5th SASTech
Iran |Mashhad
May 12 - 17 | 2011
5th Symposium on Advances in Science & Technology

Examining Possibility of Building Temporary Shelters after Disasters Using BAMBOO Technology in IRAN

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Paper Reference Number: **0802-1075**
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Abstract

Providing temporary shelters for survivors has been a problematic issue after earthquake events in the world, including Iran. Some time, using tents is not compatible with climate conditions. Some time using pre-fabricated containers to be used as temporary houses is indicated a very expensive way. Some global new experiences show that using Bamboo technology has been dramatically expanded and became popular in many countries such as China, India, Pakistan, Indonesia, Brazil and some other countries. Some Bamboo special characteristics such as its flexibility can enable it to be used as main building materials for providing shelters in short times after disasters.

This paper attempts to examine possibilities of using Bamboo technology in Iran at recovery and reconstruction programs. Using wooden building materials in "Guilan" province after the "Manjil" earthquake of 1990, on the base of the local building technology of "Zegali" was indicated as a successful experience by researchers then. A comparison study has been conducted in this regard comparing between "Zegali" local technology and the technology of Bamboo.

The results of the study which is presented in this paper indicate that local knowledge on building shelters using wooden materials could help technology transformation of Bamboo technology to Iran in a short time.

Key words: Building Technology, Bamboo, Earthquake, Reconstruction, Iran

1. Introduction

Nowadays natural and human-induced disasters destroy millions of buildings and infrastructure components that need reconstruction. There are many objectives that have impact on approaching better reconstruction after disaster such as an earthquake.
Each disaster may cause many fatalities, injuries and of course destroyed constructions.
Many operations could be done in order to improve the reconstruction methods and also reduce the number of homeless and rate of collapsed buildings and debris, by considering all effective items such as choosing appropriate materials, using building standards, and so on.

Iran's Earthquakes:

Iran, one of the most seismic countries of the world, is situated over the Himalayan-Alpied seismic belt, and has experienced many catastrophic earthquakes in the past, some of which are "Tabas" earthquake 1978 (18,000 deaths), "Manjil" earthquake 1990 (40,000 deaths), Bam earthquake 2003 (40,000 deaths), and "Dahoeieh-Zarand" earthquake 2005 (650 deaths).Most of the casualties took place in the rural regions showing the necessity of investigation of retrofitting methods for these houses. (Mousavi, E., Khosravifar, S. E. (2006). *Structural Typology of Traditional Houses in Iran Based on Their Seismic Behavior).*

One of the most important features of Iran plate is young tectonic movements. In Iran region faults movements do not have a logic process. In many regions especially in "ALBORZ" region horizontal movements can be observed along the faults in addition to vertical movements which are a reason for turbulent deformations. The best type of these deformations in central "ALBORZ" region has become apparent after 1990 "Manjil – Rudbar" earthquake. This paper presents probabilistic horizontal seismic hazard assessment of "Gilan" province.(Ghodrati Amiri & Razavian Amrei, 2008, *Seismic Hazard Assessment of GILAN Province* Including MANJIL in IRAN).

MANJIL Earthquake:

"Manjil" is a town in "Gilan" province in Iran. It has experienced one of the largest earthquakes in Iran on 21 June 1990 with magnitude of Ms = 7.7 Richter that caused many destructions and human casualties. With respect to historical earthquakes in the region of "Gilan" province and existing active faults like "Manjil-Rudbar" and also according to the distribution of earthquakes, this region has high seismic potential.
The "Manjil-Rudbar" Earthquake caused widespread damage in areas within a one hundred kilometer radius of the epicenter near the City of Rasht and about two hundred kilometers northwest of Tehran.
The cities of Rudbar, Manjil, and Lushan and 700 villages were destroyed, and over three hundred villages were affected.100,000 adobe houses sustained major damage or collapsed

resulting in forty thousand fatalities, and sixty thousand injured.500,000 people were left homeless.(WIKI PEDIA Website).

In this article more emphasis is on choosing types of materials and construction methods and of course considering and analyzing the effective items that may lead to choose a proper one.
Different materials and methods of construction are used in structural elements of rural houses. This variety is influenced by climate and availability of materials. It is noticeable that villagers used to employ local materials to build the elements of their houses such as walls, roofs, foundations, columns and etc. To investigate the seismic behavior of these houses it is necessary to study the specifications of these elements.

