10	ERRA
Hair-Pain	90	10	15	65	Self-Built
Kandi	250	200	40	10	ERRA
Jabbar	135	50	45	40	Self-Built

Among the selected villages, only Hair Paina was the least affected community. Almost 90% of the buildings in the village were safe and intact (Figure. 5)



Figure 5:A House in Hair Paina Immediately after 2005 Earthquake

Construction Techniques

Certain construction methods and materials gained popularity in the affected areas due to some reasons. In the following paragraphs, these techniques are discussed.

ERRA-NESPAK Technique

One of the most important and extremely popular techniques adopted in the affected areas was the ERRA-NESPAK construction technique. The technique was a modified shape of confined masonry usually executed using concrete blocks. RCC columns were used on the corners of the rooms after the rest of the walls had been erected to a certain height. Pouring of concrete after completing masonry to a certain level acted dual purpose: one to provide strength to the overall structure and the other to hold together the masonry and the structure columns (Figure 5 & 6)

There may be several reasons for the popularity of this technique but the most obvious and apprehensible is that the technique was completely sponsored by the ERRA. It was this construction technique that introduced hollow concrete blocks



Figure 5 & 6:ERRA-NESPAK Construction Technique Using Brick (Left) and Concrete Blocks (Right) in the area at a large scale and it became popular even in the subsequent self-made constructions.

Karavan Ghar

Karavan Ghar was based on the locally used technique Bahitter which was already being practiced in many villages of the Siren Valley. Wood, stone, lime, and 5% cement was used as the basic construction and binding materials in the construction. The technique was at the second level in the rank of popularity among the community (Figure 7).

KotDhajji Technique

This method was already in practice in the affected areas. This was a historically evolved construction method that was more stable and earthquake resistant. The method was based on the use of diagonal braces which added to the strength of the structure and also divided the walls into relatively smaller sections. In case of sudden collapse, such structures caused minimum damage to the lives of residents and other livestock (Figure 8).



Figure 7:Under Construction Building Showing Technique



Figure 8:KotDhajji Technique is thought to be the Safest among the Community

It was one of its kind studies based majorly on the meticulous study and profound analysis of the selected cases which culminated in the set of some very interesting findings. The study also helped in finding reasons behind certain recurrent strange phenomena related to alien construction materials and techniques. Answer to the question why people adopted different types of the structure after the earthquake can very easily be found in a few points given hereunder:

1. Most of the constructions were sponsored and free of cost
2. Materials were available easily and often provided on-site by the donors
3. Buildings were easy to construct
4. The time required to build was relatively short
5. Roof trusses and steel was ready to use without the assistance of any technical person
6. In some cases, prefabricated structures were to assemble on site without any complications

The study brought forward some interesting findings. It can be concluded that communities in the earthquake-affected areas were willingly or unwillingly made to follow a few construction techniques to be practiced in certain selected materials{Celani, 2012 #8}. Techniques introduced by various organizations which became popular among the community can be described as follows:

ERRA-NESPAK or Hollow Block Masonry Method

After the earthquake, ERRA and NESPAK jointly developed an earthquake-resistant construction technique, and a whole village of “Kandi” was reconstructed using this technique (Figure 9). The materials used were steel and concrete. The method derives its concept from the frame structure technique. Hollow concrete blocks are laid in cement sand mortar. RCC columns are used on the corners of the rooms. Vertical steel bars are also used at a regular distance in the walls. Walls so built resemble with shear (Figure 10).



Figure 3.1:Details of ERRA-NESPAK Construction Method

Table 3
Merits and Demerits of ERRA-NESPAK Technique

Merits	Demerits
It is a time-saving technique	The technique is expensive
The structure is based on international standards	Materials are not locally available
Joinery details are very simple	The product is not climate-responsive
The structure is lightweight	Roofing technique cannot withstand harsh winter climate
The overall form is earthquake resistant	The placement of rooms is extroverted
Plans meet the needs of users to some extent	Plans do not respect the socio-cultural environment of the locale

Karavan Ghar or Stone Masonry

Karavan Program Pakistan presented a model house for the rehabilitation of the affected community. The technique and materials used in the construction were not a new thing for the community (Figure 11 & 12).

The technique was based on the revival of locally evolved stone masonry technique, traditionally laid in mud mortar and also plastered with the mud for aesthetics, weatherproofing, and protecting the masonry joints from wiping away during the rainy season.



Figure 11 & 12: Karavan Ghar or Stone Masonry

Table 4
Negative and Positive Points of the Karavan Ghar/ Stone Masonry

Positive Points	Negative Points
The material used in the technique was indigenous and easily available usually without cost	Extraction and dressing of the stone used in construction was time-consuming
The structure was based on load-bearing walls	Wall thickness needed to be more than concrete blocks
Roofs were made up of GI sheets and were	Roofs were not climate-responsive

quick to fabricate

Form blended with the context

The structure was heavy and needed a finishing coat

KotDhajji Technique

The most famous and popular among the community was the traditionally evolved through millennia the KotDhajji technique. The technique is based on the concept of diagonal bracings between the courses of masonry. Space between the braces is filled up with rubble stone masonry (Figure 13). The technique is the most preferred and trusted among the community.



Figure 13:KotDhajji Technique

Table 5

Negative and Positive Points of the Karavan Ghar/ Stone Masonry

Advantages	Disadvantages
The technique utilizes local materials and is based on the rubble stone masonry	Extraction of stones and dressing for foundations is needed
Wooden braces are used to break down the wall into smaller segments which if collapse during earthquake do not cause major losses	If used immature, the wood may attract termites and other pests
In the rehabilitation process, roofs were constructed with GI sheets	Roofing systems do not withstand the severe climate of the region
Construction is cheaper and skilled labor is easily available	Construction is time-consuming

Recommendations

In the light of the findings and conclusions presented earlier, the researcher proposes the following suggestions:

1. After a decade from the day of the earthquake, it is high time to look back towards the historically evolved construction techniques based on indigenous materials.

2. The researcher is not against the adoption of good things from the techniques introduced in the area after the earthquake. It is suggested that concrete blocks may be customized to fit in the gaps between wooden braces used in the locally evolved KotDhajji techniques.
3. Roofing systems based on GI sheets and steel trusses are cost-effective, safer, and easier to fabricate. It is suggested that proper insulating techniques may be introduced to make this roofing system more environment-friendly and climate responsive.
4. Demolishing all structures which do not correspond with the socio-climatic needs of the community is not recommended. So, it is suggested that these structures may be transformed into more user-friendly houses through slight modifications instead of vandalism.
5. It is also suggested that all public sector buildings like schools and basic health units may be constructed using the KotDhajji technique executed in contemporary materials customized for the purpose. This would be a motivation for the community to blend the traditional techniques with the contemporary methods in a saner and thoughtful way.
6. After 15years of the earthquake the organizing system is suggested to establish the name of Disaster Risk Mitigation Centre in the Districts to study and find out sustainable construction techniques i.e. earthquake resistance, thermal comforts, low cost, locally constructed, traditional touch, and sustainable unit.

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