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A study on Construction Practices of Non-Engineered Structures in Different Countries

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Abstract - Non-engineered buildings or structures are the oldest type that where the majority of population lives. This type of structures is very popular in many countries because in the olden days there is a lack of knowledge towards the structures. Unfortunately, this type of structures susceptible to many natural disasters, especially earthquakes and loss of death rate of people is also high due to this type of disasters. As we know that the construction practices and skills of workers differ from country to country, strength of this type of structures also differs. A sample study was conducted on the six different developing countries i.e. Turkey, Malaysia, Dubai, Japan, India and USA to collect the data on their design and construction characteristics. All the countries will follow the different guidelines for the construction purposes. While construction practices differ from every country there are some certain similarities such as availability of workers and materials, supervision and project delivery method by the owner, construction period to finish the structure, foundation types, wall materials and thickness, work experience of workers etc.

Key Words: Non-engineered buildings, developing countries, construction practices

1. INTRODUCTION

In the construction of structures there are three different types' i.e. structural engineering buildings, semi-structural engineering buildings and non-engineering buildings. Most probably majority of population lives in non-engineering buildings as compared to other two types. Non-engineering structures means the structures which are constructed in disorganized manner using non-processed materials with little or no engineering input design locally accessible materials such as wood, adobe, burned brick, concrete blocks, rubble stone, or rammed earth, and their construction has not been planned or overseen by engineers or architects. This type of buildings is rarely susceptible to many natural disasters and loss of damage is also high. The collapse of non-engineering buildings masonry is one of the most important causes of death and destruction during major earthquake events worldwide. These structures prevail in the rural areas of countries such as Turkey, Iran, Afghanistan, Pakistan, India, Nepal, China, some countries in Latin and South America and many other developing countries in seismic prone areas. As these types of structures do not include load resistance, damage of structures due to earthquakes is very high.

This study has been done in the six different countries i.e. Turkey, Malaysia, India, Japan, USA and Dubai. The data has been collected through the journals and by survey among engineers who are working in the construction sites from the different chosen countries.

2. OBJECTIVES OF THE STUDY

- The body of the paper consists of numbered sections that present the main findings. The study major goal is to enhance better knowledge of existing non-engineered construction practices in different developing countries.
- General difficulties can be identified and recommendations for enhancing non-engineered construction in different developing countries can be made based on the information required.
- The research goals include creating a data sheet to gather data, sharing data, and comparing non-engineered building applications in various developing countries.

3. METHODOLOGY

There were three stages to the research project.

Firstly, matter is gathered in the form of survey forms by contacting some of the known persons in selected countries and they were represented in bar graphs and pie charts. The following information was collected in the survey form;

- General information and Building regulation codes

- General information on project and project site facts,
- Masonry and Concrete material technical data
- Contractor data and non-structural material technical data

Secondly, workers and/or building owners were interviewed as part of the survey. To gain information on the quality of construction materials, such as compressive strength of concrete and bricks. Due of the rarity of non-engineered construction projects, certain countries undertook surveys on existing structures, which were backed up by secondary data from literature research. Because non-engineered construction is uncommon in urban areas, the survey in Turkey focused on old non-engineered buildings.

Thirdly, each site's data was compared using factors from the data sheet, such as average value, smallest value, greatest value, most used/available, or item availability, and possible similarities and discrepancies. General difficulties are derived from individual problems, and recommendations are made to improve non-engineered building construction in developing countries.

4. SELECTED SAMPLES

The six selected developing countries involved in the study are responsible to select several non – engineered houses that represent the current practice of non – engineered construction in various sites in the country.

Table -1: Details of Samples

Samples	Country	City / Region
1	India	Hyderabad- Kukatpally old, Secunderabad old, Andhra Pradesh- Vijayawada, Nandigama - one town, Chennai - Tambaram, Madhavaram, Alandur, Mumbai- Dharavi
2	Japan	Tokyo- Kanagawa, Saitama, Hyogo, Nakano, Osaka
3	USA	Georgia-Albany, Dacula, Hiram, Athens, Norcross, Washington, Amber.
4	Dubai	Alkhwaneej, Naif
5	Turkey	Yenikapi, Istanbul-Fatih, Esenyurt
6	Malaysia	Esenler, Sisli, Kuala Terengganu, Malacca city

5. BUILDING REGULATIONS

Most of the selected countries have been following different building regulation codes or guidelines for the construction of structures such as India, Turkey, USA, Malaysia, Japan and Dubai. Unfortunately, some of the countries are not implemented regulation codes for non-engineered structures. In Malaysia, these days they were focusing on green buildings for sustainability and in Japan, most of the structures were earthquake proof structures. Hence regulation codes in Japan were different as compared to other selected countries. In Turkey, only for the engineered structures regulation codes were implemented. In India, percentage of rural houses is higher as compared to urban houses and they follow Indian Standard Codes for the construction purposes.

i) India

In India the most common type of non-engineered buildings are brick masonry buildings. Here most of the bricks used for the construction are fired bricks.