First of all a careful assessment must be made of available building materials. Not only must they be easily available, affordable, and of sufficient quality for hazard-proof construction, but also acceptable to the local community.

In this paper, studying the "Manjil-Rudbar" earthquake and analyzing "Zigali" as an indigenous material of this province, and concluding that "zigali" is a appropriate material for this region and also comparing bamboo with "ziagali", surveying some objectives that could be helpful and may lead to get better building constructions by improving building techniques, and also helping from new techniques that make bamboo unique material.

2. Data and Material

Earthquake that hit surrounding Yogyakarta in May 27th 2006 caused devastation of housing, Public-buildings and infrastructures. There are several alternatives of building reconstruction for housing and public building by using bamboo material. Bamboo construction can be use to construct even temporary, semi-permanent, or permanent housing/building. After this disaster people are getting aware with bamboo construction and they are belief that bamboo is an earthquake resist housing material. This condition is also ensuring some communities to build their housing using bamboo construction. These alternatives give us several possibilities to design the bamboo building construction and give people impression of the bamboo construction. Some bamboo building designers also give alternates for using bamboo as temporary or semi permanent building construction, but other bamboo building designer still worry to try to make bamboo construction as permanent bamboo building construction. Actually the designers are capable to make permanent bamboo building construction by using modern preservation techniques for bamboo material and developed bamboo construction. This should be followed by producing a national standard for bamboo building construction.
After earthquake hit surrounding Yogyakarta it was found that bamboo houses or buildings are still standup without any physical damages. This phenomenon is also giving a signal to the people that these houses can be classified as earthquake resistant houses. People in this area have a local wisdom, and technology to build own bamboo houses before they removed them into masonry house. They found that their masonry houses were collapse after the earthquake hit Yogyakarta on May 27, 2006. People and Housing/building designers then find out some alternative house/building material as a temporary shelter or semi permanent building. They still do not know that bamboo can also be used as permanent

housing/building material. (Mardjono**,** F. *Bamboo construction on the building after earthquake disaster in Yogyakarta.* Gadjah Mada University. Yogyakarta).

Building with bamboo looks back on an ancient tradition in the regions in which plant grows in abundance, such as South America, Africa and, in particular, in South-East-Asia. Bamboo is one of the oldest construction materials.There are several alternatives of building reconstruction for housing and public building by using bamboo material.

Unfortunately, bamboo is kind of unfamiliar materials in Iran, but the positive point is that the soil of north of Iran (coast of Caspian sea, especially "Gilan" province) has the potential for growing this plant, and It is hoped to make it more familiar as popular earthquake-resist materials in rural places of Iran.

Researches show that bamboo is a kind of resistant structural material. Especially about some species that are found in "Thailand", and comparing with steel implicates about bamboos more tensile strength than steel.

It is apparent that, Properties that make bamboo as an appropriate engineering material besides its tensile strength, the compressive strength, shear and also bending strength is more considerable.

Considering the strength combined with lightness and also flexibility of bamboo, this plant is defined as one of the earthquake resist building materials. In the 1992 earthquake with 7.6 on Richter scale/magnitudes in "Costa Rica" the wooden houses made with bamboo were more flexible and of course weren't destroyed any more. Although bamboo is a delicate and light one, but the quality that makes it more noticeable, is its fire resistance.

Bamboo is used for making low cost housing in many regions. However, wall and roof Elements made of simple bamboo mat do not last long due to their poor strength against Static as well as impact loads and durability. Also use of cement-sand mortar panels with bamboo as reinforcing material could be suggested.
The recent phenomenal rise of prize of building materials and construction costs Have stood in the way of providing cheap houses for millions of people. Best way of making A low cost house is to make best use of locally available material. (Prasad, J., Pandey, B.S., Ahuja, R. (2005). *Low Cost Housing for Hilly Regions Using Locally Available Material.)*

Experiences of other countries such as America and Japan shows that, wooden houses are more suitable for disaster prone areas when if the connections are more convenient. And also the statistics destruction reports of, the "Manjil-Rudbar" earthquake on the 20th June 1990, has proven that, living in wooden houses is more secure than other types of houses such as (brick ,stone, adobe, and, ...).

