



## **STUDY ON CHANGE OF BUILDING STYLE AFTER EARTHQUAKE EVENTS**

### **Case Study: 2006 Borujerd Earthquake, IRAN**

Civil Engineering

Disaster Management

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#### **Abstract**

It has seen as a problematic issue following earthquake events, that reconstruction programs are associated with dramatic changes affects building styles of houses and other buildings. Changes affecting buildings usually occur because of changes affecting living style emerge after earthquake events. Some thinkers and researchers saw these changes as necessary phenomenon usually happens after any dramatic changes as earthquakes. Some look at these changes as problems may affect the affected regions as a whole and cause chaos.

This paper attempts to examine changes to houses buildings associated with the reconstruction programs aftermath the March 2006 Borujerd Earthquake, in Iran. Conducting a comparison study between changes in Borujerd some other cases such as Turkey, India and Kenya shows that some vital elements such as cultural issues should be considered with any changes to building style after earthquake events. Knowledge of native people can ease coping with side effects of such changes. Important factors such as technological development can help safer transformation from pre-modernization into pro-modernization era.

**Key words:** Building Change Modernization, Earthquake, Reconstruction, Borujerd

## 1. Introduction

As Iran is located on an earthquake prone area, many earthquake events happened during the last decades and many houses experienced severe destruction, and many reconstruction projects done following each hazard. Most reconstruction programs were associated with dramatic changes affected building styles. The changes usually influence building materials as well as construction techniques and architectural forms. Consequently, living style of survivors and their social relations usually change due to these physical changes. Some thinkers and planners take this situation as an opportunity to do what can be taken as delayed needs to do required changes, especially in developing countries and regions.

Needs for changes were significant between survivors were interviewed in earthquake stricken area at Lorestan Province, Iran in November 2010. Both local people and officials who were involved in the reconstruction program in province were happy with the results of the reconstruction process which caused dramatic changes to the region on physical as well as social sides.

The paper is based on a field study done on changes to building styles and social aspects, relatively. The most important question raised in this research is on how turn these changes to be successful rather than having negative outcomes? The main hypothesis in this research based on the speed of changes and preparedness for implementation with fully understanding by both people and authority. The paper is consisted of five parts which the first reflects theoretical works and international experiences. The second deals with research methodology and the research methods. The third part is presenting analytical works done on the data collected, while the fourth section tries to extract some concluding points. The final section contains some acknowledgement points.

## 2. Data and Material

This section is consisted of two parts; the first one deals with literature review of some theoretical works and international experiences as following. The cases reviewed are on experiences in Turkey, Kenya and India which compared in this study with experiences in Lorestan (the case study).

### **DINAR-TURKEY:**

Dinar (population 35,000 in 1990) is in a sparsely populated rural agricultural city center in the "Lake District" of southwestern Anatolia, Turkey. It was struck by an earthquake with magnitude 6.1 at Richter scale, in 1st October 1995.

The damage that it caused in residential areas was; 1,228 houses which were totally destroyed or heavily demolished, 990 houses were moderately damaged, and 1,558 received minor damages and at least 90 men, women, and children died in their houses or in public buildings. Over 250 people were injured. Before the earthquake, buildings in Dinar were with one to five stories.

Permanent post-disaster housing construction was finished one year after the earthquake disaster.

Two types of post-disaster houses were reconstructed, first type has 4 stories and 16 flats (Fig. 1) and Second type also has 4 stories, 4 shops in ground floor and 6 flats in upper floors totally. With the new urban master plan of Dinar, instead of narrow, disordered, spontaneously developed streets within one or two stories, solid or hollow brick walled buildings with large gardens; new formed wide streets and four stories buildings constructed by tunnel mould system with small gardens, were organized.



Fig. 1: Post Disaster Houses

In the context of the case study, these results were found throughout analysis on architectural design of post-disaster houses in rural and urban areas;

- Need of garden, according to family structure
- Living in an apartment, being citizen
- Use of semi-opened space
- Feature of building elevation and aesthetical appearance
- Building, garden and street relations
- Density of occupants in houses

Therefore, with the help of the case study held in Dinar district, we might easily understand the user background, requirements and preferences for suitable design of the post-disaster houses in rural and urban areas. (Enginoz, 2006)

### **KENYA:**

River Nzoia lies in the western region of Kenya and is well known with flooding in its lower reaches. The river floods frequently, annually. This is due to the large catchment area versus one river to empty the water into the lake. Floods appeared to be real hazards in Budalang'i since 1940s through 1950s. Flood disasters occurred in 1945, 1948, 1951, 1961 – 1962, 1975, 1977, 1978, 1997 – 1998 (El Nino rains), 2001, and 2002 (Mango, 2003). Lately floods have occurred in April and August, 2003. In this region people in Budalang'i traditionally live in grass-thatched roof, wood poles structure support the roof and mud walls. These materials are generally ideal for keeping houses cool since the area experience high temperatures and long sunny days due to its location on the equator. There are two construction techniques practiced in this area; houses constructed to resist damage by floodwater and those constructed temporarily. The materials of walls are mixture of ant-hill soils and soils collected at the construction site, the thatching of the roof with grass is done by tightly tying grass twigs against the strong wooden runners with tree barks or sisal.

