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إدارة المشروعات الهندسية

Mud Building Practices in Construction Projects in the Gaza Strip

ممارسة البناء بالطين في مشاريع الإنشاءات في قطاع غزة

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A Thesis submitted in partial fulfillment of the requirement for the

Degree of Master of Science in Civil Engineering – Engineering Projects Management

The Islamic University - Gaza-Palestine

July, 2011

بسم الله الرحمن الرحيم

{ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِير }

صدق الله العظيم

سورة المجادلة (11)

{ وَقَالَ فِرْعَوْنُ يَا أَيُّهَا الْمَلأ مَا عَلِمْتُ لَكُمْ مِنْ إِلَهٍ غَيْرِي فَأَوْقِدْ لِي يَا هَامَانُ عَلَى الطِّينِ فَاجْعَل لِي صَرْحاً لَعَلِّي أَطَّلِعُ إِلَى إِلَهِ مُوسَى وَإِنِّي لأظُنُّهُ مِنْ الْكَاذِبِينَ}

صدق الله العظيم

سورة القصص (38)

Dedication

To my loving parents who supported me all the way; to my wife for her unlimited encouragement; to my sons whose innocent energy was and still is a source of inspiration; to all of my friends and colleagues who stood beside me with great commitment; I dedicate this work, hoping that I made all of them proud.

Hamed E. Abu Ajwa

ACKNOWLEDGMENT

First and foremost I would like to thank Allah for what I am and for everything I have.

Next I wish to express my deepest appreciation to Dr. Nabil El Sawalhi under whose supervision and advice this thesis was developed. Without his considerable efforts, this thesis could not have been carried out through completion. Thanks to him for being my mentor and for the friendship he offered me.

Special thanks to Higher Education Division at Engineering Faculty for their administration and academic support.

Special thanks for Palestinian contractors and subcontractors for their participation in filling-up the questionnaire and interviews.

It is always impossible to personally thank everyone who has facilitated successful completion of the work. To those of you who I did not specifically named, I also give my thanks for motivating me towards my goal.

Finally I would like to thank my parents, wife and lovely children for their love, support and for tolerating the time I spent working with my research.

ABSTRACT

Construction industry is considered as one of the most important industries in Palestine. It is known that most construction projects in Gaza Strip have been exposed to various problems due to the shortage of building materials and the siege on enclave. There has been a genuine need to think thoroughly of alternative materials and techniques of construction.

The purpose of this thesis is to improve and reinforce the construction industry in the Gaza Strip and the Palestinian territories through a practical and thorough research investigating the applicability of using mud materials in construction in the Gaza Strip. The historical background of this practice, the merits and demerits of earth materials in construction, the barriers and challenges encountering the construction with earth materials, and the techniques used in building with these materials, were studied.

This study relied principally on analytical, descriptive and field study methodologies. The first approach was by reviewing the studies and literatures in this area. The second approach was a questionnaire which targeted the participant in the mud building practices and specially the companies that participated in the construction of UNRWA and Ministry of Public Works and Housing. The third approach was structured interview with the companies which implemented those mud building works. The Fourth approach was a case study at two projects that were carried out using clay or mud materials. A questionnaire was designed in the light of the literature review applied on a sample of 48 contracting companies. Collected data is manipulated by SPSS software using many statistical tools as, frequencies, Means, Pearson coloration coefficient and t-test.

It is concluded that the construction with Mud building was existed with a certain period of time where no construction materials were available in the local market due to the imposed blockade on Gaza Strip.

Finally, the study recommended conducting more detailed studies the stockholders perceptions and attitudes about mud buildings, to prepare a comprehensive research of how

to improve the characteristics and behaviors in the weaknesses mud building resistance against weather conditions, and to find ways of examining the mud construction materials and methods adopted in local laboratories as well as the work of ratings and records of all the materials needed to build with mud and all related data.

الخلاصة

تعتبر صناعة الإنشاءات أحد أهم الصناعات في فلسطين. و من المعروف جيدا أن معظم مشاريع الإنشاءات في قطاع غزة تتعرض لمشاكل مختلفة بسبب نقص مواد البناء والحصار على قطاع غزة، ولذلك كان هناك حاجة ماسة للتفكير جيدا في المواد والتقنيات البديلة للبناء.

الهدف من هذا البحث هو تحسين وتعزيز قطاع الإنشاءات في قطاع غزة وفلسطين بشكل عام من خلال بحث علمي وشامل يحقق مدي قابلية تطبيق ممارسة واستخدام الطين (muds) في صناعة التشييد في قطاع غزة، والخلفية التاريخية لهذه الممارسة، ومزايا وعيوب مواد الأرض في الإنشاءات، والعقبات والتحديات التي تواجه البناء بالطين، والتقنيات المستخدمة في البناء مع هذه المواد.

الدراسة اعتمدت أساسا على دراسة وصفية تحليلية ذات منهجيات مختلفة، النهج الأول كان من خلال استعراض الدراسات السابقة في هذا المجال. النهج الثاني الاستبيان الذي استهدفت فئات الشركات التي شاركت في ممارسات بناء الطين وخصيصاً للشركات التي شاركت في مشاريع الأونروا ووزارة الأشغال العامة والإسكان. وكان النهج الثالث مقابلة ميدانية مع الشركات المنفذة لأعمال بناء بالطين. وكان النهج الرابع دراسة حالة في اثنين من المشاريع التي نفذت باستخدام الطين أو المواد الأرضية. و قد تم تصميم استبيان في ضوء استعراض الدراسات السابقة وتطبيقها على 48 عينة من شركات المقاولات. وقد استخدم البرنامج الإحصائي SPSS في معالجة البيانات وذلك بتطبيق العديد من الاختبارات الإحصائية كحساب النسب والتكرار والمتوسطات ومعامل ارتباط بيرسون و تحليل التباين (T - test).

اختتمت الدراسة بأن وجود بناء الطين مرتبط بفترة معينة من الزمن، حيث لا تتوفر مواد البناء في السوق المحلي بسبب الحصار المفروض على قطاع غزة.

وأخيرا، أوصت الدراسة بضرورة إجراء مزيد من الدراسة من خلال قراءة المواقف والتصورات للمساهمين في المباني الطينية، لإعداد بحث شامل يوضح كيفية تحسين الخصائص والسلوكيات الخاصة بالطين وتحسين ضعف الطين ضد المقاومة وظروف الطقس، والبحث عن طرق لفحص مواد البناء من الطين والأساليب المعتمدة في المختبرات المحلية وكذلك عمل تقييمات وسجلات تحتوي جميع المواد اللازمة لبناء الطين وجميع البيانات المتعلقة بها.

LIST OF ABBREVIATIONS

$	Dollars
AD	After Date
BC	Before Christ
CEB	Compressed Earth Block
CI	Corrugated iron
CSEB	Compressed Stabilized Earth Bricks
ECB	Energy Codes for Buildings
EU	European Union
GS	Gaza Strip
GVA	Gross Value Added
IAEE	International Association for Earthquake Engineering
ILO	International Labour Organization
IS	India Standard
IUG	Islamic University - Gaza
MPWH	Ministry of Public Works and Housing
NGO	Non- Governmental Organizations
No.	Number
PASSIA	Palestinian Academic Society for the Study of International Affairs
PCBS	Palestinian Central Bureau of Statistics
PCHR	Palestinian Center for Human Rights
PCU	Palestinian Contractors Union
RE	Rammed Earth
RII	Relative Importance Index
SPSS	Statistical Package for Social Science
UK	United Kingdom
UNDP	United Nations Development Program
UNRWA	United Nations Relief and Works Agency
USA	United States of America

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1 INTRODUCTION

1.1 Introduction

This chapter introduces a background about the mud building practices in construction industry. The importance of this research area is discussed also in this chapter followed by the research aim and objectives and the research methodologies that are used to achieve the research objectives. The chapter highlights also the limitations of this research. Finally the research structure is be presented.

1.2 Background

Construction is one of the important sectors overall countries in the world. This sector is considered the economical back bone of many countries; in addition, it contributes to absorb high percent of the labour forces. In United Kingdom (UK), the construction industry is considered the second largest industry in the European Union (EU). This sector is contributing around 8.2% of Gross Value Added (GVA), employing 7 % of the UK's workforce and providing some 2.2 million jobs and that figure is expected to increase to over 2.8 million by 2011(AGCAS, 2008). In the United States of America (USA), the construction industry is considered the largest in the world. The sector is adding approximately 1 billion square feet of commercial construction annually, the US market accounts for 25% of the total global construction industry (AGCAS, 2008).

The construction industry in Palestine is considered one of the main sectors that contribute strongly to the Palestinian economy. In year 2009, this sector contributed to absorb 12.2 % from the Palestinian labor forces in the West Bank and Gaza Strip (PASSIA, 2010). As most other countries in the world, this sector is in critical need for continuous improvement and development due to its direct and indirect impact at industrial, service, economical, and other countries' sectors.

In this research, the study focus on the practices of construction by mud building. The barriers, benefits and techniques is studied. The study is expected to provide a crucial benefit for all stockholders operating in construction projects especially the clients and the contractors. Besides, the research is expected to improve the decision making attitudes for the contractors as well as clients to participate in such type of building.

1.3 Problem statement and expected benefits

After the last war on Gaza and the huge mass of destruction for the buildings overall Gaza Strip, in addition to the siege imposed on Gaza Strip that prevent construction materials to enter Gaza, there was an urgent need to think thoroughly in an alternative materials and techniques in the construction. From this needs the idea of this research was born. Moreover, because of the global and local shortage of resources, constructing with substitute materials such as packed sand, mud, wood and others are becoming a crucial and too important in our life. Houses requiring cement and steel cannot remain the standard given the rate of urbanization added to the figures of housing demand in the context of a rapidly deteriorating environment. In earlier times, housing was largely built with local natural materials and by the users themselves.

In the other side, nowadays the crucial desires for mud materials and construction are becoming radical demands. The immediate need to enhance indigenous construction

capabilities and create more awareness of the economic value of local materials to meet the urgent need for housing is becoming essential (Block et al., 2010) support this argument.

In contrast to available literature on construction by mud material in construction industry, there is very scanty material in regard to this research area, although we are strongly satisfied the importance of this subject to be investigated. These challenges push us to conduct deep field survey baking of completely built mud houses.

1.4 Research Aim and Objectives

1.4.1 Research Aim

The aim of this research is to improve and enhance the construction industry in the Gaza Strip and Palestine through a practical and thorough research investigating the applicability of using mud materials in the construction industry in the Gaza Strip. Besides, to provide practical recommendations for all parties operating in construction industry that will facilitate overcoming the barriers in this field. This aim will be achieved through sub objectives as follow:

1.4.2 Research Objectives

1. Review of mud building system.

2. To evaluate barriers/challenges of constructing mud building in the Gaza Strip.

3. To investigate the techniques used in mud building practices.

4. To evaluate failure/success of implementing the mud building in the Gaza Strip, UNRWA as case study.

5. To identify the practical benefits of constructing mud building and its applicability in the Gaza Strip.

1.5 Research Methodology

Four research methodologies were conducted in this research to achieve the targeted objectives.

1. The literature review that have studied and investigated this research area were introduced also in our research.
2. Questionnaire approach targeting the contractors implemented mud building and contractors invited by clients in this type of works in Gaza Strip-Palestine. The questionnaire is designed to identify the practical benefits of constructing mud building and its applicability in the Gaza Strip.
3. The structured interview with companies participated practically in the construction of mud building was targeted in this part. The benefits expected from the diversity of these research methodologies is to triangulate and strength and verify the obtained results in more than one resource
4. Case study: In this methodology, a deep study is applied at the clients executed clay building in the Gaza Strip (UNRWA and Ministry of Public Works and Housing). The stages of (design, procurement and implementation) is analyzed to identify and evaluate the methods, barriers and motivations to conduct these projects. The lessons learned is elaborated and discussed to add value in our industry.

1.6 Research Limitations

Three research limitations are shown in this research as follows;

1. The research is conducted in the Gaza Strip while other Palestine areas such as West Bank are not considered. This is returned to the political situations and the closure imposed at Gaza Strip.
2. This research targeted the contractors who were invited by the client to implement such type of works (Mud building). It is believed that to obtain more practical and

concrete results the parties that were involved in such work will introduce better contributions.

3. Partial limitation to access raw materials that relate to procurement and design stage (client's information limitations). The clients believe confidentiality in these materials and information.

1.7 Contents of The Thesis

This research was structured to include all the important sections as follows:

Chapter 1: Introduction.

Chapter 2: Literature review

Chapter 3: Research Methodologies including (field survey" questionnaire, structured interview and analytical case study")

Chapter 4: Results and discussions of the questionnaire survey, structured interview.

Chapter 5: Case study.

Chapter 6: Conclusion and Recommendations.

References

Annexes

2 LITERATURE REVIEW

This chapter introduces a theoretical background about the mud building practices in construction industry. The importance of this research, the challenges and barriers face the adoption of this practice, the advantages and the techniques used will be highlighted in this chapter. At the end of this chapter a summary showing what was found in the previous researches is introduced. The findings in this chapter is used as a main part in the developing and designing of the research methodologies approaches that is used in the practical parts of the research.

2.1 Background

Soil has been widely used for building for thousands of years and still today. It is an effective and economic form for housing construction. According to the United Nations, about a third of the world's population live in earthen structures today (Arumala and Gondal, 2008). The use of earth in construction has been significant throughout human history. In addition to the creation of simple shelters, many of the world's great feats of construction involved the use of mud or dirt. The Great Wall of China (246-209 BC) was built of earth along most of its route. Hannibal's watchtowers were built with compressed earth in Europe in 300 BC, stood for more than 600 years (Buffington and London, 2005). Situmbeko and kanyemba (2002) examined and suggested alternatives building techniques and designs that while still providing acceptable housing, do so at reduced costs.

Auroville Building Centre (2005) illustrated that the oldest earthen building can still be seen in Egypt, near Luxor, which was built around 1300 BC: the vaults of the Ramasseum, in the "rest" of Thebes. In Saudi Arabia, people were used to build with earth since very ancient times. The capital of the first state of Saudi Arabia, Al Dir'iyah has been built with earth very long ago. The first recorded settlements in Dir'iyah date since 1446 AD. From 1745 to 1818 AD, Al Dir'iyah became a large city and an amazing example of earthen architecture (Auroville Building Centre, 2005). Figure 2.1 (A&B) shows two samples of earthen building one in Egypt and the second in Saudi Arabia.

Figure (2.1-A) **Figure (2.1-B)**

Figure (2.1-A): Al dir'iya, Sa'd Palace – Adobe-Saudi Arabia and Figure (2.1-B) Ramasseum – Adobe Egypt, ±1300 BC [Source: Auroville Building Centre (2005)

Around 30% of the world's population lives in earth-made construction. Approximately 50% of the population in developing countries, including the majority of the rural population and at least 20% of the urban and suburban population, live in earthen dwellings (Houben and Guillard 1994)[cited in: Blondet et al, 2003]. For example, in Peru, 60% of the houses are built of adobe or rammed earth. In India, according to the 1971 Census, 73% of all buildings are made out of earth (67 million houses inhabited by 375 million people). By and large, this type of construction has been used mainly by low-income rural populations (Blondet et al, 2003)

2.2 Introduction to literature review

Blondet et al. (2003) illustrated that adobe mud blocks are one of the oldest and most widely used building materials. Use of these sun-dried blocks dates back to 8000 B.C. The use of adobe is very common in some of the world's most hazard-prone regions, traditionally across Latin America, Africa, Indian subcontinent and other parts of Asia, Middle East and Southern Europe.

Situmbeko and kanyemba (2002) explained that building materials may be classified as traditional, conventional or adapted. Traditional materials mainly consist of earth construction, conventional materials refer mainly to cement and concrete based building methods and tiled or corrugated sheets roofing while adapted materials refers to the several new methods comprising mainly of combinations of the other two methods such as Ferro cement, fired clay bricks, timber panels, rice husk and lime stabilizer, sisal fiber reinforced roofing sheets, etc.

2.3 Classified the factors influencing mud construction

Sassu Mauro (2005) classified the factors influencing vernacular construction to three groups. These groups are: 1) Locally Available Materials. It is observed that in many areas, the locally available resources have governed the use of the following constituent materials for walls; Adobe (mud blocks or whole walls); Masonry (stone, clay, or concrete blocks) or timber. 2) The second factor is Building Layout. This is another determining factor that means, the typical shape of a building plan, usually related to many cultural, historical, and urban planning traditions. Three main plan shapes have been identified in traditional buildings: Circular plan, rectangular plan and linear plan (row houses or wagon-houses in Romania) and the circular floor plan offers the best resistance to earthquake forces. 3) The third factor is building size. Based on their size, these buildings can be classified as: Single story and multistory buildings. The size of the building is governed by its particular use. For example, a dwelling can be used for sleeping only, for sleeping and

eating, or for mixed use (sleeping, eating, and working). Clearly, the mixed-use buildings necessitate construction of an additional floor, which calls for increased wall load-bearing capacity, especially if these walls also need to withstand earthquake effects. It should be noted that the building size is also related to the population pattern and housing density in a given area. For example, single-story buildings are common for rural areas, whereas multistory buildings are most often found in densely populated urban areas.

2.4 Techniques used in mud building

From the literature review in this research topic it was found that many construction techniques were used over the past years that are relying mainly on the earth materials such as clay, mud, sand, stones and others. The techniques used in building with mud materials was studied by several researchers in different directions such as [*Backed-Insitu, Fire clay bricks, Tile valuating techniques, Compressed Earth Block, Compressed Stabilized earth block, and others*].

ECB (2002) reported that the buildings in West Bank and Gaza Strip are divided to Traditional and Contemporary buildings. The construction techniques used in traditional buildings depends on traditional materials which are with good thermal properties and the compositions of them in which the walls and the slabs are thick; these properties gives the result of low thermal transmittance which means thermal comfort inside the buildings. The construction techniques used in contemporary buildings depends on the new materials as stone and concrete and the compositions of them in which the walls and slabs thickness are small; these properties gives the result of high thermal transmittance which affects negatively the thermal comfort inside the buildings.

Harris (2010) in his research introduced some definitions of the techniques used in the mud materials. These techniques are;

2.4.1 Rammed Earth

Rammed Earth (also known by the French term pisé de terre): moist, loose earth is compacted in layers between shuttering or formwork. The forms are then moved along or upwards, to form a whole wall. The exact composition of the soil and the right degree of water are critical for the success of this method. However, a small proportion of cement or lime may be added to correct for any deficiencies. This 'stabilization' is considered necessary for soil with low clay content. Over a period of time, perhaps up to two years, a rammed earth wall will dry out and become as durable as sandstone, as long as it is waterproofed top and bottom.

2.4.2 Cob

Cob: Sub-soil is mixed with straw and water, and then pounded or trodden until it reaches a suitable consistency. It is then laid in horizontal layers, and again trodden down, to form free standing mass walls. The use of timber shuttering was a late development - from the 1820's onwards.

2.4.3 Adobe

Adobe or sun-dried earth blocks can be made from most types of sub-soil. Enough clay is required to bind the mix together, but not so much that the block cracks on drying. In the past, the earth was trodden to a paste (often by animals) then mixed with chopped straw, pushed or thrown into moulds and left to dry in the sun. The blocks were then laid and bonded with a mud and lime mortar and rendered with a mud and dung mix, and/or lime washed. Mud bricks have the advantage of being simple to make and therefore appropriate for unskilled labor. They can be produced all at once, or in small batches, as and when time permits. The quality can be checked, and any suspect bricks rejected, before they are built into a wall.