Cause of dense forests of "Gilan" province, and also easy access to wood, makes it as a low cost and ingenious building material. These conditions provide an opportunity to officials to expand the construction of wooden houses in this region, as affordable and accessible ones.

Familiar materials in Gilan province and the structural uses:

Wooden Flat Roofs:

These roofs are the traditional format of joist roofs using wooden beams instead of Reinforced concrete or steel beams. Gravitational load of the roof is transmitted to the walls through wooden beams which are embedded in adobe or stone walls and usually no longitudinal or transverse anchorage is observed. Wooden beams are covered with branches of trees, earth and mud and finally coated with mud-straw that works as an insulator. Wooden flat roofs are common in cold and mountainous regions such as Azerbaijan, North of Khorasanand Fars provinces and in general in those parts of Iran that construction Wood like aspen trees is available.

Wooden Inclined Roofs

This type of roofs is mainly found in the Caspian Coast provinces, Gilan, Mazandaran and Golestan with high annual precipitation. The structure of these roofs is a wooden truss That is covered with mission tile, galvanized iron, "azbest" or that. These roofs are relatively light and therefore less vulnerable to seismic loads. Wooden elements are connected to each other with nails with poor workmanship.

Wooden Walls

These walls are mainly found in the Caspian Coast area where wood is easily accessible. In these walls, after erecting wooden columns (10 to 20 cm diameters) some skew or horizontal timbers (5 to 15 cm diameters) are positioned between columns and then the space among timbers is filled with mud and finally coated with mud-straw. The local name of these walls is "Zegali" or "Zogmei".

These structures have shown a good behavior in past earthquakes (e.g. Manjil 1990), That seems to be due to their light weight and skew elements that transfer seismic loads.

The ZIGALI structure is the wooden structure. Vertical lumbers are knocked to the lumbers of the foundation or under stone walls to provide walls and floor. Wooden columns are erected (with a space of one meter with each other), and installed on the beams of the foundation or stone walls and with the upper beam make a frame from the room. The space between the columns is covered with twinges in diagonal and counter directions. This increases the stability of the building against lateral forces. Vertical poles are installed on the horizontal cradles of the walls to make the roof completed by setting up the sloping ceiling truss. Finally, the crevices among the twinges of the walls are covered with cob, mud and kind of white soil for decoration.

Temporary housing and primary expansion:

After rudbar-manjil earthquake, because of the appropriate performance of Zigali structure against earthquakes, this structure was selected by the authorities for temporary shelter and survivors welcomed it. There for after the earthquake, temporary shelters were built using the native structure "Zigali", which later expand to permanent houses of the rural.

In the temporary sheltering stage, survivors set up temporary wooden shelters in small distance (30 to 50 cm) from the ground. These rooms were 3*4 meters with a veranda in front of them covered with sloping roofs.