Fig -1: Typical non-engineered buildings in India

ii) Turkey

Mainly in turkey there are three types of non-engineered buildings i.e. reinforced concrete frame with clay hollow brick infill wall, unreinforced brick masonry and wooden structures. These types of structures can be seen rarely in turkey.

Fig -2: Typical non-engineered buildings in Turkey

iii) U.S.A

In USA for the construction purposes mainly they give high priority to the high-quality wooden structures and less priority to the brick masonry structures.

Fig -3: Typical non-engineered buildings in USA

iv) Dubai

As we know that the Dubai is one of the well-developed countries in the world. Most of the constructions in this country are engineered structures. So, there is less chance for the non-engineered structures in this country.

v) Japan

The main type of non-engineered structures in Japan is wooden structures. And these wooden structures are entirely earthquake resistant buildings.

Fig -4: Typical non-engineered buildings in Japan

vi) Malaysia

In rural area most of the non-engineered structures can be seen. The roof of non-engineered buildings varies from locality to locality and it depends on the availability of materials.

Fig -5: Typical non-engineered buildings in Malaysia

6. SURVEY RESULTS

The information obtained during the survey on each site is extracted into single representative information of each country, based on the average value, the smallest value, the most common information or the available information, similarities, and differences.

i) Project site and building information

The majority of non-engineered buildings found in India, Turkey, Malaysia, Dubai, the United States, and Japan are created by craftsmen assigned by the owner, using simple construction tools. In general, the availability of construction materials for non-engineered buildings is not an issue or a constraint. The majority of the buildings are privately owned, and the owner is the one who makes the majority of the design decisions. The majority of non-engineered structures are discovered to be supervised by their owners. In India, Turkey, Japan, and Dubai, home owners and workers agree that earthquakes are the most common natural disasters. Other nations, such as India and Malaysia, are also affected by floods. A non-engineered building is typically completed in 6 to 17 weeks.

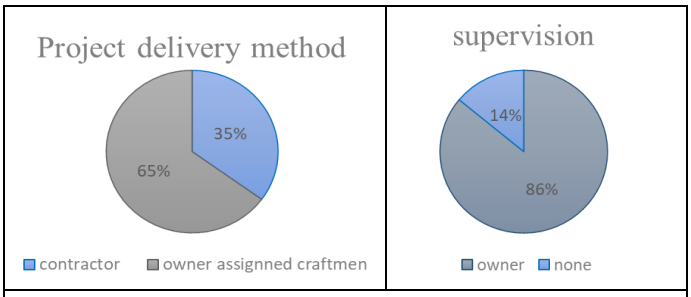

Fig -6: Project delivery method and Supervision

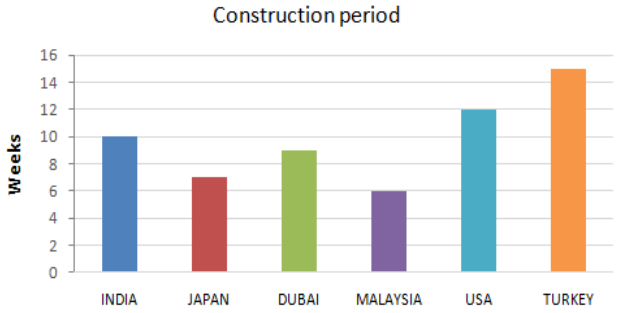

Fig -7: Construction period among various countries

ii) Building Information

The majority of non-engineered structures are utilized as residential and small commercial structures, with some being used as school structures. The simplest foundation system, “strip and isolated pad,” is mostly seen in non-engineered buildings examined, which are made of various materials such as stone and RC. Reinforced concrete confinement is used in the majority of buildings for restricted masonry. The most prevalent material for door and window framing systems is wood. In this general building information, we are discussing about the area of building and number of rooms in a house. Building area is always depends on the owners and number of rooms division is based on the area of the building and it varies to every house. Below the graphs are about “Area of building” and “Number of rooms” depends on their average values.