Revuelta-Acosta et al. (2010) explained that the adobe production consists of molding a mixture of soil with 5 to 10% of straw. The necessary quantity of water is about one quarter of the dry earth volume. A soil will react very differently depending on the amount of water it absorbs. The four fundamentals states are: dry, humid, plastic and liquid. The adobe is produced at the plastic state which enables molding. When the soil goes back to the solid state it reduces its volume, resulting in cracks in the bricks. In order to stabilize the adobe, sand or straw are added to reduce the size of the cracks. Mixing by the feet of human's or animal's is the most common for small scale production. Sometimes the adobe is produced by using compressed soil in the humid stated to improve its mechanical behavior.

Arumala and Gondal (2008) illustrated that soil can been used in three traditional methods of construction namely: Adobe block which is sun-dried soil mixed with straw/rice husks to strengthen the blocks, Wattle and daub; which is made up of interwoven timber, reeds or bamboo daubed with soil. Rammed earth; this is soil mixed with stabilizers and subjected to high compressive pressure.

Rodriguez et al. (2002) in their research that was conducted in Argentina showed that the construction with adobe block type is considered a single-family house and in general, it is a single-storey building, an isolated construction found in the rural areas of San Juan and Mendoza. The traditional adobe block masonry walls are reinforced with foundations and plinth structure, which provide structural strength. Moreover, Buildings of this construction type can be found in the province of San Juan and such type of housing construction is commonly found in rural areas.

2.4.4 Compressed Earth Block & Compressed Stabilized Earth Bricks

These are earth blocks made harder and more durable by the addition of small amounts of lime or cement (5 -10%). Bitumen can also be added as a water repellent. The blocks are compressed in a machine which exerts a large amount of pressure on the mould, to produce the blocks in standard sizes. Stabilized compressed earth blocks perform at least as well as many commonly used bricks or blocks in terms of their load bearing capacity, long life and freedom from maintenance.

2.4.4.1 Stabilization procedure types

Zami and Lee (2008) illustrated two techniques used in the mud materials called stabilised and un-stabilised earth blocks. They examined in their research the meaning, relevance and reasons of the use of stabilised and un-stabilised earth in the construction of urban housing in developed and developing countries. Zami and Lee (2008) illustrated that there are three stabilization procedures that can be used in construction clay building which are: 1) Mechanical stabilization 2) Physical stabilization and 3) Chemical stabilization.

2.4.5 Tile vaulting building technique

Block et al. (2010) studied Tile vaulting building technique. They illustrated that this technique was adopted as an un-reinforced masonry construction method with a 600 year tradition in the Mediterranean, where the bricks have traditionally been made from fired clay.

Block et al. (2010) discussed in their paper the potential of tile-vaulted systems which make use of local material, and follow the tradition of compressed earth block (CEB) construction in Africa to meet the need for more sustainable construction technology in the field of low-cost housing. Block et al. (2010) illustrated some of the techniques used in mud building in the roofing or (Tile vaulting). They defined Tile vaulting as a construction

technology requiring little to no formwork as well as minimal material for the shell. The technology was developed during a period in which building with local material was a necessity, and not merely fashionable. Such frugal practice is rapidly becoming a necessity again.

Sassu Mauro (2005) illustrated common techniques used to improve seismic resistance of masonry structures include the addition of reinforcement, usually in the form of wooden planks, or steel bars or ties connecting the walls to the floors, and ring beams ensuring structural integrity.

Block et al. (2010) illustrated that to construct a brick vault between parallel walls one of several different vaulting methods may be considered (Figure 2.2). European style vaults would provide a durable solution from local materials, though excessive formwork (centering) should be avoided to protect scarce timber resources in many African locations.

Mediterranean tile vaulting makes use of thin ceramic tiles for structural vaults in which minimal centering is required during construction. This type of construction flourished in medieval Spain, and was successfully imported to the United States by the Spanish immigrant, architect and engineer, Rafael Guastavino (1842-1908). Such type of building has high load capacity, fire resistance, and long spans, these structures were a cost-effective solution to spanning space. Tile vaulting is a construction technology requiring little to no formwork as well as minimal material for the shell. The technology was developed during a period in which building with local material was a necessity, and not merely fashionable. Such frugal practice is rapidly becoming a necessity again. This system employs typically three layers of thin brick, the first of which is set with a fast-setting Plaster-of-Paris mortar, with subsequent layers built with a typical cementations mortar. The tiling pattern is altered in each layer to prevent tile joints from being continuous

between layers and to establish a strong structural bond. The flat bricks are typically 3cm thick.

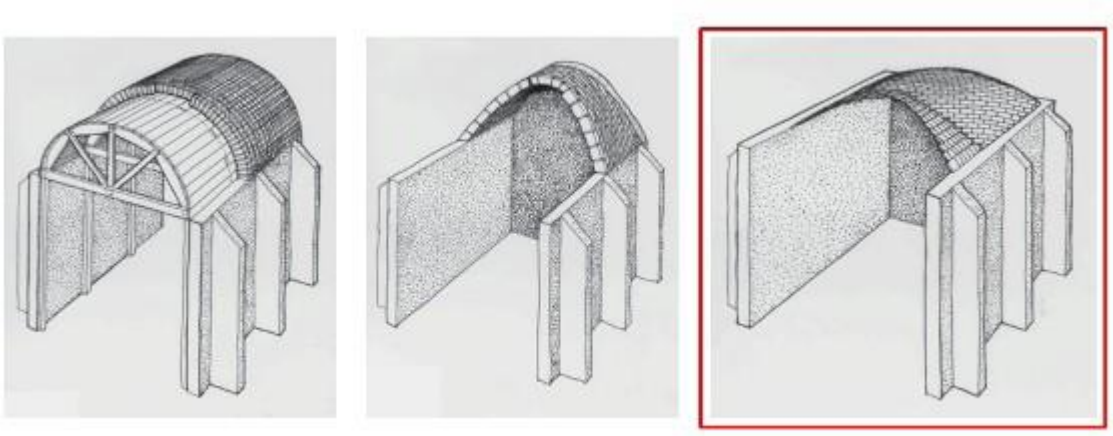

Figure 2.2: Brick vault technique between parallel walls (Block et al., 2010)

2.4.6 Baked-In-situ (Building with Fire)

Kundoo (2008) introduced a study titled as 'Building with Fire'. He illustrated that this title is meant to suggest first and foremost, the literal uniqueness of a technology where fire is introduced to the building construction process, as 'cement' for bonding building elements together permanently. But 'building with fire' is also meant to suggest the passion with which the experiments have been undertaken, and the element of risk involved in the process. This unique technique of 'baked-Insitu' mud structures has recently emerged through the pioneering work of a single person, which is radically innovative. This technology is still largely unknown and undocumented, and has not as yet been assessed for its performance (Kundoo, 2008).

Kundoo (2008) explained that a 'Baked-In-Situ' mud structure can be defined as a house that is primarily built using sun-dried mud bricks and mud mortar as the principal building material, which is fired on site to high temperatures suitable to the locally

available brick clay (ranging from 850-1000°C as in brick manufacture) until the material of the mud brick and mud mortar are transformed to ceramic. Nader Khalili, an Iranian architect who originally envisioned this technology in the late 1970s, named it ‘Geltaftan’; "Gel", means "clay", and "taftan", means "firing, baking, and weaving clay" in Persian (Kundoo, 2008).

2.4.7 Oven-fired clay brick

Buffington and London (2005) clarified that clay Brick or which called oven-fired clay brick is used extensively throughout the developing world for affordable construction. Brick making in both India and Mexico is a traditional, unorganized industry, generally confined to rural and suburban areas. Like CEB, clay brick can be used for simple construction with little or no need for reinforcement in areas that are not seismically active. Brick is also commonly used for non-load bearing walls in apartment buildings and other larger construction projects.

2.5 History of mud building

Earth as a construction material has been used for thousands of years by civilizations all over the world. Many different techniques have been developed; the methods used vary according to the local climate and environment as well as local traditions and customs. As a modest estimate it is thought that as many as 30% of the world’s population lives in a home constructed in earth.

Auroville Building Centre (2005) explained that the new development of earth construction really started in the nineteen fifties, with the technology of the Compressed Stabilized Earth Blocks (CSEB): a research Programme for affordable houses in Colombia proposed the first manual press–the Cinvaram. Since then, considerable scientific researches has been carried out by laboratories. The knowledge of soil laboratories concerning road building was adapted to earth construction.

Since 1960 – 1970, Africa has seen the widest world development for CSEB. Social programmes and prestige demonstration projects are not computable anymore. Africa takes, these days, a further step with semi industrialization and standards. India developed CSEB technology only in the nineteen eighty's, but sees today a wider dissemination and development of CSEB. The soil, raw or stabilized, for a compressed earth block is slightly moistened, poured into a steel press (with or without stabilizer) and then compressed either with a manual or motorized press. The input of soil stabilization has made it possible to build higher with thinner walls, which have a much better compressive strength and water resistance. With cement stabilization, the blocks must be cured for four weeks after manufacturing. After this period of time, they can dry freely and be used like common bricks with a soil cement stabilized mortar (Auroville Building Centre, 2005)

2.6 Techniques used to constructed mud building

Buffington and London (2005) introduced that in both ancient times and today in many developing countries, builders have relied on two primary earth-building techniques. One, commonly referred to as "slip-form", involves the building of walls in place using frames. Mud is packed into a long rectangular form to create a section of wall. Once it dries and becomes hard, the form is used again to place another section of wall on top of it. In this manner, the structure is built from the bottom up in a series of two- to three-foot high sections. The horizontal lines left by this approach are clearly visible in housing throughout the world. A second technique involves the use of forms to make individual blocks, which harden and are then stacked into place once construction begins. Due to the low cost and the fact that these techniques lend themselves well to building by the homeowner, these types of mud construction have remained popular in many parts of the developing world. It has been estimated that half of the developing world lives in houses that rely on mud during construction.

2.7 Traditional Yemeni clay buildings

Al-sakkaf (2009), introduced some examples of towns built from earth/ mud bricks. He illustrated that the tradition of mud-brick architecture in the Hadhramout region in Yemen offers a unique source of cultural and technical knowledge. It is rich in its variety; for example, the traditional houses in Shibam city are built of mud-brick on stone foundations (Figure 2.3). Walls are tapered on the outside from about 1 m thick at the bottom to less than 30 cm at the top (Lewcock, 1986) [cited in: Al-sakkaf, 2009)]. The top one or two levels of all the buildings are protected from rain by white lime plaster.

Figure 2.3: Shibam, city in Wadi Hadhramout/Yemen (Doan, 2007) [cited in: Al-sakkaf, 2009]

2.8 Mud building construction cost

Rodriguez et al. (2002) illustrated that in respect to economical point of this construction it was found that, the unit construction cost per m^2 of built-up area is approximately US$ 137. The typical amount and skill-level of labour employed in the construction of a typical building of this type of housing is 380 man-days (assuming 8 working hours/day). Experience is required in the selection of the land. Knowledge is necessary about the adequate mix proportions to manufacture the adobe blocks, and about

foundations, plinth structure, top reinforcement beam, and round log. The tools needed in this construction type are not many: shovels, baskets, hoes, pliers, spatulas, etc.

2.9 Mud building sustainable construction

Revuelta-Acosta et al. (2010) explained that sustainable construction is achieved using natural resources, such as adobe, in such a way as to meet economic, social and cultural needs, but not depleting or degrading these resources to such an extent that they cannot meet these needs for future generations. Besides, they illustrated that earth is a cheap, environmentally friendly and abundant building material and has been used extensively for construction around the world. Today the prevalence of earth as a building material may be attributed to its proven durability demonstrated by the number of ancient earthen buildings that remain standing today. An adobe has low thermal conductivity and high heat capacity enabling earthen building thermal stability compared with concrete building.

2.10 Characteristics adobe building in Argentina

Rodriguez et al. (2002) illustrated that the blocks of walls used in the adobe building has strength of 3 kg/cm² - 10 kg/cm² of clayey soil and thatch materials. These walls are joined with mud and have the following characteristics: (1) resistance to compression, (2) resistance to flexion. Rodriguez et al. (2002) introduced the main architectural aspects and characteristics of adobe building in San Juan.-Argentina that are the following;

2.10.1 Siting

These buildings are typically found in flat terrain. They do not share common walls with adjacent buildings. When separated from adjacent buildings, the typical distance from a neighboring building is 5 meters.

2.10.2 Building Configuration

The typical shape of a building plan for this housing type is rectangular. The typical house has approximately seven openings, with an average area of 1.60 m². These openings are: 5 (five) windows, placed in the middle of the walls, and 2 (two) doors. The doors are placed to one side of the wall. The opening area is about 10.40% of the whole wall area.

2.10.3 Functional Planning

The main function of this building typology is single-family house. In a typical building of this type, there are no elevators and no fire-protected exit staircases. Usually, there are 2 doors to one side in the building.

2.11 Characteristics of mud building

Arumala and Gondal (2008) concluded that the suitability of the soil in the compressed Earth Block (CEB) depends on its constituents that are sand, silt and clay proportions. Too much clay will cause cracks in the blocks while too much sand will cause the blocks to crumble. The suitable soil must contain the right proportions of sand, silt, clay and water

2.11.1 Soil suitability and stabilization for CSEB

Arumala and Gondal (2008) used the following proportions to manufacture the CEB in their research. They discovered, also that blocks that they made were enhanced by the addition of 5% of ordinary Portland cement that become compressed stabilized earth block "CSEB".

Gravel:0- 40%

Sands: 25-80%

Clay: 8-30%

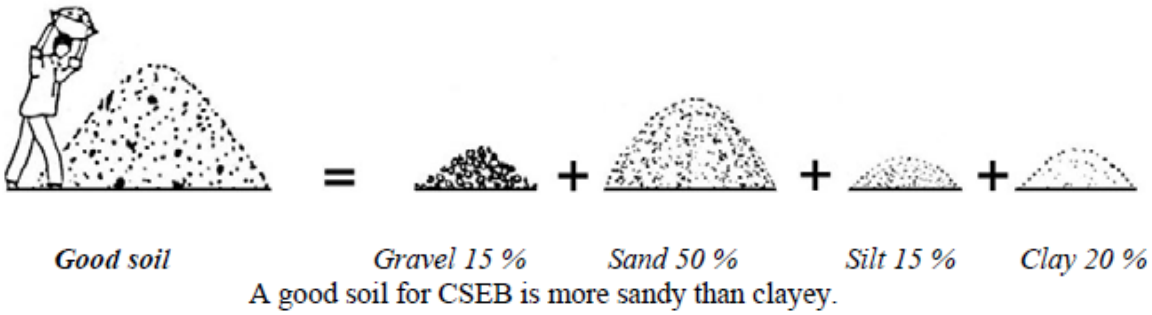

Figure 2.4: Components of good soil CSEB blocks (Doan, 2007) [cited in: Al-sakkaf, 2009]

A soil contains four components: gravel, sand, silt and clay this illustrated in figure 2.4. In concrete, the binder of gravel and sand is cement. In a soil, the binder is silt & clay. But silt and clay are not stable in water. Thus, the aim of stabilization is to stabilize silt and clay against water, so as to give lasting properties with the minimum of maintenance. Topsoil and organic soils must not be used. Identifying the properties of a soil is essential to create, at the end, good quality products. Not every soil is suitable for earth construction and CSEB in particular. But with some knowledge and experience many soils can be used for producing CSEB (Auroville Building Centre, 2005).

2.11.2 Stabilizers of mud materials

Jaquin (2009) illustrated that in many parts of the developing world, cement is added to earth bricks to improve their durability and strength. The majority of research into cement stabilization has been heuristic and the reasons for successful or unsuccessful experiments have not been effectively probed. An understanding of the behavior of water in earth structures allows a better comprehension of how the cementing reaction continues within earth bricks. Jaquin (2009) illustrated that there are many studies such as (Minke 2007, Houben and Guillaud 1994) have shown that the strength of mud brick buildings increases with increasing cement content up to critical cement content, beyond which the strength reduces with increasing cement content. The reasons for this peak cement content

have previously been unclear. Two aspects competing for water within the earth structure; these are the cement reaction, which requires water to form the cementing products, and the formation of liquid bridges which are a result of the relative humidity of the surrounding air. As a result of evaporation of water from the cement stabilized sample, there is insufficient water to form the cementing products, leaving unreacted cement powder within the bricks, which do not contribute to strength. Any increase in volume of cement within a brick will not lead to an increase in strength because there is insufficient water with which to form a cementing matrix.

2.11.3 Ratios stabilizers

Al-sakkaf (2009) studied in his research the relationships between soil properties, several stabilizers and their compressive strength and density using local soil taken from site at city of Penang in Malaysia. He used hydraulic machine to cast stabilized compressed earth blocks with the five percentages of each stabilizer, and these blocks were tested at (1, 7 and 28 days).Compressive strength results showed the best result and the appropriate percent of each stabilizer were chosen. These percentages are 10% cement, 5% lime, 6% (of the used cement) bitumen and 0.75% (of the used cement) calcium silicate. A mix of 10% of cement and 5% of lime is recommended. He conducted laboratory tests to investigate the properties and performance of the blocks in its normal conditions.

Auroville Building Centre (2005) explained that many stabilizers can be used. Cement and lime are the most common ones. Others, like chemicals, resins or natural products can be used as well. The selection of a stabilizer will depend upon the soil quality and the project requirements:

Cement will be preferable for sandy soils and to achieve quickly a higher strength.

Lime will be rather used for very clayey soil, but will take a longer time to harden and to give strong blocks. The average stabilizer proportion is rather low: Cement

stabilization = 5% average. The minimum is 3% and the maximum is 8% (only for cost reasons). Lime stabilization = 6% average. The minimum is 2% and the maximum is 10% (for technical reason).

2.11.4 Compressive strength mud building

Al-sakkaf (2009) found that the compressive strength of the compressed earth blocks for five samples at 180 days prospectively for cement, lime, lime with cement, calcium silicate, and bitumen, were 13.2 N/mm2, 6.4 N/mm2, 16.3 N/mm2, 11.7 N/mm2 and 12.6 N/mm2 while it were 3.8 N/mm2, 1.5 N/mm2, 3.5 N/mm2, 2.8 N/mm2 and 3.4 N/mm2 for the manually cast blocks.

2.12 Advantages of building in mud materials

Kundoo (2008) illustrated that building by mud material (clay materials) have many advantageous implications. The economic sustainability means creation of new markets and opportunities for growth of sales; cost reduction through efficiency improvements and reduced energy, and raw materials use; and creation of additional added value. Using locally available low energy materials and helping the money to remain in the local economy by increasing the labor component of the building cost, and by creating value addition in both, the structure as well as the products.

Harris (2010) explained that building with mud brick or block in particular, requires little or no specialist skills. The process is labor-intensive and the work is often heavy, but it can be phased to suit both the weather and the availability of helpers. In Australia, where owner-builders have elevated ‘muddies’ into something of an art form.

Revuelta-Acosta et al. (2010) concluded that the worldwide tradition of earth construction has shown that it is possible to achieve long lasting and majestic buildings from single to multi storey. One of the main advantages of adobe is that the raw materials are locally available. In fact adobe may be produced from the soil excavated from the building site reducing transportation and other energy intensive processes. Adobe low thermal conductivity provides a more stable temperature behavior inside a house and reduces heat losses. Moisture content in adobe has been proposed as new trends to gain fundamental knowledge about the thermal behavior of earth building.