When flooding occurs, mud walls usually demolished from the ground to an estimated level of floodwater to avoid damage by wetting the upper part of the wall by capillarity movement. In other cases, onsite wall materials are used for walling lower part of house, likely to be damaged by floods, while ant-hill and other imported soils are mixed with onsite soils before preparation of wall material for upper part of the wall, which is not likely to be damaged by the flood water.

The result shows that to identify indigenous knowledge can be very appropriate in the rehabilitation and reconstruction phase of the disaster cycle. Using indigenous techniques and materials in post-disaster houses lead to successfully reconstruction program. (Makhanu, 2006)

### INDIA:

When the tsunami of December 2004 hit the southern coast of India, small coastal fishing villages made up of mainly thatch huts were hit. Many of these villages were completely destroyed and lives were lost. Aid agencies stepped in to build new houses for these villagers according to the strict guidelines of the Indian Government. The houses were built by



concrete block or mud brick, but the resulting new villages were foreign in many ways to the beneficiaries in their materiality and layout. 109 houses from 7 villages in the Tamil Nadu area of south east India and their modifications within the houses were surveyed and the results analyzed.

Fig. 2: Houses with vernacular materials

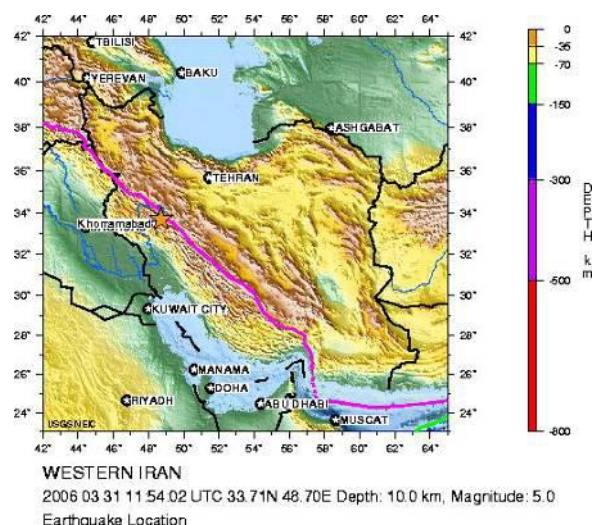
- Using vernacular materials with a feeling of sheltering;
- Using sheltering roof pattern;
- Providing shelter against the sun in tropical climate;
- Attention to climatic characteristic;
- Community involvement in the process of design and construction program.

(Russell, 2008). (Fig. 2)

### Lorestan Province:

On 30 and 31 March 2006, a series of earthquakes ranging from 2.8 to 6 on the Richter scale hit different locations of the southwestern province of Lorestan; the strongest ones hit Doroud and Borujerd districts (Fig. 3). According to government statistics, 72 people died, and 1418 were injured, while 320 villages were damaged (10-100%). Sixty villages were completely destroyed.

Nearly 15 000 buildings suffered damages of more than 50% in eight affected cities of Lorestan (Fig. 4) Some 33 000 units were destroyed or severely damaged in the affected



villages. It is estimated that around 12 000 domestic animals, the key source of people's livelihood, were killed.

Fig. 3: Earthquake location

The majority of the population in the affected villages is farmers or nomad animal breeders of low socioeconomic status with low hygienic and environmental sanitation standards (World Health Organization the Islamic Republic of Iran).

The case study in this research consisted of two villages, called Darbe-Astaneh and Babapashman, were totally destroyed by the earthquake because they were located on a most vulnerable area. For this reason, their people were moved to nearby safer place to build their houses there. A master plan for each village was prepared by the Housing Foundation (HF), institute



responsible for rebuilding houses destroyed by natural disasters in Iran. Single story houses were built by the survivors them self under technical and

Fig. 4: Lorestan province

Financial supervision of the HF. Traditionally,

They used to construct their houses in single story type because of environmental aspects. They used to keep their cattle underground avoiding cold wind as well as heating their house by the cattle warmth. The traditional roofs of the houses used to be built flat by heavy traditional materials as wood and mud. Locally available materials for building walls were stones and sun-dried bricks.