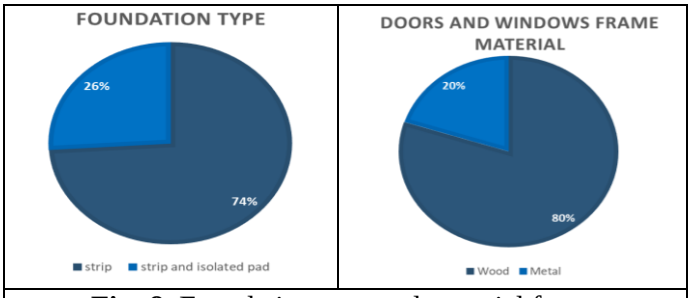

Fig -8: Foundation type and material frame

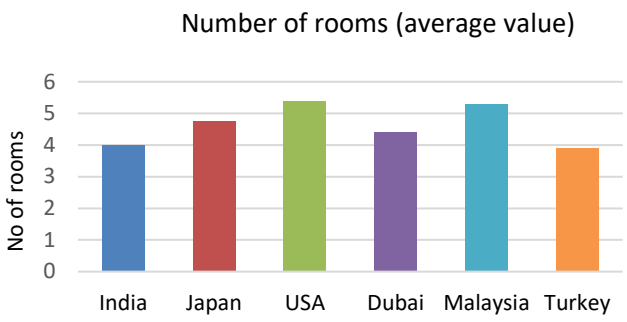

Fig -9: Number of rooms

iii) Technical characteristics

The countries which we have chosen mostly utilizing the fired bricks. Some of them are selecting stones and concrete blocks for the construction of walls. According to the selected country thickness of the exterior wall is mentioned in the form of below bar graph.

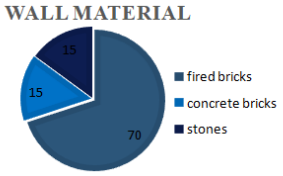

Fig -10: Wall materials

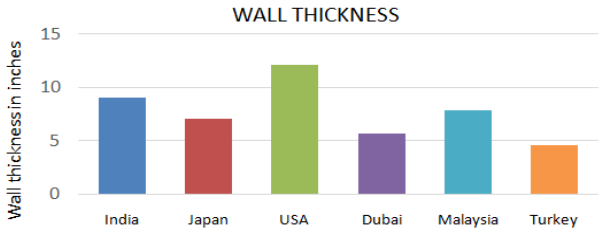

Fig -11: Wall thickness

iv) Masonry Material

For wall materials, the majority of non-engineered buildings in the selected countries employ baked clay or stone masonry. When compared to clay bricks, the compressive strength of brick units ranged from 4.3 to 6.9 MPa, with an average of 5.7 MPa. These bricks were found to be soft and weak. A decent mud brick has a compressive strength of 1.6 to 1.9 MPa, whereas a clay-fried brick has a compressive strength of 14 MPa.

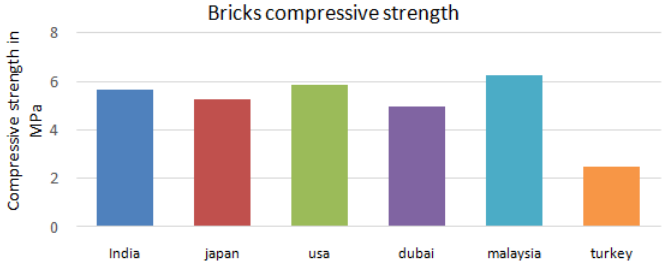

Fig -12: Bricks Compressive strength

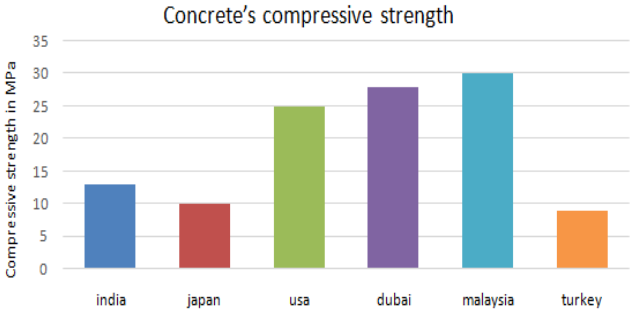

Fig -13: Concrete's Compressive strength

v) Concrete Material

According to the report, some non-engineered structures have structural parts with very low concrete strength. Malaysia has the highest concrete compressive strength, over 30 MPa. Turkey has the lowest concrete compressive strength, around 4.5 MPa. Ordinary Portland cement is used in the construction of all of these countries. The majority of the aggregates come from river and mountain quarries.

vi) Contractor data

In this contractor data we have gathered the matter of number of workers and their work experience. We have followed up the data of 6 countries like turkey, India, Japan, Malaysia, USA and Dubai. Based on the work in the construction site workers will be taken. In Dubai most of the workers are migrant workers and in remaining countries there is a possibility of both migrant and non-migrant workers. Here is some of the data which is being represented in the form of graph.