Kundoo (2008) illustrated additional advantages of building with clay or mud materials that are related to the dimensions of Social Sustainability. Some of these advantages are; worker health and safety; impacts on local communities, quality of life; and benefits to disadvantaged groups. Besides, giving unskilled labor ample opportunities to find work, while also providing jobs to the local potter whose lively hood is threatened by the plastics and metal industries that are replacing the products that potters used to provide. These benefits are 1) Generating employment 2) Local materials replacing building materials from industries 3) House as a generator of building materials, rather than a consumer 4) Environmental Implications and Sustainability

Kundoo (2008) illustrated also that the technique of baked-Insitu mud construction has several advantages. The structures this built have high compressive strength, have good thermal properties, use mainly local materials and mostly local earth thereby significantly reducing imported materials with high embodied energy. The technology is energy efficient, uses environmentally preferred materials as fuel, and does not generate unwanted ‘waste’ even upon demolition. The construction involves low-tech equipment and tools, and is labour-intensive, and does not add to the demand on existing infrastructure or necessitate the creation of new infrastructure. Thus the technique can be considered to be environmentally sustainable. The technology is low-cost and labour-intensive, and its

production generates financial returns through simultaneous manufacture of building materials and ceramic products to be fired inside it. The process of firing products inside the house brings added value to the structure by turning it into ceramic and making it durable as compared to other mud structures. Thus the technique can be considered to be economically sustainable. As the process of its construction is labour-intensive and generates further more employment through the simultaneous production of building material, and provide direct benefits in upgrading the quality of life of those who couldn't have afforded a 'standard' house; the technique can also be considered as socially sustainable.

Zami and Lee (2008) summarized the advantages of earth construction in urban housing such as:

1. Earth construction is economically beneficial,
2. It requires simple tools and less skilled labour,
3. It encourages self-help construction,
4. Suitable for very strong and secured structure,
5. It saves energy,
6. It balances and improves indoor air humidity and temperature which ensures thermal comfort,
7. Earth is very good in fire resistance,
8. Erath construction is regarded as a local job creation opportunity,
9. Earth construction is environmentally sustainable,
10. Earth wall (loam) absorbs pollutants,
11. Easy to design and high aesthetical value,
12. Earth building provides noise control,
13. Earth construction promotes local culture and heritage and others.

Arumala and Gondal (2008) explained that using local soil on a building site has many advantages. Firstly, it eliminates transportation costs. Compressed earth blocks are inexpensive, strong, made with locally available materials and are dimensionally uniform.

Workers with little prior building knowledge and experience can be used for the wall construction. Moreover, Arumala and Gondal (2008) showed also that compressed earth blocks are resistant to sound transmission, fire, insect damage and durable if properly protected. The mass of the compressed earth block walls makes the walls energy efficient systems. Little energy is needed for their production compared to other wall systems and soil is an environmentally friendly material.

2.13 Disadvantages of mud building/ Barriers and challenges to use Mud building

Lal, (1995, P.120) [Cited in: Zami and Lee (2008)] explained that the majority of disadvantages (i.e. problems of earth wall erosion by rain and flood water, rodents making holes in wall and floor, and poor performance during earthquake) associated with mud houses (un-stabilised earth) can be overcome by suitable improvements in design and technology, such as soil stabilizations, appropriate architecture, and improvement in structural techniques. Besides, Kundoo (2008) illustrated that there are also several limitations to construct mud building. The structure is prone to rain damage being extremely vulnerable to water. It can also therefore not be built throughout the year. The structure is limited to forms suited to compression structures and also to kiln systems. Some problems of technical supervision and quality control. Rodriguez et. al (2002) illustrated that deficiency in adobe type of construction is that the adobe blocks deteriorate due to prolonged exposure to humidity.

Zami and Lee (2008) summarized the disadvantages of earth construction, besides; they believed that stabilization can help to overcome these disadvantages. Some of these disadvantages are:

1. Less durable as a construction material compared to conventional materials,
2. Earth construction is labour intensive,
3. Mud houses behave poorly in the event of earthquakes,
4. Structural limitations,
5. Need high maintenance. Loam is not a standardized building material,
6. Special skills needed for plastering. Need higher wall thickness,

7. Suitable only for in sit construction.

Zami and Lee (2008) concluded that in the case of addressing the urban housing crisis the disadvantages of earth construction can be overcome by the adoption of appropriate stabilised earth construction such as, rammed earth (RE) and compressed stabilised earth block (CSEB), stabilised adobe and other contemporary stabilised earth construction techniques.

2.13.1 India model disadvantages

Kumar (2002) explained that the building type of rural mud house is classified as grade-A (most vulnerable) per the IAEE building classification and IS Code 1893:1984. This is a low-strength masonry construction and it is considered extremely vulnerable to seismic forces. Buildings of this construction type can be found in all parts of rural areas in India. Variations of this type of construction are found all over India except where very high rainfall is experienced. This construction type has been in practice for more than 200 years. Currently, this type of construction is being built. Figure 2.4 shows this type of building.

Figure 2.5: Grade-A (most vulnerable) per the IAEE building classification (India)

This sensitivity to water and lack of durability in its untreated form highlights the main barrier to the widespread use of compressed earth as a building material. To prevent this, the wall surface must be protected by the application of rain resisting "plaster" to prevent this type of deterioration, and walls need to be protected from wind-driven rain by an appropriate overhang of the roof over the walls. A cement-clay (1:1) plaster could be used to reduce costs (Arumala and Gondal, 2008).

2.13.2 Bangladesh model disadvantages

Das et al. (2007) introduced another model of the building by mud. This model was in Bangladesh. They illustrated that in Bangladesh, a mud house is one of the traditional housing types that are used by poor families' mainly in rural areas as well as in the outskirts of small cities. This building type is typically one or two stories and preferably used for single-family housing. It is more predominant in less flood prone areas, i.e. in the highlands or in mountainous regions. The masses of these buildings are generally high and their walls are characterized by insignificant strength, particularly against forces that act out-of-plane. This type of building is highly vulnerable to both seismic forces and high pressures due to flood flow. The main load bearing system consists of mud walls of 1.5 to 3.0 ft thickness, which carry the roof load. Clay tiles, thatch or CI sheets are used as roofing materials. The application of these materials depends on their local availability and the ability of the house owners. There is no monolithic joint between the wall and the roof. For this reason, these buildings behave poorly under any type of lateral load (e.g. earthquake, wind). Figure 2.6 shows the case illustrated by Das et al. (2007).

Figure 2.6: The case illustrated by Das et al., (2007).

2.14 Barriers face the construction with mud materials

2.14.1 Barriers associated with equipment

Buffington and London (2005) clarified that some of the barriers that face the construction with mud or clay materials are the related to the equipment and machines used to produce the blocks. These machines have been working well enough to build a few small structures, including a dairy processing plant, but not well enough for the machine shop to comfortably provide warranty support. Problems have included slower than expected block production and overheating, for which improper installation or maintenance of the hydraulics have been suspected as the likely culprit.

2.14.2 Barriers associated with using soils

Arumala and Gondal (2008) explored the possibility of using soils for making compressed earth blocks for constructing affordable residential buildings, using relatively cheap and locally available technology. What he found was blocks made using this approach satisfied code requirements for compressed earth block one-storey housing

construction. What his work also showed was that using small amounts of additives, such as agricultural fiber – readily available in many developing countries could also make a significant and positive impact to the performance of the blocks.

2.14.3 Barriers associated with skilled labors

Block et al. (2010) concluded that construction with clay or CEB building in the roofing has many barriers. Some of these barriers related to the needs of skilled labors in the implementation besides, the critical needs for the experienced supervising staff who will control and monitor the process it self. Besides, one of the most crucial challenges related to the safety requirements. The authors stressed also on the critical concern regarding material testing, standards and building codes need to be developed for testing purposes, which should not be dependent on expensive laboratory equipment.

2.14.4 Barriers associated with design details

Ramage et al. (2010) showed that the biggest challenge in constructing tile vaults using compressed Stabilized earth block CSEB made of local earth and sand mixed with 5% cement and pressed using a modified Hydra-form block press is the deep attention in the design details, the time to lay the tiles to ensure they are placed in exactly the correct angle, pitch and direction that takes a lot of concentration. Moreover, the construction requires close attention.

2.14.5 Barriers associated with training

Ramage et al. (2010) illustrated that training new people on the vaults meant more breaking down and repairing of low quality work, more building waste, more loss of time and less aesthetic appeal. Over the eight-month course of building the vaults, there were nearly a hundred people trained in the tile-vaulting technique. Constructing the vaults took significant project management where close coordination between the contractor and the design team was required to avoid idle workers and unnecessary delays. Besides, the team

building, cultural resistance and different skills levels are observed critical challenges facing the construction in this type of work.

2.15 Benefits from the construction using earth material

Ramage et al. (2010) concluded several benefits obtained from the construction using earth materials such eliminating steel reinforcement in the construction by using dome or arch systems. They expect longer life span without concern for deterioration due to corrosion. The passive environmental has benefits for more conventional solution. The building costs at least 30% less than a conventional solution, and benefits the local population through using predominantly local labor with the added benefit of a tangible skills transfer. Besides, better understanding of which forms are better for training and skill-building are gained. Figure 7 and 8 shows the construction technique used by Ramage et al. (2010).

Figure 7 and 8: The surfacing of all of the masonry in local rubble stone creates a timeless quality, as if they had erupted from the earth in a geological event [Source: Ramage et al. 2010].

Auroville Building Centre (2005) illustrated the advantages of CSEB in respect Cost effectiveness. CSEB are generally cheaper than fired bricks. This will vary from place to place and specially according to the cement cost. The cost break down of a 5 % stabilized block will depend on the local context. In India with manual equipment (AURAM press 3000), it is usually within these figures: Labor: 20 - 25 %, Soil & sand: 20 - 25%, Cement: 40 - 60 % and Equipment: 3 - 5 %

Michael and Taub (2010) studied the problem and potential of sustainable design in Rwanda; they found that Rwandan case studies show that expensive and foreign technologies are not needed to make significant contributions to sustainable design. Using local materials, local labor, and informed architectural strategies such as natural ventilation, is possible to expand the impact of design to areas of health, education, and policy. In addition, choreographing the economic impacts of infrastructure development could allow for new economic opportunities, better environmental performance, and positive social change. They believed that environmental sustainability alone cannot be considered as the primary means by which architecture can revolutionize development. While low-cost and locally available techniques like natural ventilation represent an eco-conscious approach to the design. If architecture serves the poor, then building and the building process must do more than construct walls and roofs.

2.16 Construction Mud Building in the Gaza Strip

After the last war, the construction with mud building was shown as one alternative to the cement buildings. Some organizations such as UNRWA and Ministry of Public Works and Housing start working in this model of materials.

ECB (2002) illustrated that building Techniques in West Bank and Gaza Strip is influenced by the materials available domestically as well as techniques in neighboring

countries. In general, there are four main kinds of building materials which are widely available in West Bank and Gaza Strip. These are mud or adobe; concrete, concrete block and cut stone. These kinds of building materials can be used individually or together with each other to form the structure of buildings. Mud and adobe are widely used in many Palestinian areas to construct the houses. It is believed that these houses provide the inhabitants with more comfortable internal environment that the new concrete houses built in many areas. Some of the newly constructed concrete houses and others built of mud bricks in West Bank and Gaza Strip showed that the internal temperature in mud brick houses was 5-6 lower than the external temperature. While the internal temperature was only 0.5- 1 deg C lower than the external temperature in concrete blocks houses. Concrete and concrete blocks are widely used in towns and cities. In West Bank and in the particular Northern parts; most houses are built from concrete and concrete blocks. In other cities, most buildings are constructed with concrete columns to transfer the load of the roof to the ground while the concrete or the concrete blocks fill the area between these columns.

2.17 Mud Walls (Unfired Brick) in Palestine

ECB (2002) illustrated that the type of mud walls (unfired brick) is associated with simple stone continuous foundation system. This type of wall is used for all types of buildings such as housing, commercial, farmhouses, convents and monasteries. The building materials used for this type of wall was stones, unfired bricks, earth, wood and pebble. The material used in production is sun-dried clay, which is not hard. This technique is very old, this type of walls were built in Jericho and one of the most known refugee camps called Ein Al-Sultan camp in the Jordan valley was built with mud in 1950s. Walls of this type have good thermal performance, since they are of light material; they serve as good insulation from the weather conditions outside. On the expansion and the extraction level this type is suitable for the weather conditions. Mud walls are to be permanently maintained, since material used in construction is very light and not resistible for the outside natural changes such as sun ,water and vegetation .Those usually cause cracks in

the plaster allowing for water to penetrate , which causes weakness in structure by flushing out the mortar causing the falling after that.

2.18 Frame - Domes in Palestine

ECB (2002) reported that the domes were used in rich houses or in important public or religious building such as mosques, tombs, khans, caravanserai and madras's (schools). This technique is very old one, dating back to Byzantine times in the 5th century .This technique disappeared because of the excessive costs and lack of materials and the skilled workers to do the work. The creation of the new building concepts using concrete made it easier and quicker to construct bigger and higher buildings or domes. The report added 5 meters is a possible spanning structure with this type of frame .In this case, the frame is of 30- 50 cm. There are no specific methods to increase the span, but the thickness of the walls and the frame make it possible to increase the span (the thicker the walls and the frame the longer span one gets).

2.19 Summary of the chapter

This chapter introduced the practices of building with earth materials. The historical background of this practice, the advantages and disadvantages of the earth materials in the construction, the barriers and challenges face the construction with the earth materials, the techniques used in building with these materials was introduced. The use of earth in construction has been significant throughout human history. In addition to the creation of simple shelters, many of the world's great feats of construction involved the use of mud or dirt. The Great Wall of China (246-209 BC) was built of earth along most of its route. Many techniques was used in the building with earth materials, some related to the materials itself such as adobe mud blocks, Cob, Adobe, CEB, CSEB, baked-Insitu mud, fired clay or oven-fired clay brick while others related to the structural implementation such as using arch, domes, frames, vaults, mix clay and corrugated iron sheets(CI) used as roofing materials.

The mud building (earth materials) has many advantages such as: economically beneficial, it requires simple tools and less skilled labor, it encourages self-help construction, suitable for very strong and secured structure, it saves energy, it balances and improves indoor air humidity and temperature which ensures thermal, comfort, Earth is very good in fire resistance. In the other direction it has many disadvantages that represent real challenges such as: Less durable as a construction material compared to conventional materials, earth construction is labour intensive, mud houses behave poorly in the event of earthquakes, Structural limitations, need high maintenance. Loam is not a standardized building material. Special skills needed for plastering. Need higher wall thickness, suitable only for in situ constructions.

3 METHODOLOGY

This chapter discusses the methodologies used in this research. These methodologies include information about the research design, population, sample size, data collection, questionnaire design, questionnaire content, instrument validity, pilot study, and the method of processing and analyzing the data. Four research methodologies were conducted in this research; each one will be discussed in details in the next sections.

3.1 Research design

The purpose of any research is to discover answers to questions through the application of scientific procedures. In line with this and as stated in chapter 1, the main purpose of this research is to review the mud building systems, to evaluate barriers/challenges of constructing mud building in the Gaza Strip, to investigate the techniques used in mud building practices, to evaluate failure/success of implementing the mud building in the Gaza Strip, UNRWA & Ministry of Public Works and Housing (MPWH) as case study and to identify the practical benefits of constructing mud building and its applicability in the Gaza Strip.

3.2 Methodologies

In this research, four research methodologies were conducted, the first approach was questionnaire approach targeted the categories participated in the mud building practices and specially the companies that participated in the construction of UNRWA and Ministry of Public Works and Housing. The second approach was structured interview with the companies implemented this mud building works. The third approach was a case study

at two projects implemented using clay or mud materials, while the fourth approach was by reviewing the studies and literatures in this area.

3.2.1 Comprehensive literature review

- The fourth approach was a comprehensive literature review of the studies dealt with the mud building practices in Arab and non Arab countries. The lessons learnt were very fruitful to be examined in our research.

3.2.2 The questionnaire approach

- The questionnaire approach was used to collect the factual, perceptive and attitudes of the respondents, in addition, the questionnaire was used as a quantitative approach to understand people's perception regarding the practices of mud building in Gaza Strip construction projects.

3.2.3 The structured interview

- The structured interview with Fourteen companies participated practically in the construction of mud building was targeted in this part. The benefits expected from the diversity of these research methodologies is to triangulate and strength and verify the obtained results in more than one resource.

A structured interview is a technique to collect information from respondents through an interactive, verbal, real time contact. It is often used as a first step in collecting information for a needs analysis, is a qualitative research method commonly employed in survey research. The aim of this approach is to ensure that each interview is presented with exactly the same questions in the same order. This ensures that answers can be reliably aggregated and that comparisons can be made with confidence between sample subgroups or between different survey periods (Kvale& Brinkman. 2008).

Interview scan be used to (1) provide information to develop the questions for a written survey questionnaire; (2) as a stand-alone method for producing information for subsequent analysis; or (3) in conjunction with other data-gathering methods in order to correlate and validate information obtained through multiple data gathering methods (McClelland, 1995). There are three types of interviews that are applicable for gathering needs analysis information: structured, semi structured, and unstructured. The depth and extent of information and feedback being sought for a particular needs analysis will determine which type to use (EMRA, 1998).

The structured interview with Fourteen companies participated practically in the construction of mud building was targeted in this part. The benefits expected from the diversity of these research methodologies is to triangulate and strength and verify the obtained results in more than one resource. Respondents were divided on their views to answer separate groups according to the question directed to them, through the answers was to clarify the vision and attitude of the contractors according to questions

Four open Questions for investigating the applicability of using mud materials in the construction industry in the Gaza Strip. The structured interview contents some open questions, to be answered by the contractors. This research intends to review mud building system, to evaluate barriers/challenges of constructing mud building in the Gaza Strip, to investigate the techniques used in mud building practices, to evaluate failure/success of implementing the mud building in the Gaza Strip.

3.2.4 The Case study approach

- The Case study approach was used also in this research. One UNRWA project was studied that has been tendered and implemented in the year of 2010. This case study includes the architectural and structural models used in this project, the techniques used in building as well as background and justifications to use this type of buildings. The second case was analyzed from the Ministry of Public Works and Housing. In fact the researcher faced a huge of difficulties in gather the data and information related to this

case study of the Ministry of Public Works and Housing. In fact there was no clear filling system that might be used as guidance. This approach was considered supportive and efficient approach to obtain actual and real information about the mud building in the construction projects in the Gaza Strip.

3.3 Research period

The study started on October 2010 when the initial proposal was approved. The literature review was completed on 1st February 2011. The case study, validity testing, structured interview and questionnaire distribution and collection took two month and half and completed on the beginning of April 2011. The study was carried out in Gaza Strip contractors and clients. The analysis, discussion, conclusion and recommendation was completed on the beginning of June 2011.