But the earthquake event in these two villages was taken as an opportunity to do changes towards modern building style and modern life. People interviewed in these two villages expressed their desire for development and accepted the HF master plan as well as the modern single type of houses' plan, implementing eagerly. The master plan for the villages were designed in a modern style differ from their traditional ones, while the houses design was done in a single pre-fabricated steel skeleton type (Fig.5).

The new designed villages provide easy access into the houses by car which made them very



happy. The houses design provides modern

life style for the families with open kitchen designed according to fashions available in urban houses in Iran (Fig.6).

Fig.5: Pre-fabricated steel frame houses

Fig.6: New houses design

All design works both providing the village master plans and their houses were eagerly accepted by the people seeking modern and urban life style.

People interviewed in these villages mentioned some problems occurred with mismatch between environmental aspects in the area and the modern houses, regarding heating and preventing wind. It seems that the traditional style at the old villages match environmental characteristics in a better way. Because the modern houses' design was insisting only on modern style, designers could not respect environmental issues.

A single modern design of all houses seems not satisfying all people who differ because of social structure of the community. One type houses could not reflect social differences between families there, so wealthier families attempted latter to use some expensive building materials added to their houses to show their social situation.

Modern village and houses have affected the families on socio-economic way. Building small houses, with 80 to 90 square meters area, on urban houses style prevent farmers from keeping animals in their houses, which was traditionally common before the earthquake event. So, most households were seen changing their jobs to matching their new houses and new villages' design.



Fig.7: Store of stuffs

But changes went further affect their behavior style at their houses. Traditionally they used to put a store just behind their kitchens to store some stuffs needed mainly for cooking. Now, their new houses designed without such stores. The main problem occurs when they could not find a space for storing such stuffs, and disorder appears with loading their things in their sitting rooms (Fig.7)

### 3. Research Methodology

Literature review of Turkey, Kenya and India experiences show that a qualitative approach was selected to be done. A data analysis was based on descriptive analyses. Data collection in this research was preformed by observation, in-depth interviews done with some key figures to some villagers and occupant of Borujerd's villages.

### 4. Results and Analysis

Reviewing data provided in the cases of Turkey, Kenya and India, there are some points of view gained same emphasis and importance. All emphasis was on change of construction style and interesting in modern life the case villages in Lorestan. The more important points are as following:

- New houses were designed without considering households' conditions and number of family members as well as their life style. A single pattern for house's design could not match all types of social structures in the region. These small houses were suitable only for households with 3-4 members, while the traditional families in the region are based on tribal structure that encourage more members. Changing houses to small scales was affecting the social relations in the area, dividing and separating families. This may match a modern life style, but rapid changes caused social disorders.
- Rigid design of a single type for all houses may speed up the reconstruction process, but it did not satisfy traditional people who used to live in whole living space with their special design.
- A single type of pre-fabricated houses could enable neither providers (HF) nor people to specify their houses from the others, by different design or elevation; so, after reconstruction terminated, most people attempted to change their houses elevation. Speeding up the reconstruction process was the main reason for this ignorance. But the people needed different appearance to their houses to express their social variety. One can see that these changes were done without consideration to architectural and beatification roles.
- Construction with the modern style could be done with respect to traditional building techniques and local materials. Innovation could be achieved with moderate changes, so living style could not be fully influenced.
- Participation of local labors in the reconstruction process of the houses could be taken as opportunity for moderate adaptation of modern construction styles to traditional culture of the region, avoiding any social disorder.

## 5. Conclusions

Doing the reconstruction process in the rural region affected by the earthquake in Lorestan, using pre-fabricated steel frameworks was dramatic change in a traditional and tribal-based community in the region. This caused total ignorance to traditional construction techniques and building materials. Speeding up the construction process may be true and useful in an earthquake stricken area, but the outcome should suit the long time life of the community. So, a modern construction style should not affect the long term life of the people in a negative way. It also may be true that a modern pre-fabricated steel framework could be more resistance and can sustain expected earthquake destruction, but it should also suit the continuance of the traditional life of the native people who used to live so for thousands of years. Change should be done in a moderate way, avoiding shocks may occur because of rapid reconstruction.

Environmental aspects are very important to be considered in a reconstruction process after earthquake or any natural hazard. Local building materials were been used in the region for a long time, and they were adapted with the region ecology. Changes to construction styles to match with modern life, should not ignore environmental issues.

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