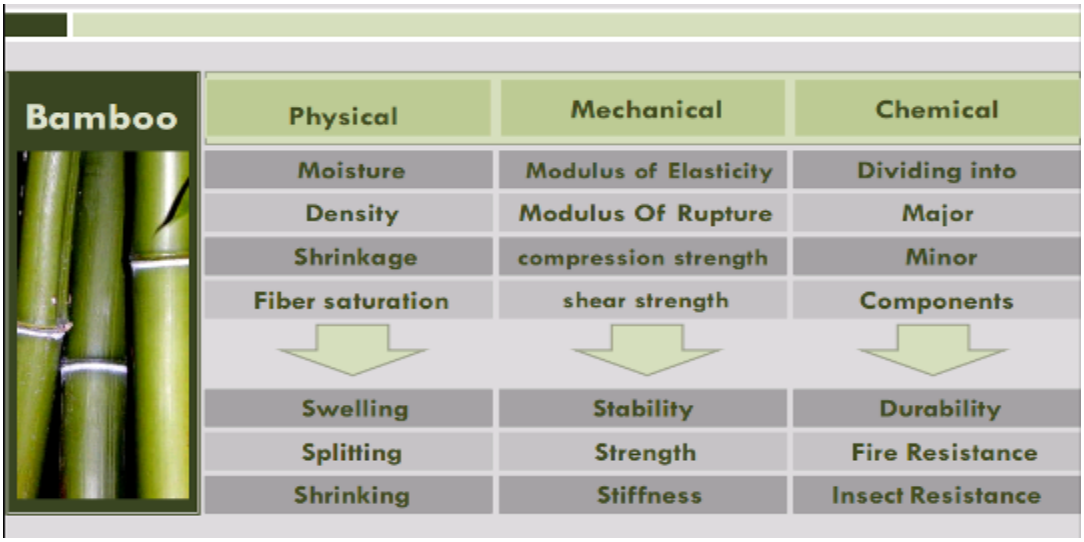
4. Research Methodology

This paper presents a summary of the information obtained from field investigations about different types of rural materials emphasis on wooden types and their resistance against earthquake, and specifications of their constituting elements.

5. Results and Analysis

As it is mentioned above, bamboo is an earthquake resist material that improved a lot in building constructions in many countries and also there are a lot of techniques that used to strengthening it and different kinds of connections that are profitable in making bamboo as an appropriate building material.

Bamboo has various physical, mechanical and chemical properties. These properties are reflected in its characteristic durability, fire and insect resistance. There is no way of improving the durability except by keeping the moisture content low using appropriate means, protecting the bamboo from insect attacks using preservation methods, and also protecting the bamboo from fire hazards.



Expanding and promoting wooden houses in this region (Gilan Province) is fully justified with regard to:

Compatibility with the rural culture.

Locating Gilan in an earthquake prone area,

Affordability

Accessibility

Easy to perform

Lightness

Flexibility

Mentioning some disadvantages of wood as bellow:

Physical and mechanical properties may vary in different directions.

Decay due to frequent water changes.
High drying shrinkage.
Flammability
Traditional buildings have appropriate capabilities that could easily get adopted with regional and cultural environment, and it could be a proper reason for reinforcing them as building structures. In order to promote technical skills and familiarity with the issues of construction, it could be suggested that, kinds of different samples of traditional engineering housings be made in rural regions, such as public places, schools, health house, and etc.

5. Conclusions

Based on those above explanation and discussion, it was found that bamboo can be used as one of building alternative material to provide earthquake resist building. Some important factors when we use bamboo construction on this building, the types of connection, connection methods should be taken into account by bamboo construction designer. National Building standard for bamboo construction should also be made as guidance for designer, contractor, and user of the bamboo building, during the design, construction, and maintenance process respectively, and also considering If the bamboo building is located in an earthquake area then:
1. Primary suggestion is to select lightweight material.
2. Wall frame should be reinforced using diagonal members.
3. Suggest using uniform material
(Mardjono**,** F. *Bamboo construction on the building after earthquake disaster in Yogyakarta.* Gadjah Mada University. Yogyakarta.)

Using bamboo as building material need knowledge on:

- Bamboo Properties
- How to work with bamboo?
- How to construct the bamboo construction?
- How to maintain bamboo construction always in a good condition?
- How to construct the bamboo construction to resist the earthquake forces?

Bamboo can be used as one of building alternative material to provide earthquake resist building. Some important factors:

- Types of connection
- National building standard for bamboo construction

These Items may also help in achieving proper methods:

Integrates temporary and permanent housing stages into continual process.
Training survivors could be helpful.
Adopting to traditional living patterns.

Familiarity of local carpenters and survivors to "Zigali" as an indigenous materials in the temporary setup units, encourage officials for building "Zigali" structures by people participations with a benefit of reducing costs.
There are several factors in selecting "zigali" as an indigenous structure for establishment of temporary housing units, that on of the main factors for encouraging the authorities for using them is the proper performance of it as a traditional building material against earthquake.

Acknowledgements
The authors gratefully acknowledge the people who support doing this research project. Special thanks should go to those who helped doing survey, answering questions and giving valuable information. Thanks also go to Mr. Fayyazi, who helped accessing research materials extracted from his MA dissertation on Zigali technics at the department of Reconstruction after Disaster, School of Architecture and Urban Planning, Shahid Beheshti University, Tehran.

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