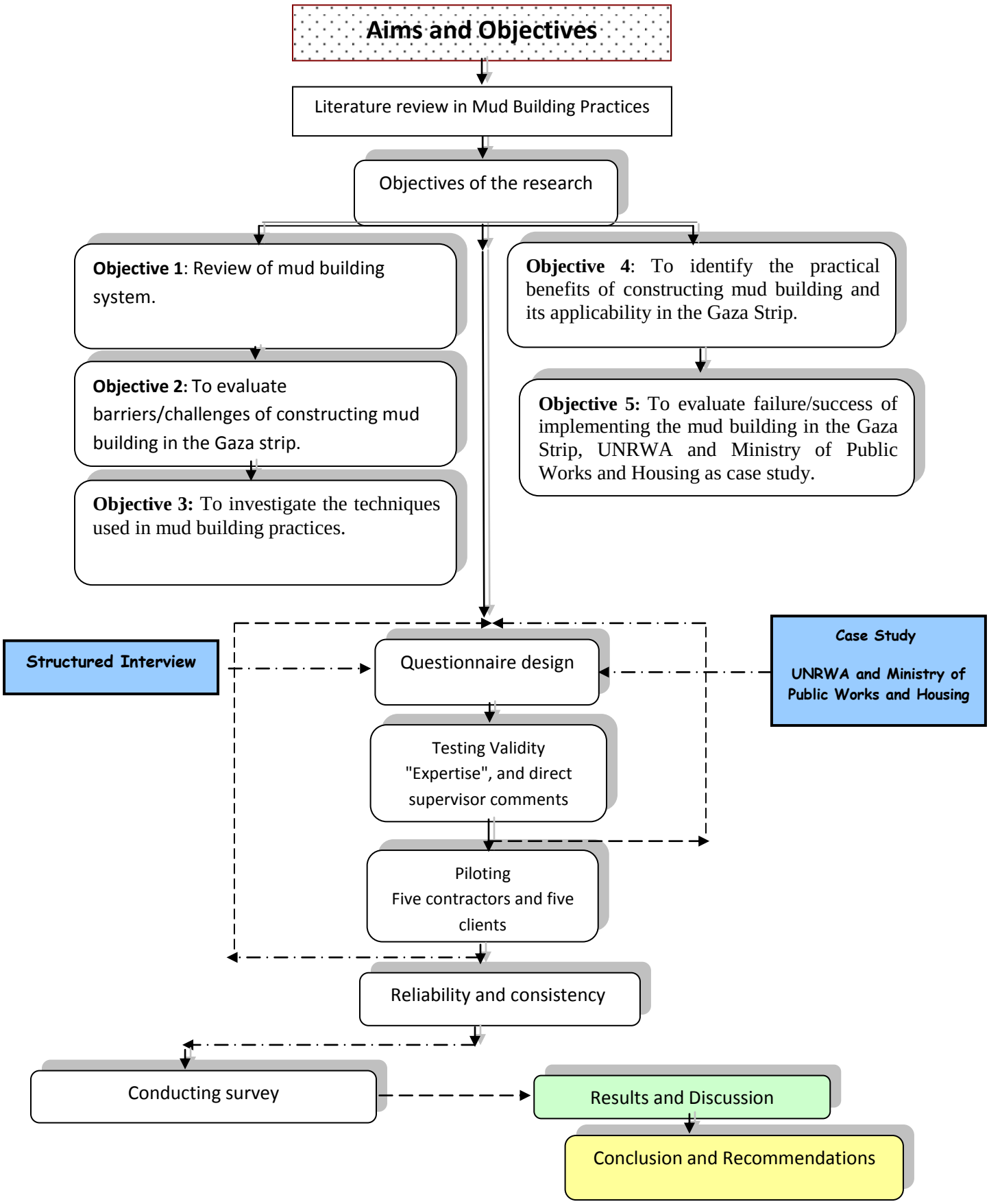

Figure 3.1: Flow chart of Methodology

3.4 Research Population and Sample size

The population targeted in this research included just about all parties (contractors and clients) either implemented mud buildings or participated in the process of this work. The population includes the invited categories in such works by UNRWA and other clients. Besides, the contractors implemented privet works such as (Al Dera Hotel, Museum Restaurant, Police centre in B-Lahya and Mabarra Al Rahma institution).

After deep investigations and survey, the researcher found that UNRWA is the only organization that has a systematic and organized process in the mud building overall stages of the project life cycle. The clients and contractors who operated in this work rather than UNRWA and Palestinian Contractors Union "PCU" contractors was targeted in this research. To the knowledge of the researcher approximately all the contractors and clients participated in this work was targeted.

The total population was targeted in this research is as follow; the first population is the contractors classified in PCU categories and who were invited to participate in the mud building projects by UNRWA and other clients. Unfortunately, there was no clear solicitation method in any of the clients work on the mud building except UNRWA project. The researcher exerts huge effort to identify the contractors invited in all mud building by all clients. After the deep investigation, it was found that these categories are 1st, 2nd and 3rd building categories in addition to some contractors who were directly awarded some of these construction contractors. After the deep study the invited contractors and all other contractors who have good or partial experiences in this work were targeted in our research. The total number targeted in our research via the questionnaire was 48 contractors; fourteen of this sample who executed mud building was interviewed via structured interview.

3.5 Sample size

Fellows and Liu, (2007) defined the sample as a part of total population that represent this population. Israel (2003) explained that, there are several approaches to determining the sample size. These include using a census for small populations, imitating

a sample size of similar studies, using published tables, and applying formulas to calculate a sample size.

As the sample size in our research is the parties that participated or collected the tender documents of mud building, as well as the parties that have partial or good experiences in the mud building practices, the sample size was not so large.

Table 3.1 Summarize the number of contractors participated in mud building overall Gaza Strip.

Table 3.1: Contractors population, sample size and response rate

Contractors		**Clients**
Participated with UNRWA	**With Other Clients**	**Clients operated in Mud practices**
1st, 2nd and 3rd	1st , 2nd and 3rd	5
33	15	
Total = 48		5

Forty eight questionnaires were distributed to all contractors that were believed aware and participated in mud building practices in construction industry in the Gaza Strip. The response was very high (as the researcher exerted huge effort to obtain the reply of all targeted party).

Out of the five clients operated in mud building two were targeted via case study analysis to investigate the techniques used, barriers and models set out in these construction projects. These two clients were UNRWA and Ministry of Public Works and Housing.

3.6 Questionnaire and structured interview design

In the early stage of designing the questions used in questionnaire and structured interview, draft was prepared and reviewed with the supervisor. The questionnaire includes four sections. The first section was designed to obtain the organizational profile for the contractors participated in the mud building, the second section was designed to obtain some facts and data regarding the mud Building practice in Gaza, the third section was designed to obtain the barriers and challenges face the contractors in constructing mud building while the fourth section was designed to evaluate the benefits/successes obtained of construction mud building.

In the structured interview, the questions were designed to investigate the practical and actual cases done by the company's implemented mud building in the construction industry in the Gaza Strip. This structured interview includes three sections. The first section was designed to obtain the organizational profile and general information about the companies, the second section investigates practically the type of mud building practice in Gaza Strip while the third section asked the companies implemented these muds building regarding the challenges/factors affecting the use of mud building in the Gaza Strip.

The questions used were extracted from actual cases from the literature review and the cases studied locally in the Gaza Strip. The researcher relies on many papers, researches and reports such as;

Sassu Mauro (2005), ecb (2002), Harris (2010), Block et al. (2010), Kundoo (2008), Rodriguez et al. (2002), Al-sakkaf (2009), Revuelta-Acosta et al. (2010), Jaquin (2009), Zami and Lee (2008), Arumala and Gondal (2008), Buffington and London (2005), Ramage et al. (2010) and others.

The questionnaire and structured interview were developed and distributed to the contractors in Arabic and English languages. The researcher believes that, this is much effective and easier to be understood to get more realistic results. Respondents were given

the choice to address their names. They were asked to give a frank and honest account of their opinions.

3.7 Questionnaire and structured interview content

The questions were provided with a covering letter explaining the purpose of the study, the way of responding, the aim of the research and the security of the information in order to encourage a high response. The questions included three types. A multiple choice question: which used widely in the questionnaire, numeric open-end questions, text open-end questions, and agreement scale questions. The variety in these questions aims first to meet the research objectives, and to collect all the necessary data that can support the discussion, results and recommendations in the research.

3.8 Instrument validity and reliability test

Heffner (2004) explained that, validity refers to the degree in which our test or other measuring device is truly measuring what we intended it to measure. Polit and Hungler (1985) give another definition, "Validity refers to the degree to which an instrument measures what it is supposed to be measuring". High validity is the absence of systematic errors in the measuring instrument. When an instrument is valid; it truly reflects the concept it is supposed to measure. Achieving good validity required the care in the research design and sample selection (Fellows and Liu, 2007).

Statistically, to insure the validity of the questionnaire, two statistical tests were applied. The first test is Criterion-related validity tests (person test) which measure the correlation coefficient between each item in the field and the whole field. The second test is structure validity test (person test) that used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. It measures the correlation coefficient between one filed and all the fields of the questionnaire that have the same level of similar scale. The P- Values were less than the significance level of 0.05 and 0.01, so the correlation coefficients of the fields are significant at $\alpha = 0.01$

or $\alpha = 0.05$ and statistically, it can concluded that the fields are consistent and valid to measure what it was set for.

Reliability of an instrument is the degree of consistency with which it measures the attribute it is supposed to be measuring (Polit and Hunger, 1985). The test is repeated to the same sample of people on two occasions and then compares the scores obtained by computing a reliability coefficient (Polit and Hunger, 1985). For the most purposes reliability coefficient above 0.7 are considered satisfactory. Period of two weeks to a month is recommended between two tests (Burns and Groves, 1987). Due to complicated conditions that the contractors are facing at the time being, it was too difficult to ask them to responds to our questionnaire twice within short period. Barakat (2007) explained that, overcoming the distribution of the questionnaire twice to measure the reliability can be achieved by using Kronpakh Alph coefficient and Half Split Method through the SPSS software.

Measuring the reliability by using the half split method showed that the corrected correlation coefficients values are between (94.1%) and (97%). This emphasizes that, according to the half split method, the results and questionnaire are reliable. Besides, The Kronpakh Alph coefficient was in the range from (90.3%) and (86.4%), This range is considered high; the result ensures the reliability of the questionnaire.

3.9 Data processing and analysis

The collected raw data was first sorted, edited, coded and then entered into computer software using SPSS software. Appropriate graphical representations and tables were obtained to understand and analyze the questions. The ordinal scale was used in the analysis process. The ordinal scale is a ranking or rating data which normally uses integers in a seconding or descending order. The Relative Importance Index (RII) was used in the analysis in addition to other approaches such as the t-test and frequencies and percentiles.

Likert scaling was used for ranking questions that have an agreement levels. The respondents were asked to give their perceptions in group of questions on five-point scale (1, for the strongly disagree to 5 for the strongly agree), which reflects their assessment regarding the factors affecting bidding process.

The importance index was computed using the following equation:

Formula Relative Importance Index = $\frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$

Where W is the weighting given to each factor by the respondent, ranging from 1 to 5, (n1 = number of respondents for strongly disagree, n2 = number of respondents for disagree, n3 = number of respondents for neutral, n4 = number of respondents for agree, n5 = number of respondents for strongly agree). A is the highest weight (i.e. 5 in the study) and N is the total number of samples. The relative importance index ranges from 0 to 1

4 RESULTS AND DISCUSSION

This chapter introduces the survey results and the discussion of the questionnaires output for contractors perspectives and attitudes. The questionnaire includes four sections. The first section was designed to obtain the organizational profile for the contractors participated in the mud building, the second section was designed to obtain some facts and data regarding the mud building practice in Gaza, the third section was designed to obtain the barriers and challenges face the contractors in constructing mud building while the fourth section was designed to evaluate the benefits/successes obtained of construction mud building. This results obtained was compared with the relevant literatures and the researcher comments was added.

4.1 Questionnaires Result

4.1.1 General Information

4.1.1.1 Organization profiles

This section includes seven (7) questions that asked about the nature of the company; name of organization (optional), contactors category in Palestinian contracting Union (PCU) classification, organization field of work, number of employees work in the organization, job title of the respondent, years of experience of the respondent, value of executed projects in the last ten years.

4.1.1.2 Contactors category in PCU–classification

Figure 4.1 shows the number and percentage of contractors' categories according to classification of PCU. It is shown that 44% (21) from the companies sample are first category, and 42% (20) from the companies sample are second category, while 14% (7) from the companies sample are third category, and there is no respondent in fourth and fifth category. Figure 4.1 shows the number of respondents and their percentage respect to the contractors' sample.

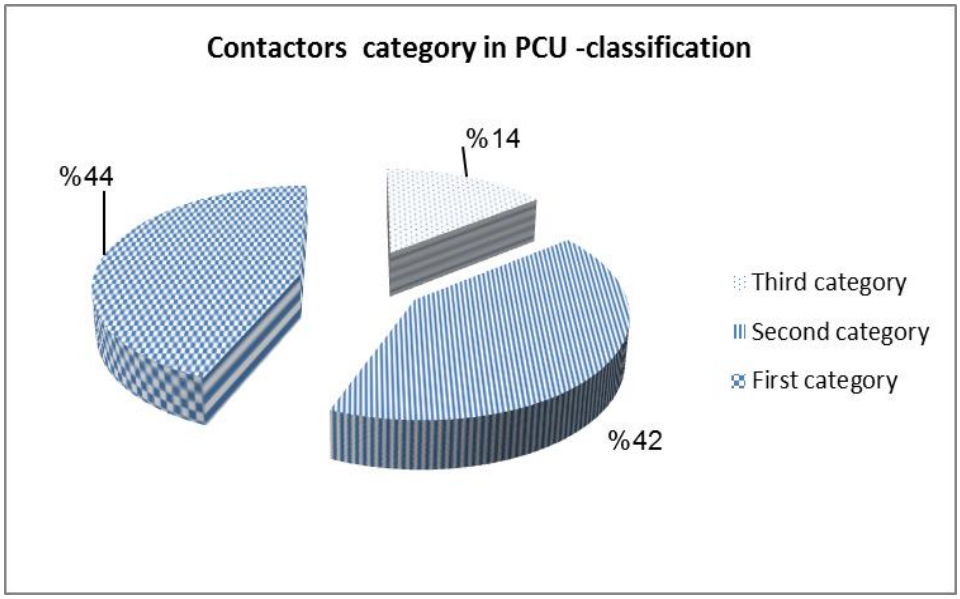

Figure 4.1: Contactors category in PCU –classification

4.1.1.3 Organization field of work

Figure 4.2 shows the number and percentage of contractor respondents according to their Organization field of work. It is shown that 36% (17) from the responding contractors are dealing with both building and infrastructure projects, and 25% (12) from the responding contractor are dealing with building construction, 25% (12) from the responding contractors are dealing with building and infrastructure and others projects, 6% (3) from the responding contractors are dealing with Infrastructure, while 4% (2) from the responding contractors are dealing with other classifications, and 4% (2) from the responding contractors are dealing with building and infrastructure and steel structures.

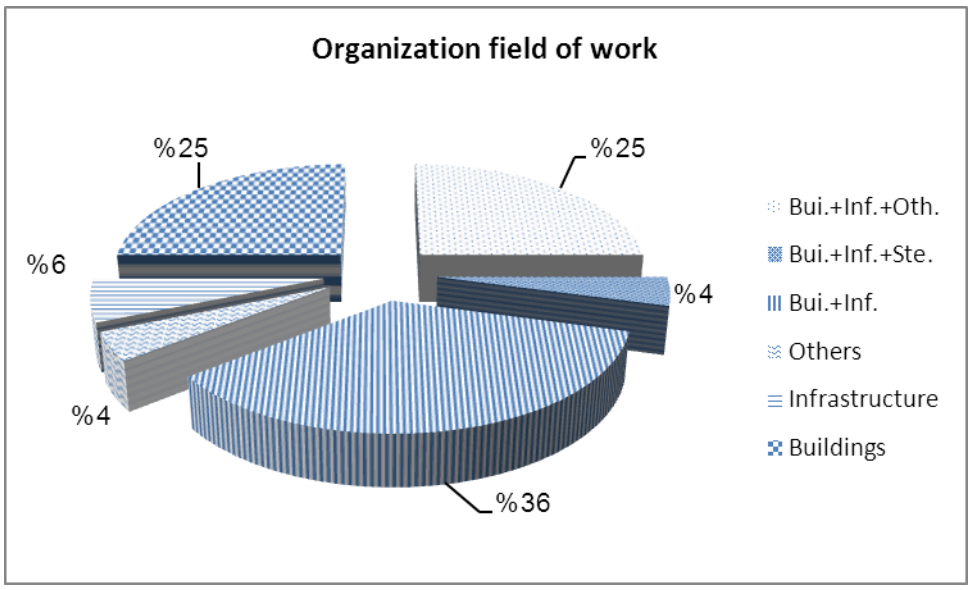

Figure 4.2: Organization field of work

4.1.1.4 Number of employees working in the organization

Due to the need of several employees in the organization to perform the required works, it can be understood from Figure 4.3 that the 33% (16) of contracting companies has less than 10 employees while only 11% (5) of companies have more than 60 employees. The 29% (14) of contracting companies have from 11 to 20 employees, while only 27% (13) of contracting companies have from 21 to 30 employees.

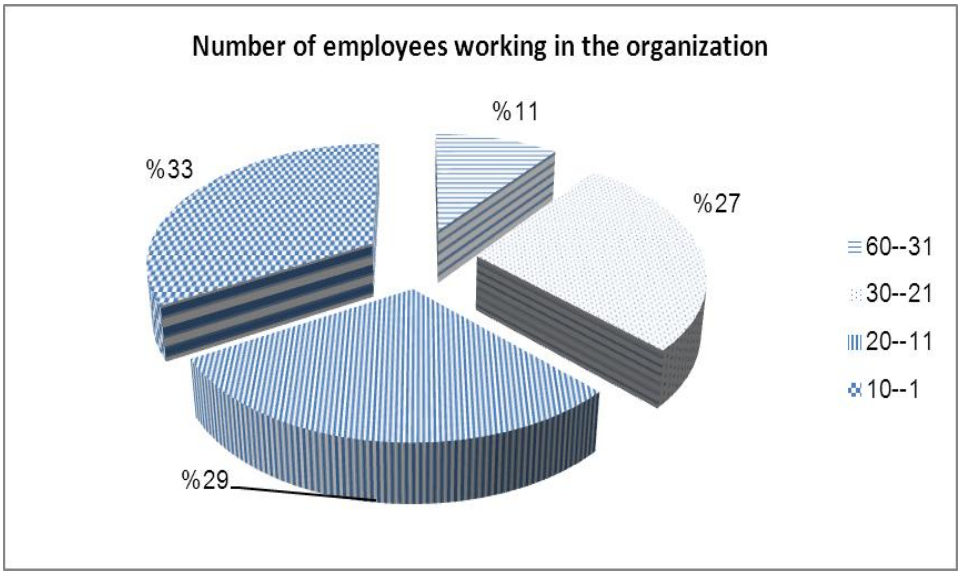

Figure 4.3: Number of employees work in the organization

4.1.1.5 Job title of the respondent

Figure 4.4 shows the number and percentage of respondents according to the position of the person filling the questionnaire. It is shown that 40% (19) from the sample the position are "site engineers", and 35% (17) from the sample the position are "projects manager/deputy", and 13% (6) from the sample the position are "organization manager/deputy", 12% (6) from the sample the position are "Other".

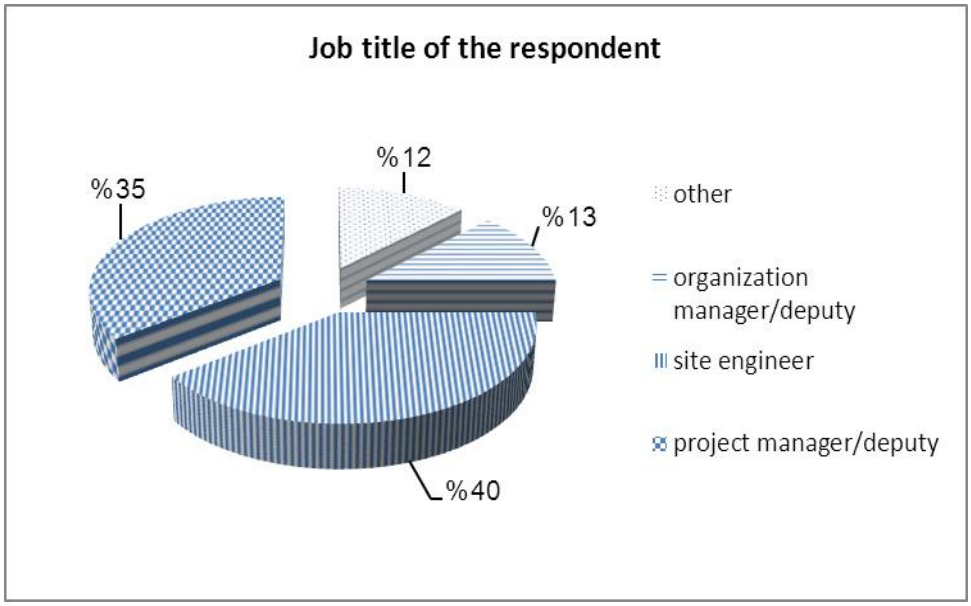

Figure 4.4: Job title of the respondent

4.1.1.6 Years of experience of the respondent

Figure 4.5 shows the number and percentage of respondents according to their years of Experience. It is shown that 63% (30) from the sample have experience between 3-9 Years, 23% (11) from the sample have experience between 10-20 years, 6% (3) from the sample have experience between 21-25 years, and 8% (4) from the sample have experience between 26-31years, which indicates reliable results.