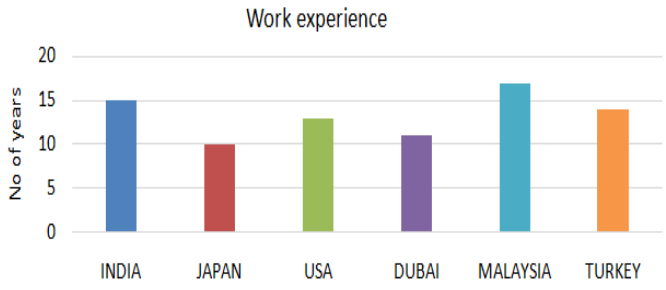

Fig -14: Work experience

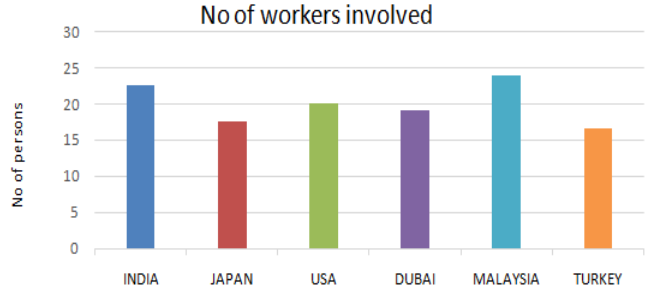

Fig -15: Number of workers involved

vii) Safety Precautions

Workers or builders who are working in the construction site have limited knowledge on the construction methods due to lack of formal education towards the construction. They were working with the guidance from their foreman and their own experience. In some of the countries still there is no implementation towards earthquake resistant buildings and the usage of building regulation codes or guidelines is also less. Inadequate detailing of structural elements, low-quality building materials, and a lack of integrity in structural elements are common issues observed on many construction sites. These issues are likely caused by workers who lack the knowledge necessary to construct earthquake-safe buildings, or who may have the knowledge but have compromised the quality of their work as a result of owners' intervention to lower construction costs. In many instances, there is no specific system in place for construction quality control from the local or national government. This is because, although some countries do have such a system, the workers who are employed on construction sites are rarely or never under the supervision of local or national government officials.

Safety precautions to be taken in the site are:

Clients should prioritize safety and health precautions over financial considerations.

Certain obligations should be assumed by the contractors, including:

- They must ensure that workers are provided with safety features.
- The site should be inspected and maintained on a regular basis.
- The staff on the job site should be well-trained in their duties.
- Safety symbols, warning notices, and caution signs should be prominently displayed.
- Every worker on the jobsite should be provided with personal protective equipment.
- Providing adequate communication and information to employees so that they are aware of how to protect themselves from hazards.
- An emergency response system should be installed on the construction site.
- Every worker on the jobsite should adhere to the safety regulations.
- Damaged tools should be replaced right away with new ones. Before going to work, senior site management should tell the workers on the hazards and control measures that must be taken.
- Before beginning construction on the site, everything should be arranged ahead of time.
- Workers must be provided with emergency route exits, danger zones, loading bays, and ramps, among other things, as part of the site layout.
- Excavators, forklift trucks, and wet trucks will have a safe working slope. Fencing should be installed around the site's perimeter.

CONCLUSIONS

- In project site facts, project delivery method of 65% and supervision of 86% mostly depends on owners in most of the countries because the land is owned by them. Only government assigned projects are depended on the contractors.
- Efficiency of work is high in Malaysia and low in turkey because the usage of advanced material handling equipment’s and workmanship is high in Malaysia as compared to turkey.
- In most of the countries, strip footing is most commonly used foundation type of 74% and remaining 26% used is strip& isolated pad type. 40% of the wall materials used for constructions is sun-dried bricks and burnt bricks but the remaining 30% used is concrete masonry blocks and other 30% used is clay bricks for the construction purposes.
- The most commonly used doors and windows frame material is wood with 80% and there is less possibility of using metal for this type of purposes i.e. 20%. The highest number of workers involved in construction of structures is Malaysia (24 workers) and lowest in turkey (16 workers) and highest work experience for the workers is in Malaysia with 17 years as compared to remaining selected countries.
- In the general building information, the highest area for buildings considered in United States is 185sq.m and lowest in Dubai of 94sq.m.
- As per the data collected from literature study of journals, both brick compressive strength and concrete compressive strength is highest in

Malaysia of 6.3MPa and 30MPa but lowest in turkey of 2.5MPa and 9MPa. Unites states is having highest wall thickness of 12inches and turkey is having lowest wall thickness of 4.5inches in the selected samples.

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