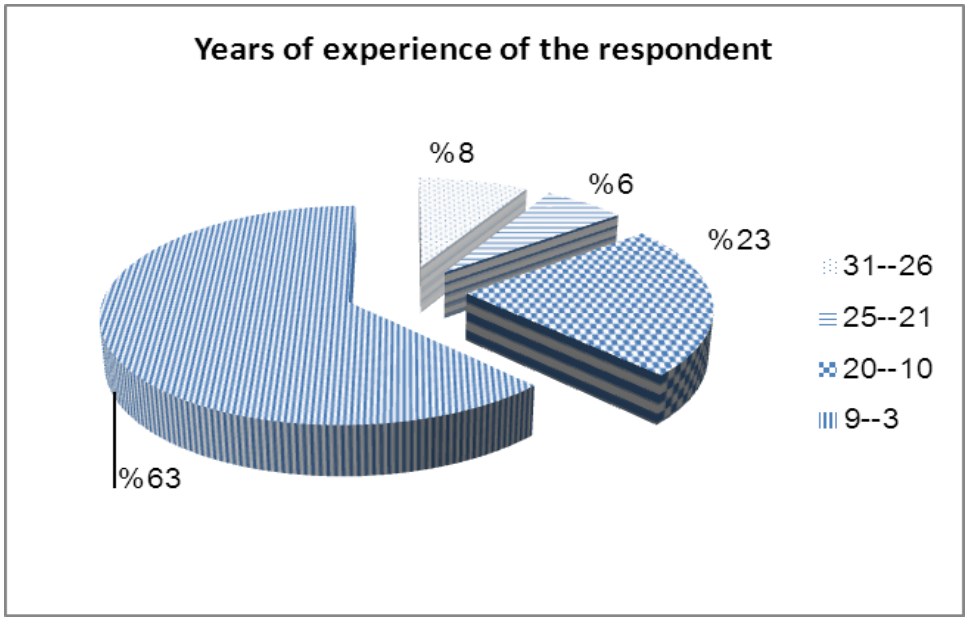

Figure 4.5: Years of experience of the respondent

4.1.1.7 Value of executed projects in the last ten years

Figure 4.6 shows that only 21% (10) of respondents executed projects with cost less than 2 million dollar in the last ten years, 44% (21) of respondents executed projects which cost more than 2-less than 5 million dollar, 16% (8) of respondents executed projects which cost more than 5-less than 10 million. On the other hand 19 % (9) of respondents executed projects more than 10 million dollar cost. It's concluded that most organizational construction is considered as large organization in regard to the project sizes in Gaza Strip.

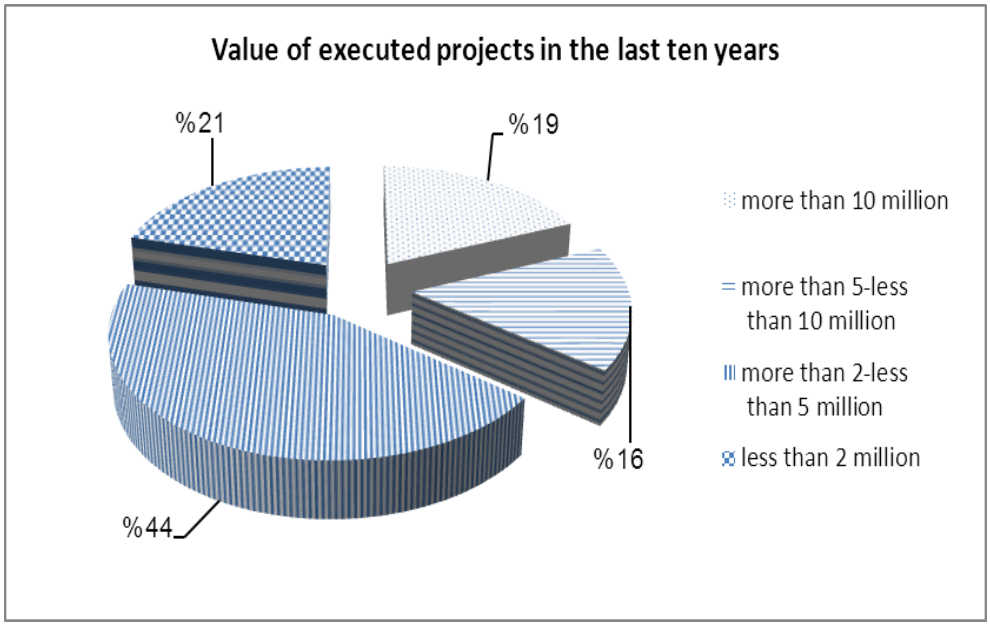

Figure 4.6: Value of executed projects in the last ten years

4.1.2 Mud building practice in Gaza

This section includes ten (10) questions that asked about mud building practice in Gaza such as number of mud building projects that the company invited and participated in, number of mud building projects that the company implemented, the participation in mud building projects was done during at any time, value of executed mud projects by your company, number of employees who work in mud project, number of units your company constructed with mud project, location of mud building projects you implemented, organizations that invited you to participate in mud building projects, organization where you implemented mud building projects, and type of techniques used in mud building projects.

4.1.2.1 Number of mud building projects the company invited to and participated in

Figure 4.7 shows that 75% (36) of respondents have invited and participated to one mud building project, 17% (8) of respondents have invited and participated to two project of mud building, 6% (3) of respondents have invited and participated to three projects of

mud building. On the other hand 2% (1) of respondents invited and participated to four projects.

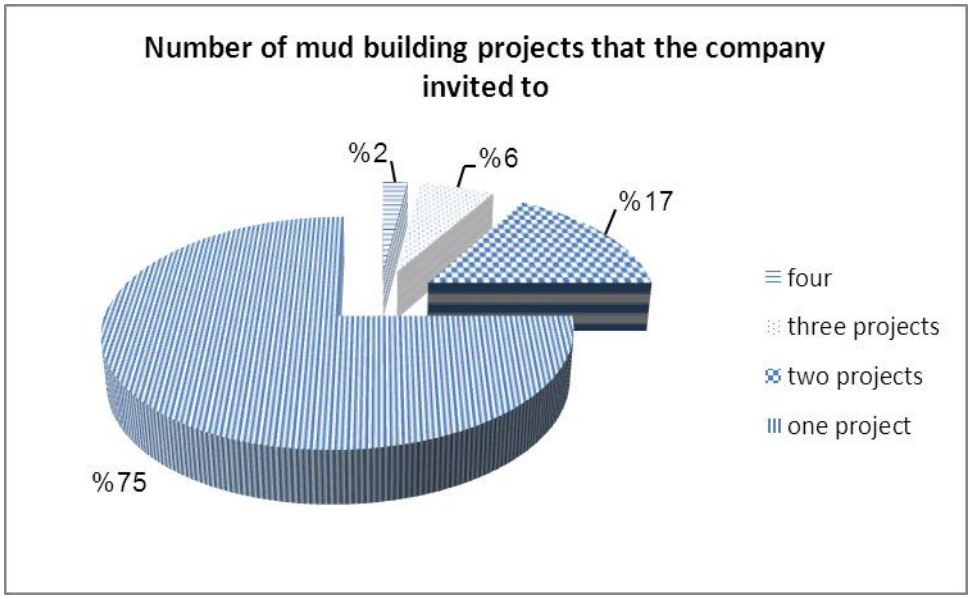

Figure 4.7: Number of mud building projects that the company invited to

The results revealed that the majority of the contractors invited in one project that indicate the low share of the mud building in construction industry in the Gaza Strip.

4.1.2.2 Number of mud building projects that the company implemented

Due to the number of mud building projects that the company implemented it can be understood from Figure 4.8 that the majority of contracting companies 71% (17) have implemented one project, while only 25% (6) of companies have implemented two mud building, and 4% (1) of companies have implemented three mud building

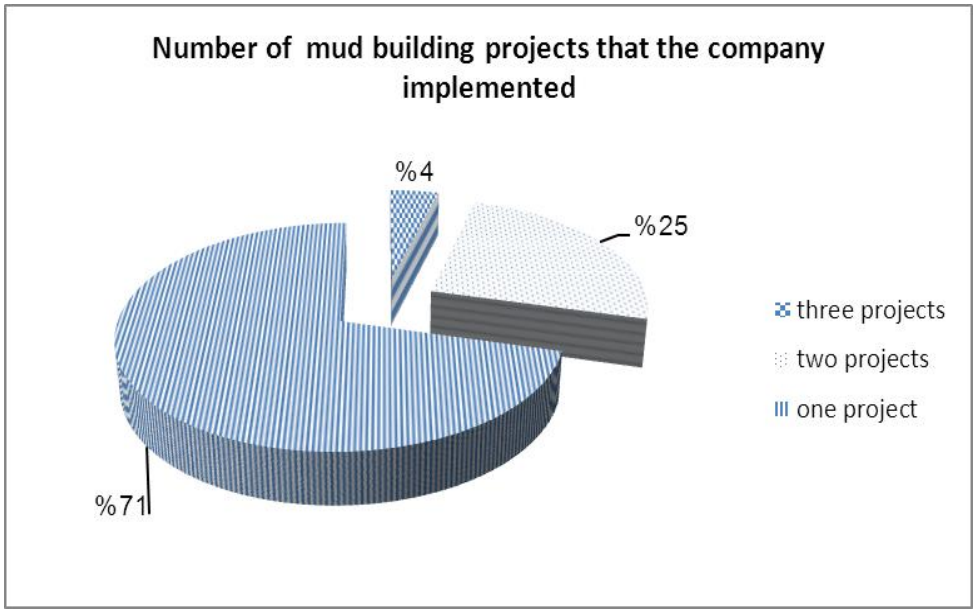

Figure 4.8: Number of mud building projects that the company implemented

Similar to the previous results, it is concluded that the majority of the contractors implemented one project only. The same conclusion can be recorded that indicate low share or portion the mud building has in the construction industry in the Gaza Strip.

4.1.2.3 The participation in mud building projects was done during

Figure 4.9 shows the number and percentage of contractors according to times were companies participated in mud building during the previous years. The results show that 77% (37) from the responding contractors have participated in mud building projects during last year (2010), and 13% (6) from the responding contractors have participated in mud building projects during 2009 and before, and 10% (5) from the responding contractors have participated in mud building projects in this year.

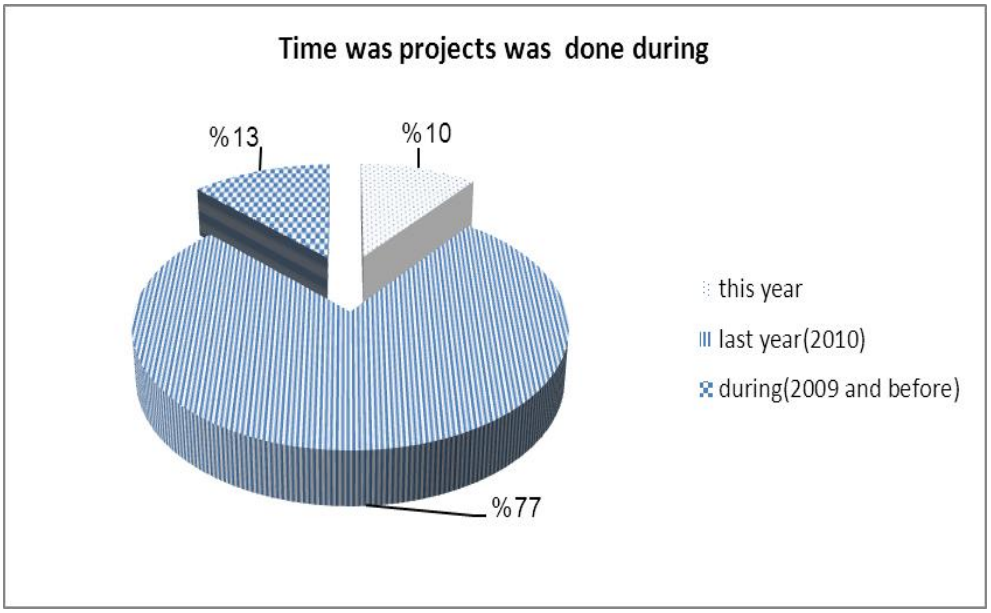

Figure 4.9: The participation in mud building projects was done during

These results illustrated that the trend of mud building practices was shown strongly in the last year (2010). This strengthens the importance of this research and the contribution of the research output.

4.1.2.4 Value of executed mud projects by your company: (Thousand dollars)

Figure 4.10 shows that 79 % (19) of respondents executed mud projects with cost less than 0.5 million thousand dollars, 17 % (4) executed mud projects with cost ranged from rang between 0.5 to 1 million dollars, while only 4 % (1) executed mud projects with cost more than1-less than 2 million thousands. From Figure 4.10, it is noticed that they haven't any executed mud projects with cost more than 2 million thousands.

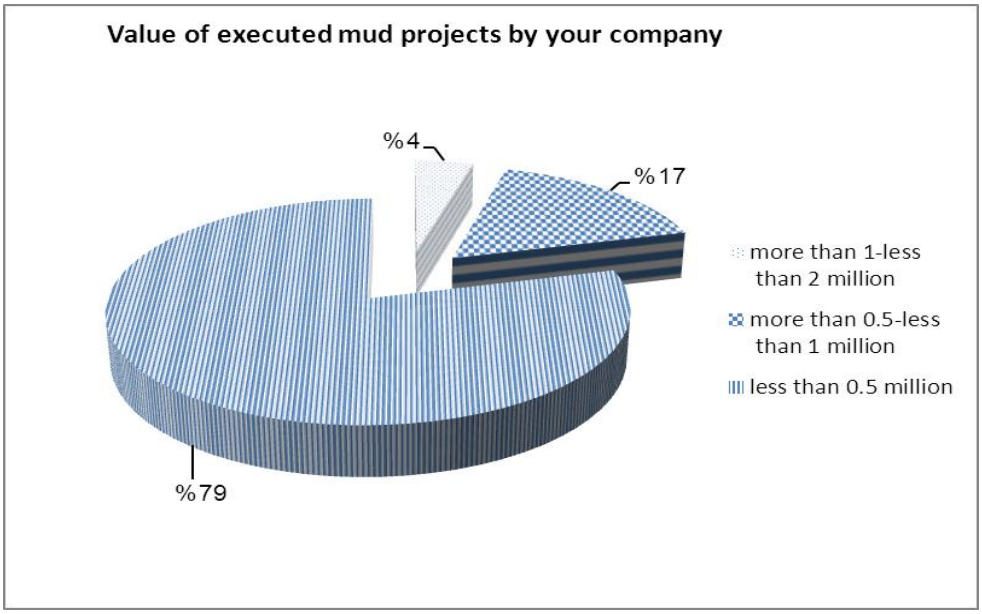

Figure 4.10: Value of executed mud projects by your company

From these results we conclude that the majority of the mud building projects are medium size projects (financially) and not reached the large size projects like the re housing projects or school and health center projects.

4.1.2.5 Number of employees work in Mud project

Figure 4.11 shows that, 37 % (9) from the contractors have employees between 10 to 25 work in mud project, 42% (10) from the contractors have employees between 26 to 40 work in mud project, and 21% (5) have employees between 41 to 60 work in mud project. Work in mud project mud building process is labor-intensive and generates further more employment through the simultaneous production of building material.

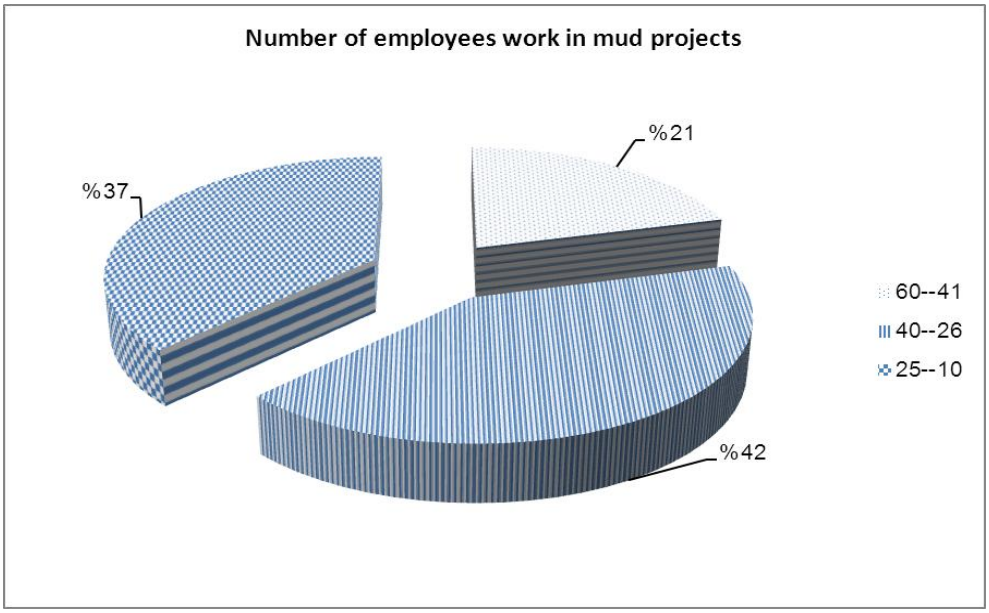

Figure 4.11: Number of employees work in Mud project

The results illustrated strongly that mud building projects are relatively lobar intensive type as the average number of labors is about 35 labors. Those labors should be available continually and daily during the implementation process.

4.1.2.6 Number of units your company constructed with Mud project

Figure 4.12 shows the number and percentage of respondents according to their number of units the company constructed with mud project. It is shown that 21% (5) from the contractor constructed one mud building, 29% (7) from the contractor constructed two mud building project, 8% (2) from the contractor constructed three mud building project, and 8% (2) from the contractor constructed four mud building project, 4% (1) from the contractor constructed six mud building project, 13% (3) from the contractor constructed twelfth mud building project, and 8% (2) from the contractor constructed fourteen mud building project, 4% (1) from the contractor constructed twenty mud building project, and 4% (1) from the contractor constructed thirty mud building project.

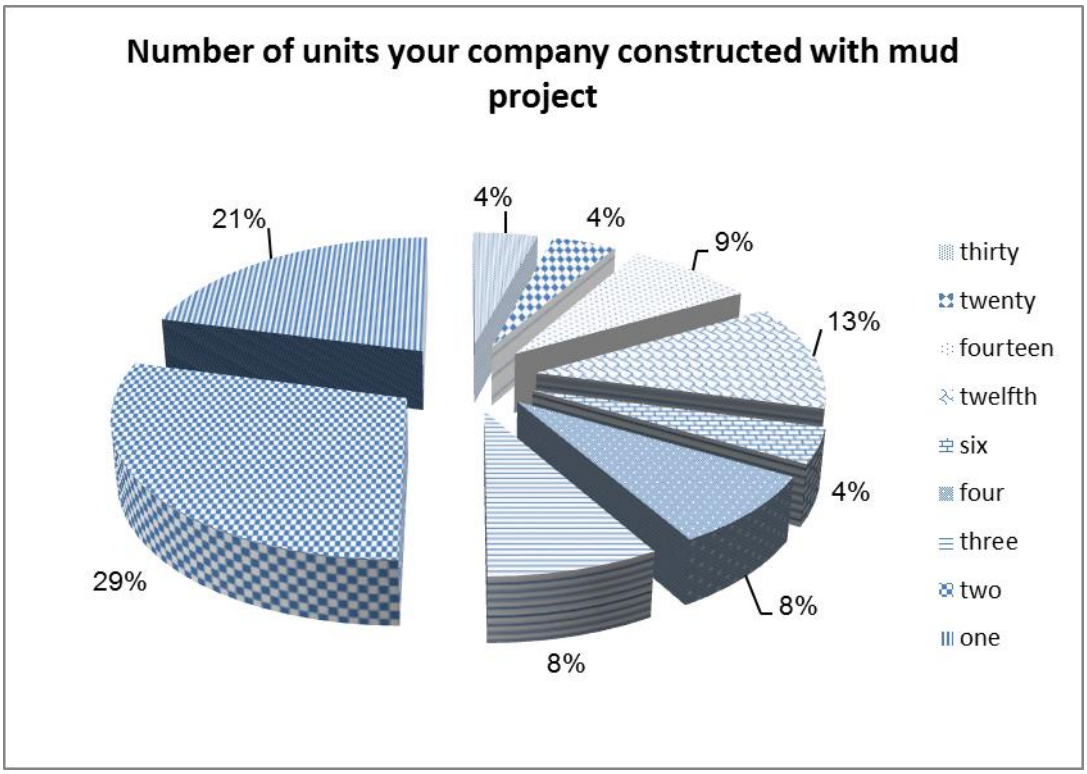

Figure 4.12: Number of units your company constructed with mud project

4.1.2.7 Location of mud building projects you implemented

In this study, Gaza Strip is divided into four geographical regions these parts are (North of Gaza, Gaza city, Middle area and South of Gaza). As shown in Figure 4.13 the response rate of mud building projects from Gaza city was 29% (7 respondents), 21% (5 respondents) of mud building projects was from North of Gaza, 33% (8 respondents) of Mud building projects was from middle area and 17% (4 respondents) of mud building projects was implement from south of Gaza.

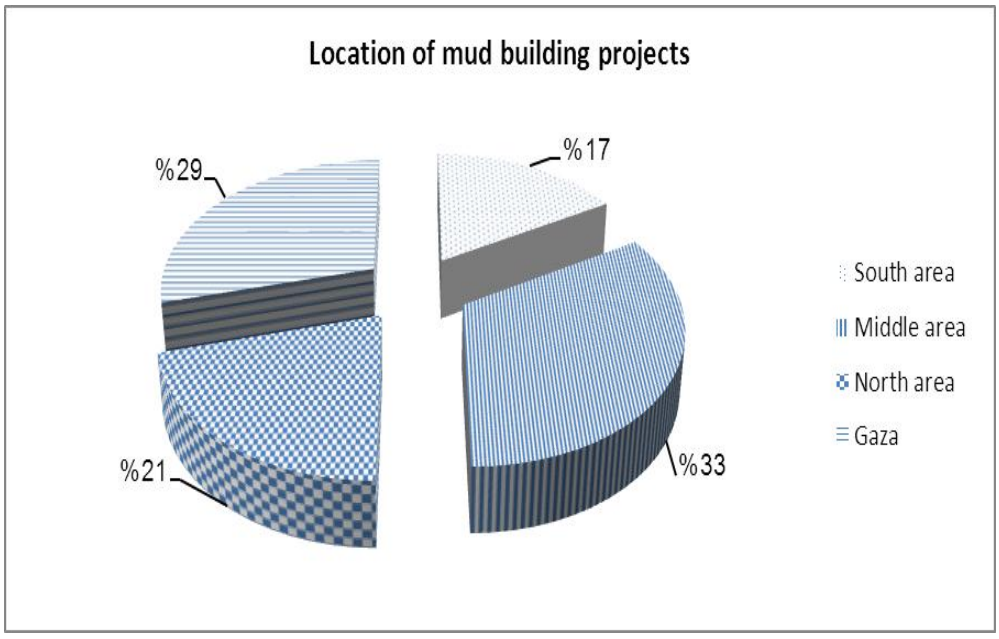

Figure 4.13: Location of mud building projects contractors implemented

4.1.2.8 Organizations that invited you to participate in mud building projects

Figure 4.14 shows the number and percentage of respondents according to the Organizations that invited you to participate in mud building projects by contractors Company. It is shown that 69% (33) from the contractor invited to participate with UNRWA, and 10% (5) from the contractor invited to participate with Ministry of Public Works and Housing, and 21% (10) from the contractor invited to participate with others.

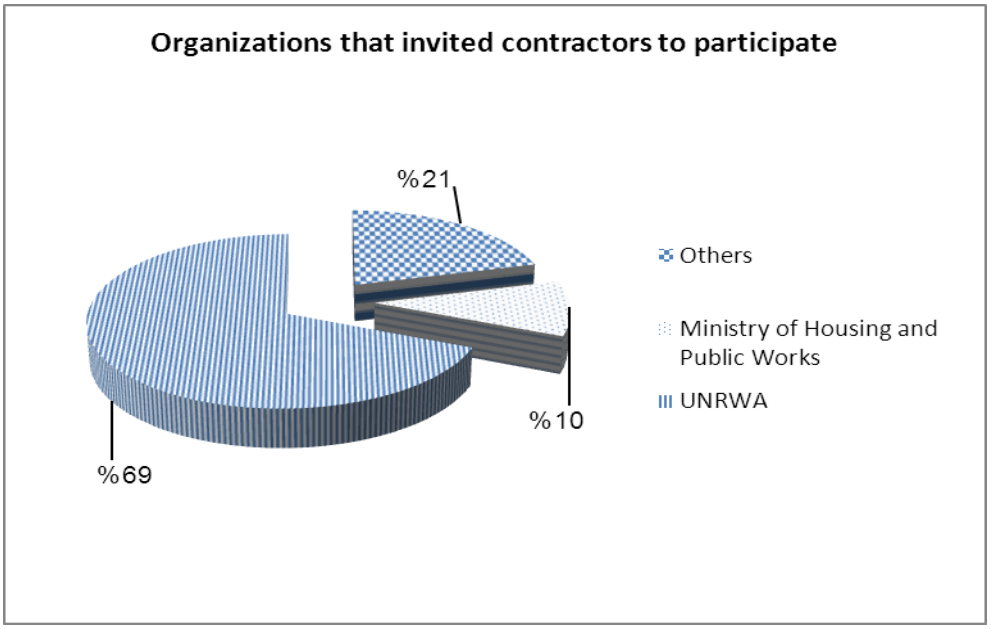

Figure 4.14: Organizations that invited you to participate in Mud building projects

4.1.2.9 Organizations that companies implemented mud building projects to them

Figure 4.15 shows the number and percentage of respondents according to the Organizations that implemented mud building projects by Contractors Company. It is shown that 62% (15) from the contractor implemented mud building projects with UNRWA, and 17% (4) from the contractor invited to participate with Ministry of Public Works and Housing, and 21% (5) from the contractor implemented mud building projects with others.

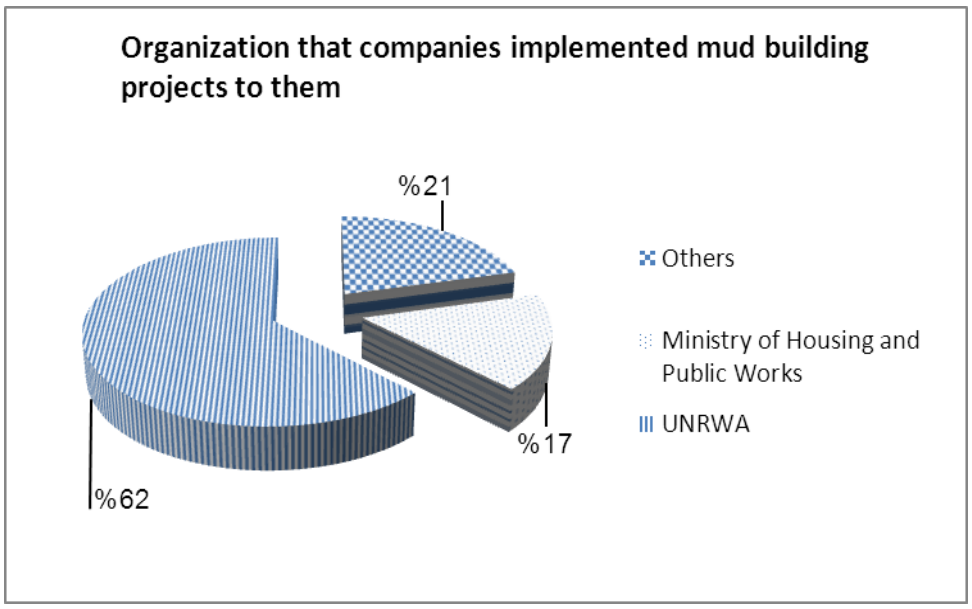

Figure 4.15: Organization that companies implemented mud building projects to them

4.1.2.10 Type of techniques used in mud building projects

Figure 4.16 shows the number and percentage of respondents according to the type of techniques used in mud building projects by Contractors Company. It is shown 67% (35) from the contractor use CSEB technique, and 25% (13) from the contractor use Adobe technique, and 6% (3) from the contractor use CEB technique, and 2% (1) from the contractor use Rammed earth technique.

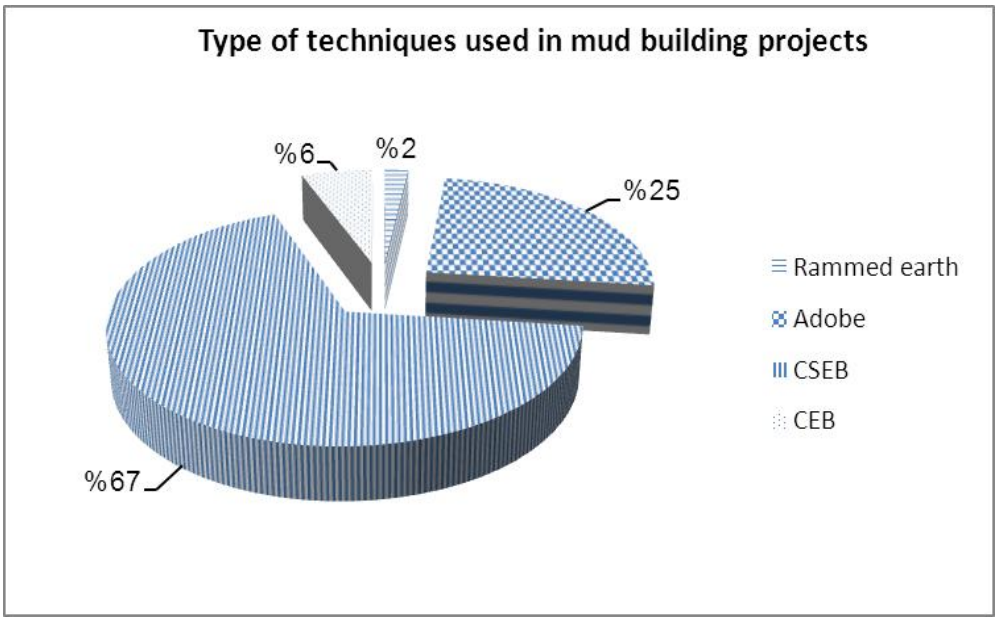

Figure 4.16: Type of techniques used in Mud building projects

The results revealed that the majority of the contractors implemented CESB types which indicate the important of adding the stabilizers (like cement) to improve the housing conditions of the mud buildings.

The technique used in Africa has seen the widest world development for CSEB. Social programmes and prestige demonstration projects are not computable anymore. Africa takes, these days, a further step with semi industrialization and standards. India developed CSEB technology only in the nineteen eighty's, but sees today a wider dissemination and development of CSEB (Auroville Building Centre, 2005).

Mud and adobe are widely used in many Palestinian areas to construct the houses. It is believed that these houses provide the inhabitants with more comfortable internal environment that the new concrete houses built in many areas (Khammash,1990).

This is consistent with the results that the technique used in Gaza Strip before 2009 were often adobe, in general after 2009 the most technique used in Gaza Strip is CSEB because large number of projects implemented through UNRWA.

4.1.3 Challenges/factors affecting the use of mud building in the Gaza Strip

This section contains five main groups, these groups are: client related factors, design and consultant related factors, contractor related factors, external environmental factors, Project characteristics related factors. Each group contains a number of factors. This section discusses the difference between perceptions of contractors who participated with UNRWA and contractor who participate with other clients. Each of the following subsections discuss one of the previously mentioned groups.

4.1.3.1 Client related factors

This group considers 13 factors in the group of client related factors. It discusses factors that may affect mud building in the construction projects. This is based on the perception of contractor participated with UNRWA and contractor who participate with other clients. In section 4.1.3.1.1, the perception of contractor participated with UNRWA will be discussed. In section 4.1.3.1.2, the perception of contractors participate with other clients is discussed. In section 4.1.3.1.3 a summary discuss the Comparison between them.

4.1.3.1.1 Perception of contractors participated with UNRWA

The result shows that the average of relative importance index of client related factors from contractors participated with UNRWA point view was R.I.I (60.8) with fifth position of the rank order among five groups as shown in Table 4.1, while the average of relative index of the overall contractor participated with UNRWA and contractor who participate with other clients was R.I.I (62.1), This means that this field can be considered as the lowest groups effects of mud building in constructions projects.

Table 4.1 shows that contractors participated with UNRWA ranked "Inadequate experience of client's staff in the design and supervision" in the first position with importance index (R.I.I = 78.2 %), as a critical factors affecting mud building in construction projects. This factor means the critical needs for the experienced supervising staff who will control and monitor the process itself. Because training new people on the vaults meant more breaking down and repairing of low quality work, more building waste,

more loss of time and less aesthetic appeal. These results are matched with Ramage et al. (2010) who showed that the biggest challenge in constructing CSEB is the deep attention and experience in the design details and time management plan.

The second important factor ranked by contractors participated with UNRWA was “Client culture and attitudes” with importance index (R.I.I =75.2%). As UNRWA policy is to build not expensive homes to help refugees demolished their home as a result of the war so UNRWA attitudes to build cheap, simple and healthy houses. The respondents believe that the client play a major role to embark this type of works (mud building) in the industry.

The third factor ranked by contractors participated with UNRWA that affecting mud building was "Client previous experience in such work" with (R.I.I =70.9%). This factor is considered important from respondents point view as mud building need high experience to deal with natural earth material and making mud shape in beautiful architectural appearance and structural status. These results matched with Arumala and Gondal (2008) and Rodriguez et al. (2002) who showed the important of experience in all stages of constructing mud building projects.

The respondents contractors participated with UNRWA as shown in Table 4.1 classify the Client's financial problems (R.I.I = 41.67 %) as the least factor that affecting on use mud building. These results are normal and expected as the excellent reputation of UNRWA's policy and regulations in this direction.

On the other hand, it is shown that, "Client culture and attitudes " and “Inadequate experience of client's staff in the design and supervision “was ranked in the first position by both the contractors who participate with UNRWA and with other client with importance index (R.I.I =78%). This result means the most important of these factors affecting mud building. These compatibility of these results emphasize the fact that the mud building practices in the Gaza Strip is started recently and has not the local community support, besides, low awareness and experiences is still obvious in our country.

Table 4.1 Client related factor

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.R.I. I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	G I: Client related factors												
1	Client culture and attitudes.	3.758	1.226	0.752	**2**	4.200	0.561	0.840	**2**	3.900	1.077	0.780	**1**
2	Client Budget.	2.970	1.571	0.594	**5**	3.133	1.126	0.627	**7**	3.020	1.436	0.604	**5**
3	Client's financial problems	2.394	1.370	0.479	**13**	2.667	1.291	0.533	**12**	2.479	1.337	0.496	**13**
4	Inadequate project objectives	3.061	1.273	0.612	**4**	3.200	1.265	0.640	**5**	3.104	1.259	0.621	**4**
5	Client previous experience in such work.	3.546	1.148	0.709	**3**	4.267	1.033	0.853	**1**	3.771	1.153	0.754	**3**
6	Inadequate experience of client's staff in the design and supervision	3.909	0.765	0.782	**1**	4.067	0.704	0.813	**3**	3.900	0.743	0.780	**1**
7	Weak coordination between the client and the local community	2.970	1.015	0.594	**5**	3.067	1.223	0.613	**8**	3.000	1.072	0.600	**6**
8	Weak coordination between the client and stakeholders "mis-needs assessment"	2.879	0.927	0.576	**8**	2.933	1.223	0.587	**10**	2.900	1.016	0.580	**9**
9	No existence of mud building code in the client	2.909	1.355	0.582	**7**	3.200	1.474	0.640	**5**	3.000	1.384	0.600	**6**
10	Budget allocated constraint	2.879	1.193	0.576	**8**	2.400	1.298	0.480	**13**	2.729	1.233	0.546	**12**
11	Client financial capability	2.727	1.526	0.545	**12**	3.067	1.335	0.613	**8**	2.833	1.464	0.567	**10**
12	Interference of client in project requirements	2.758	1.200	0.552	**10**	3.467	1.246	0.693	**4**	2.979	1.446	0.596	**8**
13	Safety considerations by client	2.758	1.300	0.552	**10**	2.733	1.163	0.547	**11**	2.750	1.246	0.550	**11**
	Total	**3.040**		**0.608**		**3.262**		**0.652**		**3.105**		**0.621**	

4.1.3.1.2 Perception of contractors participated with other clients

The result shows that the average relative importance index of client related factors from contractors participate with other clients point view was R.I.I (65.2%) with fifth position of the rank order among the five groups as shown in Table 4.1. This means that this field can be considered as the lowest groups affecting on mud building in constructions projects.

Table 4.1 shows that the respondents of contractors participate with other clients ranked the "Client previous experience in such work". (R.I.I = 85.3 %) as the first factor affecting mud building as shown in Table 4.1. This result is not conformed with the respondents of contractors who participated with UNRWA who ranked this factor in the third position with (R.I.I = 71 %), which means that UNRWA are more experience in mud building from contractor participate with UNWA but the other shown that client need to have the experience in the design and supervision of mud. This experience will avoid any risks or complications in the implementation process and to avoid any conflicts or claims with the contractors.

The second factor affecting mud building practices from the contractor participated with client other than UNRWA was "Client culture and attitudes." (R.I.I = 84 %). This result is in full conformity with the results of the respondents of contractors participate with UNRWA, this similarity of opinions indicate the importance of this factor. This factor was recorded by Zami and Lee (2008) who illustrated the impact of earth construction at the local culture and heritage.

The third factor ranked by respondents contractors who participated with other client that affecting in mud building was "Inadequate experience of client's staff in the design and supervision" with (R.I.I =81.3%) This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the first position with (R.I.I = 78 %), this similarity of opinions indicate the importance of this factor.

The respondents contractors participated with other clients as shown in Table 4.1 classify the "Budget allocated constraint" (R.I.I = 48%) as the least factor that affecting on use mud building 48.0%). This result is not conform to the respondents of contractors who participated with UNRWA which ranked this factor in the eighth position with (R.I.I = 58%). Although the different rank for this factor it is still in the low position.

4.1.3.1.3 Comparison between contractors participated with UNRWA and contractor who participated with other clients.

Contractor participated with UNRWA and contractors who participated with other clients agreed with each other regarding the importance factors" Client culture and attitudes." and "Inadequate experience of client's staff in the design and supervision". Both of them ranked this factor in the first place, but contractor participated with UNRWA have importance index lower than importance index of the contractor who participated with other clients (Table 4.1).

The factor "Client previous experience in mud works." was considered also important, from the perception of both contractors who participated with UNRWA and contractor who participated with other clients. They ranked this factor in the third position but contractor participated with UNRWA gave this factor R.I.I = 70.9% and contractor who participated with other clients gave it R.I.I =85.3%, replication of projects implemented through the UNRWA and the similarity building was a major cause of these results.

Regarding "Inadequate project objectives", both contractors participated with UNRWA and contractor who participated with other clients ranked this factor in the fourth level. They gave this factor approximately the same importance index (61.2%) and (64%) respectively. Although this factor has the same rank (R.I.I), it has relatively low impact at the mud building practices.

Table 4.10 shows that respondents contractor participated with UNRWA and contractor who participated with other clients ranked factor of "Client's financial problems" (R.I.I = 49.6

5%) as a weak factor affecting mud building. Contractor participated with UNRWA ranked this factor in position 13, with R.I.I = 47.9%, while contractors who participated with other clients ranked this factor in position 12 with R.I.I = 53.3%. These results showed that these factors are not critical to affect mud building practices in the construction industry.

4.1.3.2 Design and consultant related factors

This group considers thirty factors in the group of client related factors. It discusses factors that may affect mud building in the construction projects. This is based on the perception of contractor participated with UNRWA and contractor who participated with other clients. In section 4.1.3.2.1, the perception of contractor participated with UNRWA is discussed. In section 4.1.3.2.2, the perception of contractors participated with other clients is discussed. In section 4.1.3.2.3 a summary is discuss the comparison between them.

4.1.3.2.1 Perception of contractors participate with UNRWA

The result shows in Table 4.2 that the average relative importance index of contractors participated with UNRWA was R.I.I (64.4%) with the 3rd position of the ranked order among five groups.

Table 4.2 shows that the respondents of contractors participated with UNRWA ranked the "Need high maintenance". (R.I.I = 85.5 %) as the first factor affecting in mud building as shown in Table 4.2. This result is full conformity with the respondents of contractors participated with other client which ranked this factor in the second position with (R.I.I = 92%), which means need for high maintenance is a critical factors affecting mud building in construction projects. Problems of earth wall erosion by rain and flood

water, rodents making holes in wall and floor because mud building have high sensitivity to water and lack of durability in its. These results are compatible with Zami and Lee (2008) and Arumala and Gondal (2008) who illustrated those main needs of this type of building to the routine maintenance.

The second factor affecting in mud building from the contractor Participated with UNRWA was "Need intensive labor." (R.I.I = 83.6 %). This result is in full conformity with the results of the respondent's of contractors participate with other client who ranked this factor in the same position with higher importance index (92%), this similarity of opinions indicate the importance of this factor in mud building because process of its construction is labor-intensive and generates further more employment through the simultaneous production of building material. Building with mud brick or block in particular, requires little or no specialist skills. These results are matched with Kundoo (2008) and Harris (2010) explained that building with mud brick or block in particular, requires little or no specialist skills. The process is labor-intensive and the work is often heavy, but it can be phased to suit both the weather and the availability of helpers. Also the results in line with Block et al., (2010) who concluded that construction with clay or CEB building in the roofing has many barriers. Some of these barriers related to the needs of skilled labors in the implementation besides, the critical needs for the experienced supervising staff who will control and monitor the process itself.

The third factor ranked by contractors participated with UNRWA that affecting in mud building was" Poor in resistance to weather conditions" with importance index (R.I.I = 82.4%). The most factors that affecting in mud building is poor in resistance to weather conditions this refer to the nature of the materials used for mud building they are affected by rain and flood water, rodents making holes in wall and floor, and poor performance during earthquake.

Contractors participated with UNRWA as shown in Table 4.2 classify the "Insufficient site investigation. i.e. (Materials needed, soil data, constraints,…)" with

(R.I.I = 51.5 %) as the least factor that affecting on use mud building .Earth materials such as clay, mud, sand, stones and others are available on the site and it requires simple tools and less skilled labor which is available

Table 4.2 Design and consultant related factors

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	G II: Design and consultant related factors												
1	Difficulties in the design	3.394	1.391	0.679	**10**	4.067	0.799	0.813	**7**	3.604	1.267	0.721	**7**
2	Different design models needed	2.909	1.400	0.582	**21**	3.400	1.121	0.680	**21**	3.063	1.327	0.613	**21**
3	Un-clarity of contract documents	2.727	1.281	0.545	**26**	3.267	0.961	0.653	**24**	2.900	1.207	0.580	**26**
4	Un-clarity of drawings	2.909	1.355	0.582	**21**	3.267	0.961	0.653	**24**	3.021	1.246	0.604	**24**
5	Different site conditions	3.152	1.176	0.630	**14**	3.600	1.183	0.720	**10**	3.292	1.184	0.658	**15**
6	No technology used in the design stage	3.455	1.092	0.691	**8**	3.600	0.828	0.720	**10**	3.500	1.011	0.700	**10**
7	Lack of coordination among project parties	3.061	1.171	0.612	**18**	3.467	0.916	0.693	**19**	3.198	1.104	0.640	**18**
8	Complex design and technology	3.061	1.249	0.612	**18**	3.400	1.298	0.680	**21**	3.167	1.260	0.633	**19**
9	Inadequate shop drawing details	3.333	1.384	0.667	**12**	3.467	0.990	0.693	**19**	3.375	1.265	0.675	**12**
10	Consultant's lack of judgment and experience	3.364	1.246	0.673	**11**	4.400	0.507	0.880	**4**	3.688	1.170	0.738	**6**
11	Lack of coordination between international and local designer and supervisor teams (large scale projects).	3.152	1.034	0.630	**14**	3.600	0.910	0.720	**10**	3.292	1.010	0.658	**15**
12	Not benefiting from international specification and global experiences (eg. Testing procedure).	3.485	1.034	0.697	**7**	3.667	0.724	0.733	**9**	3.542	0.944	0.708	**8**
13	Lack of coordination between various design displaces	3.000	1.199	0.600	**20**	3.133	0.834	0.627	**26**	3.042	1.091	0.608	**22**
14	Inadequate revision and feedback system through design process.	3.515	1.21	0.703	**6**	3.600	1.183	0.720	**10**	3.542	1.129	0.708	**8**
15	Lack of consultant's knowledge of available	3.636	1.113	0.727	**5**	4.400	0.910	0.880	**4**	3.875	1.104	0.775	**5**

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	materials and equipment												
16	Inconsistency between drawings and site conditions.	3.455	1.175	0.691	**8**	3.533	1.356	0.707	**16**	3.479	1.220	0.696	**11**
17	Errors and omission of quantity estimation.	2.667	1.291	0.533	**27**	2.867	1.246	0.573	**28**	2.729	1.267	0.546	**28**
18	Omission of contract document items.	2.606	1.345	0.521	**29**	2.733	1.223	0.547	**29**	2.646	1.296	0.529	**29**
19	Errors of cost estimation.	2.758	1.415	0.552	**25**	2.933	1.580	0.587	**27**	2.813	1.454	0.563	**27**
20	Insufficient site investigation. i.e. *(Materials needed, soil data, constraints,…)*	2.576	1.324	0.515	**30**	2.667	1.234	0.533	**30**	2.604	1.284	0.521	**30**
21	Consultant's lack of required data	3.121	1.219	0.624	**16**	3.533	0.916	0.707	**16**	3.250	1.139	0.650	**17**
22	Ambiguous design details	3.091	1.528	0.618	**17**	3.933	0.884	0.787	**8**	3.354	1.407	0.671	**13**
23	Noncompliance design with government regulations	2.667	1.315	0.533	**27**	3.600	1.298	0.720	**10**	2.958	1.368	0.592	**25**
24	Noncompliance design with owner's requirement	3.182	1.236	0.636	**13**	3.600	1.183	0.720	**10**	3.313	1.223	0.663	**14**
25	Lack of coordination between designer and client	2.909	1.234	0.582	**21**	3.533	1.126	0.707	**16**	3.104	1.225	0.621	**20**
26	Change in specifications by consultant	2.879	1.269	0.576	**24**	3.400	1.121	0.680	**21**	3.042	1.237	0.608	**22**
27	Weak resistance to earthquake	3.939	0.933	0.788	**4**	4.400	0.828	0.880	**4**	4.083	0.919	0.817	**4**
28	Poor in resistance to weather conditions	4.121	1.083	0.824	**3**	4.667	0.817	0.933	**1**	4.292	1.031	0.858	**3**
29	Need high maintenance	4.273	0.944	0.855	**1**	4.600	0.828	0.920	**2**	4.375	0.914	0.875	**1**
30	Need intensive labor	4.182	1.044	0.836	**2**	4.600	0.507	0.920	**2**	4.313	0.926	0.863	**2**
	Total	**3.219**		**0.644**		**3.631**		**0.726**		**3.349**		**0.670**	

4.1.3.2.2 Perception of contractors participate with other clients

The result shows that the average relative index of contractors participate with other clients was (R.I.I = 72.6%) with second position of the rank order among the five groups as shown in Table 4.20. This means that design and consultant related factors can be considered as the most groups affecting mud building in constructions projects.

As shown in Table 4.2 the respondents of contractors participated with other clients ranked the factor “Poor in resistance to weather conditions “in the first position with a important index value (R.I.I =93.3%) affecting in mud building as shown in Table 4.2. This result is in not conform to the respondents of contractors participate with UNRWA which ranked this factor in the third position with (R.I.I = 82.4%). These results are matched with Arumala and Gondal, (2008) and Das et al. (2007) who introduced the weakness of the mud building in the bad weather conditions especially rain conditions.

The second factor affecting in mud building from the contractor participate with other client view was "Need intensive labor." And "Need high maintenance" with the same important index (R.I.I = 92%). This result is in full conformity with the results of the respondents of contractors participate with UNRWA who rank this factors in the same position, this similarity of opinions indicate the importance of this factor affecting mud building in construction project. Generating employment by giving unskilled labor opportunities to find work, while also providing jobs to the local potter whose lively hood is threatened by the plastics and metal industries that are replacing the products that potters used to provide. Mud walls are to be permanently maintained, since material used in construction is very light and not resistible for the outside natural changes such as sun, water and vegetation. These results were emphasized by ecb (2002) who showed that cracks in the plaster allow water to penetrate inside the walls, which causes weakness in structure by flushing out the mortar causing the falling.

The forth factor ranked by respondents contractors participated with other clients that affecting in mud building was" Weak resistance to earthquake” and “Lack of consultant's knowledge of available materials and equipment” with the same important

index (R.I.I =88%), This result is fully conformity with the respondents of contractors participate with UNRWA which ranked "Weak resistance to earthquake " in the same position with (R.I.I = 79 %), this similarity of opinions indicate the importance of this factor. So Mud houses behave poorly in the event of earthquakes. These results are compatible with Sassu Mauro (2005), Zami and Lee (2008) and Kundoo (2008).

The respondents contractors participated with other clients as shown in Table 4.2 classify the "Insufficient site investigation". i.e. (Materials needed, soil data, constraints,…) (R.I.I = 53.3%) as the least factor that affecting on use mud building. This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the last position with (R.I.I = 51.5%), this similarity of opinions indicate that "Insufficient site investigation" will not have a critical affect on mud building in construction projects.

4.1.3.2.3 Comparison between contractors participated with UNRWA and contractor who participated with other clients (Design and consultant factor group)

It is clear from previous Tables 4.2 that the perception of contractor participated with UNRWA and contractor who participate with other clients are very similar and give high ranks for the same questions, especially for the first five questions as in the following

Table 4.3 Highest factors affecting mud building

No.	Highest factors in Design and consultant factor group	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
15	Lack of consultant's knowledge of available materials and equipment	3.64	0.73	**5**	4.40	0.88	**4**
27	Weak resistance to earthquake	3.94	0.79	**4**	4.40	0.88	**4**
28	Poor in resistance to weather conditions	4.12	0.82	**3**	4.67	0.93	**1**
29	Need high maintenance	4.27	0.86	**1**	4.60	0.92	**2**
30	Need intensive labor	4.18	0.84	**2**	4.60	0.92	**2**

Table 4.3 illustrates the first five factor of the highest rank in design and consultant related factors in which mud building factors are affected by contractor participated with UNRWA and contractor who participate with other clients points of view. The result shows that the both contractor agree and give similar ranks for the Need intensive labor, Need high maintenance, Poor in resistance to weather conditions, Weak resistance to earthquake, Lack of consultant's knowledge of available materials and equipment factors as the highest relative indexes. The results indicate that the barriers and challenges to construct mud building projects outside UNRWA are slightly higher than the challenges with clients other than UNRWA. This may retain to the fact that UNRWA has high level of experiences, knowledge and trained team that may not existed outside, type of mud used in construction (CSEB).

Table 4.4 Lowest factors affecting mud building

No.	Lowest factors in Design and consultant factor group	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
3	Un-clarity of contract documents	2.73	0.55	**26**	3.27	0.65	**24**
17	Errors and omission of quantity estimation	2.67	0.53	**27**	2.87	0.57	**28**
18	Omission of contract document items.	2.61	0.52	**29**	2.73	0.55	**29**
19	Errors of cost estimation.	2.76	0.55	**25**	2.93	0.59	**27**
20	Insufficient site investigation. i.e. *(Materials needed, soil data, constraints,…)*	2.58	0.52	**30**	2.67	0.53	**30**
23	Noncompliance of design with government regulations	2.67	0.53	**27**	3.60	0.72	**10**

Table 4.4 illustrates the five factors with the lowest relative index value and the last rank in this group (design and consultant related factors) as the contractor participated with UNRWA and contractor who participate with other clients points of view. The result shows how both contractors participated with UNRWA and contractor who participates with other clients agreed that Errors and omission of quantity estimation, Omission of contract document items, and insufficient site investigation. i.e. (Materials needed, soil data, constraints,…)have the lowest relative important indexes. This means that the consensus agreement between the contractors participated with UNRWA and contractor who participate with other clients regarding these factors is the lowest rank. Also from previous Table 4.4 the result shows the both contractors respondents disagree over the "Noncompliance design with government regulations" factor, where contractor participated with UNRWA rank this factor as the twenty seven positions and contractor who participate with other clients rank this factor as the tenth position.

But in general there is a consistent agreement at the factors (high and low) between contractors participated with UNRWA and contractor who participate with other.

4.1.3.3 Contractor related factors

This group considers sixteen factors in the group of contractor related factors. It discusses factors that affecting mud building in the construction projects. This is based on the perception of contractor participated with UNRWA and contractor who participated with other clients. In section 4.1.3.3.1, the perception of contractor participated with UNRWA was discussed. In section 4.1.3.3.2, the perception of contractors participate with other clients was discussed. In section 4.1.3.3.3 a summary discuss the comparison between them.

4.1.3.3.1 Perception of contractors that participated with UNRWA

The result shows that the average relative index of contractors who participated with UNRWA was (R.I.I 62.1%) with 4th position of the rank order among the five groups as shown in Table 4.5.

Table 4.5 shows that the respondents of contractors who participated with UNRWA ranked the "Unavailability of skills (Shortage of skilled labors)"and "Experience of subcontractor with the contractor" with the same importance index. (R.I.I = 81.8%) as the first factors affecting in mud building as shown in Table 4.5. This result is full conformity with the respondent's of contractors who participated with other client which ranked Experience of subcontractor with the contractor in the 2nd position with (R.I.I = 86.7%), which means Unavailability of skills (Shortage of skilled labors) and Experience of subcontractor with the contractors are a critical factors affecting the construction of mud building in construction projects. Earth constructions in urban housing require simple tools and less skilled labor. Building with mud brick or block in particular, requires little or no specialist skills but it may refer to poor experience of the

contractor in this area. The results introduced by Ramage et al. (2010) illustrated that training new people in mud building projects will achieve high outcome and high level of development. The results are consistent with Block et al. (2010) who concluded that some of these barriers related to the needs of skilled labors in the implementation besides, the critical needs for the experienced supervising staff who will control and monitor the process it self.

The third factor ranked by respondents contractors participated with UNRWA that affecting in mud building was "Number of skilled labors that contractor have" with importance index (R.I.I =80.6%) this factor is very important because mud building are labor-intensive and the work is often heavy so it need many worker to product all material needed and transport it.

The responded contractors participated with UNRWA as shown in Table 4.5 classify "Unfamiliarity of the contactor with the exact location of materials (earth materials- clay, sand, silt, etc) with (R.I.I = 44.8%) as the least factor that affecting on use mud building. Locally available materials. It is observed that in many areas, the locally available resources have governed the use of the following constituent materials for walls, Adobe (mud blocks or whole walls); Masonry (stone, clay, or concrete blocks) or timber. These materials are safe and environmentally friendly. Michael and Taub (2010) found that using local materials, local labor, and informed architectural strategies such as natural ventilation, is possible to expand and improve the building practices with the local materials such as mud or earth materials.

Table 4.5 Contractor related factors

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	G III: Contractor related factors												
1	Lack of contractor's involvement in design.	2.364	1.085	0.473	**15**	2.933	1.335	0.587	**13**	2.542	1.184	0.508	**15**
2	Unavailability of equipment to implement the project.	2.879	1.364	0.576	**9**	3.800	0.941	0.760	**6**	3.167	1.310	0.633	**8**
3	Unavailability of skills (shortage of skilled labors)	4.091	1.182	0.818	**1**	4.533	0.516	0.907	**1**	4.229	1.036	0.846	**1**
4	Contractor's financial difficulties	2.515	1.349	0.503	**14**	2.467	1.187	0.493	**16**	2.500	1.288	0.500	**16**
5	Unwillingness of contractors to construct such type of work	3.515	1.176	0.703	**4**	4.267	1.223	0.853	**4**	3.750	1.229	0.750	**4**
6	Location or place of the contractor	2.667	1.451	0.533	**12**	3.333	1.175	0.667	**9**	2.875	1.393	0.575	**11**
7	Unfamiliarity of the contactor with the exact location of materials (earth materials- clay, sand, silt, etc)	2.242	1.276	0.448	**16**	3.267	0.799	0.653	**11**	2.563	1.236	0.513	**14**
8	Lack of a specialized construction managers	3.333	1.164	0.667	**6**	3.533	0.916	0.707	**8**	3.396	1.087	0.679	**7**
9	Poor (unclear) procurement process	2.606	1.059	0.521	**13**	2.533	0.990	0.507	**15**	2.583	1.028	0.517	**13**
10	Poor experience of the Contractor in this area	3.333	1.315	0.667	**6**	4.333	0.488	0.867	**2**	3.646	1.212	0.729	**5**
11	Number of skilled labors that contractor have	4.030	1.045	0.806	**3**	4.200	0.414	0.840	**5**	4.083	0.895	0.817	**3**
12	Experience of subcontractor with the contractor	4.091	0.980	0.818	**1**	4.333	0.488	0.867	**2**	4.167	0.859	0.833	**2**
13	Misunderstanding of tender documents during cost estimation stage.	3.061	1.499	0.612	**8**	3.267	1.487	0.653	**11**	3.125	1.482	0.625	**9**

14	Unbalanced tender price due to closure.	2.849	1.523	0.570	**10**	2.867	1.060	0.573	**14**	2.854	1.384	0.571	**12**
15	Lack of the necessary documents to built mud	2.697	1.425	0.539	**11**	3.333	0.900	0.667	**9**	2.896	1.309	0.579	**10**
16	Lack of construction materials and equipment spare parts due to Closure and siege	3.394	1.273	0.679	**5**	3.667	0.724	0.733	**7**	3.479	1.130	0.696	**6**
	Total	**3.104**		**0.621**		**3.542**		**0.708**		**3.241**		**0.648**	

4.1.3.3.2 Perception of contractors participate with other clients

The result shows that the average relative index of contractors participated with other clients was with R.I.I of (70.8%) in 3rd position of the ranked order among the five groups as shown in Table 4.5.

As shown in Table 4.5, the respondents of contractors who participated with other clients ranked the rank "Unavailability of skills (shortage of skilled labors)"in the first position with a important index value (R.I.I =90.7%) affecting in mud building as shown in Table 4.5 This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the same position with lower relative important index (R.I.I = 81.8%), The results shows how both contractor participated with UNRWA and contractor who participate with other clients agreed that unavailability of skills is very important factor affecting in mud building.

The second factors affecting in mud building from the contractor Participate with other client view was " Poor experience of the Contractor in this area " And " Experience of subcontractor with the contractor " with the same important index (R.I.I = 86.7%). This result is in full conformity with the results of the respondents of contractors participate with UNRWA who rank Experience of subcontractor with the contractor in the first position, this similarity of opinions indicate the importance of this factor affecting mud building in construction project. Number of mud building implementation in Gaza Strip is too small. These results agreed with Rodriguez et al. (2002), Auroville Building Centre, (2005) and Arumala and Gondal (2008) who stressed the importance of experience for the parties operating in mud building practices.

The forth factor ranked by contractors participated with other clients that affecting in mud building was "Unwillingness of contractors to construct such type of work" with (R.I.I =85.3%). This result is fully conformity with the respondents of contractors

participated with UNRWA which ranked this factor in the same position with (R.I.I = 70.3%), this similarity of opinions indicate the importance of this factor.

The respondents contractors participated with other clients as shown in Table 4.5 classify that Contractor's financial difficulties (R.I.I = 49.3 %) as the least factor that affecting on use mud building. This is logic as the companies rely mainly on the clients in the sustainability of their works.

4.1.3.3.3 Comparison between contractors participated with UNRWA and contractor who participated with other clients

It is clear from previous Table 4.5 that contractors who participated with UNRWA and contractor who participated with other clients' points of view are nearly similar and give high ranks for the same questions.

Table 4.6 Highest factors affecting mud building in construction projects

No.	Highest factors in Contractor factor group	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
3	Unavailability of skills (shortage of skilled labors)	4.09	0.82	**1**	4.53	0.91	**1**
5	Unwillingness of contractors to construct such type of work	3.52	0.70	**4**	4.27	0.85	**4**
11	Number of skilled labors that contractor have	4.03	0.81	**3**	4.20	0.84	**5**
12	Experience of subcontractor with the contractor	4.09	0.82	**1**	4.33	0.87	**2**

Table 4.6, illustrates the four factor of the highest rank in group 3 (Contractor related factors) from contractors' participated with UNRWA and contractor who participate with other clients point of view. The results show that contractors' participated with UNRWA give attention to the factor of "Experience of subcontractor with the contractor" and "Unavailability of skills (shortage of skilled labors)" as the highest rank in this group and the contractor who participated with other clients give attention to the

factor of “Unavailability of skills (Shortage of skilled labors) “as the highest rank in this group. The contractors’ participated with UNRWA and contractor who participate with other clients agreed that “Unavailability of skills (shortage of skilled labors)”, a factor that ranks it as the first position in this group and also they agreed that "Unwillingness of contractors to construct such type of working" the forth position. The agreeability between the both parties regarding these factors as the highest rank. This proved that these two factors can be considered as the highest factors affecting mud building.

Table 4.7 Lowest factors affecting mud building in construction projects

No.	Lowest factors in Contractor factor group	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
1	Lack of contractor's involvement in design	2.36	0.47	**15**	2.93	0.59	**13**
4	Contractor's financial difficulties	2.52	0.50	**14**	2.47	0.49	**16**
7	Unfamiliarity of the contactor with the exact location of materials (earth materials- clay, sand, silt, etc)	2.24	0.45	**16**	3.27	0.65	**11**
9	Poor (unclear) procurement process	2.61	0.52	**13**	2.53	0.51	**15**

Table 4.7 illustrates the four factors of the last rank in group 3 (Contractor related factors) from contractors who participated with UNRWA and contractor who participated with other clients point of viewpoint of view. The result shows that lack of contractors involvement in design and, Unfamiliarity of the contactor with the exact location of materials (earth materials - clay, sand, silt, etc) has the lowest ranks in this group. This means that these two issues are considered as the lowest factors affecting mud building in this group.

Also from previous Table 4.7 the result shows that both respondents disagree over the “Unfamiliarity of the contactor with the exact location of materials (earth materials-clay, sand, silt, etc)” factor, where contractor participated with UNRWA rank this factor as the sixteenth position and contractor who participated with other clients rank this

factor as the eleventh position. Maybe the contractors who participated with other clients consider this factor of more value than the contractor participated with UNRWA because. The important issue here that the weak impact of the procurement process at the mud building process. This means that such contracting type is not different that other type of contracts although the content and specifications are different. We conclude from this that any procurement process can apply with a minor impact on the contracting activities it self if the wide frame is structured well.

4.1.3.4 External Environmental Factors

The external environmental factors include nine factors. It discusses factors that may affect mud building in the construction projects. This is based on the perception of contractor participated with UNRWA and contractor who participated with other clients. In section 4.1.3.4.1, the perception of contractor participated with UNRWA was discussed. In section 4.1.3.4.2, the perception of contractors participated with other clients was discussed. In section 4.1.3.4.3 a summary will discuss the comparison between them

4.1.3.4.1 The perception of contractor participated with UNRWA

Table 4.8, illustrates the results of the average of relative index of contractors participated with UNRWA was with R.I.I (67.4%) with 2nd position of the rank order among the fifth groups as shown in Table 4.8, it can be inferred that the contractor participated with UNRWA respondent opinions are positive in classifying the factors of the mud building according to their opinion.

Table 4.8 shows that respondents rank “Unwillingness of people to built their houses" with mud in the first position with (R.I.I =87.9%) under this group and contractor participated with other client rank this factor in the first position. This means that Unwillingness of people to build their houses can be considered as the main factor affecting of mud building in construction projects. This could be returned to the people

attitudes and culture in the Gaza Strip that such type of building is not used for long time, and they may face many challenges in the future in case of their willingness to extend the stories or the floors. Al-sakkaf (2009) and Das et al. (2007) and others shows high willingness of people in these countries such as (Yemen, Bangladesh,) to construct in mud building

The contractors participated with UNRWA respondents rank “Weather conditions" as the second most important factor affecting in mud building position with important index (85.5%) under this group. This result is full conformity with the respondents of contractors participate with other client which ranked this factor in the second position with (R.I.I = 88%), which means weather conditions is a critical factors affecting build mud building in construction projects. Material used in construction is very light and not resistible for the outside natural changes such as sun, water and vegetation. Those usually cause cracks in the plaster allowing for water to penetrate, which causes weakness in structure by flushing out the mortar causing the falling after that. Most contractors agree that weather conditions is the most important factor affects in use mud building because. These results are match with ecb (2002) and Harris (2010).

The third factor ranked by respondents contractors participated with UNRWA that affecting in mud building was” Non-government agencies to encourage construction with mud. “With importance index (R.I.I =81.2%).

On the other hand, the contractors participated with UNRWA respondent's rank the lowest factors for this field as illustrated in Table 4.8. Where the contractors respondents rank “Cost inflation" as the ninth position with (R.I.I = 52.7%) This means that contractor participated with UNRWA agree that this factor is not serious in use mud building, because the main advantages of mud building is the raw materials are locally available with lower cost. In fact adobe maybe produced from the soil excavated from the building site reducing transportation and other energy intensive processes, and the tools

needed in this construction type are not many: shovels, baskets, hoes, pliers, spatulas, etc which are available and cheap so earth construction is economically beneficial.

Table 4.8 External Environmental factors

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	G IV: External Environmental factors												
1	Force Majeure	2.788	1.293	0.558	**6**	3.333	1.291	0.667	**6**	2.958	1.304	0.592	**6**
2	Weather conditions	4.273	0.801	0.855	**2**	4.400	0.737	0.880	**2**	4.313	0.776	0.863	**2**
3	Change in government regulations	2.667	1.164	0.533	**8**	2.600	1.121	0.520	**9**	2.646	1.139	0.529	**9**
4	Change in economic conditions (inflation , currency change rate)	2.758	1.251	0.552	**7**	2.667	1.633	0.533	**8**	2.729	1.364	0.546	**7**
5	Unwillingness of people to built their houses with mud	4.394	1.059	0.879	**1**	4.800	0.414	0.960	**1**	4.521	0.922	0.904	**1**
6	Non-government agencies to encourage construction with mud.	4.061	0.748	0.812	**3**	4.067	0.884	0.813	**3**	4.063	0.783	0.813	**3**
7	Unforeseen problems	3.818	0.846	0.764	**4**	3.733	0.961	0.747	**4**	3.792	0.874	0.758	**4**
8	Cost inflation	2.636	1.410	0.527	**9**	2.867	1.408	0.573	**7**	2.708	1.399	0.542	**8**
9	stakeholders attitudes	2.909	1.259	0.582	**5**	3.400	1.183	0.680	**5**	3.063	1.245	0.613	**5**
	Total	**3.367**		**0.674**		**3.541**		**0.708**		**3.421**		**0.684**	

4.1.3.4.2 The perception of contractors who participated with other clients

As illustrated in Table 4.8. The result shows that the average of relative importance index of contractor participated with other client were (R.I.I = 70.8%) with a third position of the rank order among the fifth group as shown in Table 4.8.

Contractors participated with other clients respondents rank "Unwillingness of people to build their houses with mud "in the first position with a important index (R.I.I = 96%). This means that awarding Unwillingness of people to build their houses with mud is the most factor affecting on mud building. This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the same position with higher important index (R.I.I = 87.9%), The result shows how both contractor participated with UNRWA and contractor who participated with other clients agreed that Unwillingness of people to build their houses with mud is very important factor affecting in mud building. These results matched with Revuelta-Acosta et al. (2010) who concluded that the worldwide tradition of earth construction has shown that it is possible to achieve long lasting and majestic buildings from single to multi storey. Moreover, one of the main advantages of adobe is that the raw materials are locally available. In fact adobe may be produced from the soil excavated from the building site reducing transportation and other energy intensive processes.

The second factor ranked by respondents contractors participated with other factor that affecting in mud building was "Weather conditions" (R.I.I =88%). This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the same position with (R.I.I = 85.5%), This means that the natural conditions factors (bad weather, etc…) obliged contractors to stop project activities as result of bad weather, this similarity of opinions indicate the importance of this factor.

The third factor ranked by respondents contractors participated with other client that affecting in mud building was" Non-government agencies to encourage construction with mud" With importance index (R.I.I =81.3%). The researcher observed this in the

structured interview results were the majorities of the ministries and official sections did not give the empowerment and support in practical trend to the mud building.

The respondents contractors participated with other clients as shown in Table 4.8 classify that "Change in government regulations" (R.I.I = 52%) as the least factor that affecting on use mud building.

4.1.3.4.3 Comparison between contractors who participated with UNRWA and contractor who participated with other clients

It is clear from the previous Tables 4.8 that contractor participated with UNRWA point of view and contractor who participate with other clients point of view are similar and give high ranks for the same questions especially for the first five questions in the external environmental factors as the following:

Table 4.9 Highest factors affecting mud building in construction projects

No.	External Environmental factors	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
2	Weather conditions	4.27	0.86	**2**	4.40	0.88	**2**
5	Unwillingness of people to build their houses with mud	4.39	0.88	**1**	4.80	0.96	**1**
6	Non-government agencies to encourage construction with mud.	4.06	0.81	**3**	4.07	0.81	**3**
7	Unforeseen problems	3.82	0.76	**4**	3.73	0.75	**4**
9	Stakeholders attitudes	2.91	0.58	**5**	3.40	0.68	**5**

As illustrated in Table 4.9, the five factors with the highest rank in group 4 (External Environmental factors) from contractor participated with UNRWA and contractor who participated with other clients point of view. The result shows that both

contractors participated with UNRWA or not give attention to the factor “Unwillingness of people to build their houses with mud” as the highest rank in this group and "Weather conditions" a factor ranked as the 2nd position in this group. In this group the result shows that both contractor agreed upon this factor and ranked it according to their beliefs which proved the agreement between contractors participated with UNRWA and contractor who participate with other clients about these issues.

Table 4.10 lowest factors affecting mud building in construction projects

No.	External Environmental factors	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
8	Cost inflation	2.64	0.53	**9**	2.87	0.57	**7**
3	Change in government regulations	2.67	0.53	**8**	2.60	0.52	**9**

As shown in Table 4.10, the two factors of the last rank in group 4 "Cost inflation "and "Change in government regulations". This means that these two factors are considered as the lowest factors affecting external environmental group and the agreeableness between the contractors participated with UNRWA and contractor who participate with other clients regarding these factors as the lowest rank. This proved that these two factors are considered as the lowest factors affecting in used mud building for External Environmental factors.

4.1.3.5 Project Characteristics Related Factors

This group considers thirteen factors related to Project characteristics factors. It discusses factors that may affect mud building in the construction projects. This is based on the perception of contractor participated with UNRWA and contractor who participate with other clients. In section 4.1.3.5.1the perception of contractor participated with UNRWA was discussed. In section 4.1.3.5.2, the perception of contractors participated with other clients was discussed. In section 4.1.3.5.3 a summary will discuss the Comparison between them.

4.1.3.5.1 The perception of contractor participated with UNRWA

Table 4.11, illustrates the results of the average of relative index of contractors participate with UNRWA was (R.I.I = 69.2%) with a first position of the rank order among the fifth groups as shown in Table 4.15, As illustrated in Table 4.11, it can be inferred that the contractor participated with UNRWA of the mud building according to there opinion. Most of the previous factors are considered as the most important factors that result in use mud building especially in the project characteristics related factors.

Table 4.11 shows that the respondents contractors participated with UNRWA ranked "Number of floors required" in the first position with importance index (R.I.I = 86.7%). This result is fully conformity with the respondents of contractors participated with other client which ranked this factor in the same position with important index (R.I.I = 88%). The result shows how both contractors participated with UNRWA and contractors who participated with other clients agreed that number of floors required is very important factor affecting in mud building. The size of the building is governed by its particular use. It should be noted that the building size is also related to the population pattern and housing density in a given area. For example, single-story buildings are common for rural areas, whereas multistory buildings are most often found in densely populated urban areas. And the implementation of multistory buildings is more complicated than single story. These results matched with Das et al. (2007) who

introduced building by mud in Bangladesh and they showed that one of the building limitations is that this building type is typically one or two stories and preferably used for single-family housing.

The contractors participated with UNRWA ranked "Type of clay needed" as the second most important factor with important index (R.I.I =80.6%) under project characteristics factors shown in Table 4.11, most contractors agree that this factor is very important because suitability of the soil in the compressed Earth Block (CEB) depends on its constituents that are sand, silt and clay proportions. Too much clay will cause cracks in the blocks while too much sand cause the blocks to crumble. The suitable soil must contain the right proportions of sand, silt, clay and water. The importance of type of clay needed was introduced by many researchers such as Arumala and Gondal (2008) as they explored the possibility of using soils for making compressed earth blocks for constructing affordable residential buildings, using relatively cheap and locally available technology. Also matched with Harris (2010).

The third factor ranked by respondents contractors participated with UNRWA that affecting in mud building was "Availability of materials" with importance index (R.I.I =75.8%). The important of availability of raw materials was introduced by Zami and Lee (2008) as well as Kundoo (2008) illustrated that building by mud material (clay materials) have many advantageous implications. The economic sustainability means creation of new markets and opportunities for growth of sales; cost reduction through efficiency improvements and reduced energy, and raw materials use; and creation of additional added value. Using locally available low energy materials and helping the money to remain in the local economy by increasing the labor component of the building cost, and by creating value addition in both, the structure as well as the products.

On the other hand, the contractors participated with UNRWA respondents rank the lowest factors “Type of contract to be used" as the thirteen position with (R.I.I =

46.1%) This means that contractor participated with UNRWA agree that this factor is not serious in use mud building.

4.1.3.5.2 The perception of contractors participated with other clients

As illustrated in Table 4.11, contractors participated with other clients could be inferred. The result shows that the average of relative index was R.I.I (73.7%) with a first position of the rank order among the fifth groups as shown in Table 4.11, Most of the previous factors are considered as the most important factors affecting of mud building especially in the Project characteristics factors in this field.

The contractors participated with other clients rank "Number of floors required" in the first position with important index (R.I.I = 88%) under this group. This means that the number of floors required can be considered as the most important factor affecting mud building. Most buildings can be classified as Single story and multistory buildings.

The contractors participated with other clients rank “Type of clay needed” as the second most important factor position with (R.I.I = 82.7%) under project related factors. This result is fully conformity with the respondents of contractors participate with UNRWA which ranked this factor in the same position with (R.I.I = 80.6%). The important of clay types was discussed by Arumala and Gondal, (2008).

Table 4.11 Project characteristics related factors

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	G V: Project characteristics related factors												
1	Land allocation problems	3.606	1.144	0.721	**6**	3.933	1.033	0.787	**4**	3.708	1.110	0.742	**5**
2	area of the land	3.697	0.847	0.739	**4**	3.933	1.100	0.787	**4**	3.771	0.928	0.754	**4**
3	Location	3.394	1.088	0.679	**8**	3.667	0.976	0.733	**8**	3.479	1.052	0.696	**8**
4	Site condition	3.636	1.246	0.727	**5**	3.867	0.916	0.773	**6**	3.708	1.148	0.742	**5**
5	number of floors req.,	4.333	1.058	0.867	**1**	4.400	0.737	0.880	**1**	4.354	0.956	0.871	**1**
6	Type of clay needed	4.030	0.847	0.806	**2**	4.133	0.516	0.827	**2**	4.063	0.755	0.813	**2**
7	Availability of materials	3.788	1.219	0.758	**3**	3.867	0.640	0.773	**6**	3.813	1.065	0.763	**3**
8	Value of project needed	3.152	1.034	0.630	**11**	3.600	0.737	0.720	**10**	3.292	0.967	0.658	**11**
9	Landscaping required in the projects	3.000	1.061	0.600	**12**	2.867	0.834	0.573	**12**	2.958	0.988	0.592	**12**
10	Type of contract to be used	2.303	1.159	0.461	**13**	2.400	1.404	0.480	**13**	2.333	1.226	0.467	**13**
11	Number of projects to be constructed at the same time	3.424	1.001	0.685	**7**	3.600	1.121	0.720	**10**	3.479	1.031	0.696	**8**
12	Distances between mud buildings	3.273	1.180	0.655	**10**	3.667	1.175	0.733	**8**	3.396	1.180	0.679	**10**
13	Area of the buildings	3.333	1.291	0.667	**9**	4.000	0.845	0.800	**3**	3.542	1.202	0.708	**7**
	Total	**3.459**		**0.692**		**3.687**		**0.737**		**3.531**		**0.706**	

The contractors participated with other clients as shown in Table 4.11 classify that "Type of contract to be used" was ranked with (RI.I = 48%) as the least factor that affecting on use mud building. This illustrates the non-influence of the contract type on the mud building practices.

4.1.3.5.3 Comparison between contractors participated with UNRWA and contractor who participated with other clients

It is clear from the previous Table 4.12 that contractor participated with UNRWA point of view and contractor who participated with other clients' point of view are similar and give high ranks for the same questions especially for the first two questions in the external environmental factors as the following:

Table 4.12 Highest factors affecting mud building in construction projects

No.	Highest factors in project characteristic factor group	Participated with UNRWA			With other clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
1	Land allocation problems	3.61	0.72	**6**	3.93	0.79	**4**
2	Area of the land	3.70	0.74	**4**	3.93	0.79	**4**
5	Number of floors required	4.33	0.87	**1**	4.40	0.88	**1**
6	Type of clay needed	4.03	0.81	**2**	4.13	0.83	**2**
13	Area of the buildings	3.33	0.67	**9**	4.00	0.80	**3**

Table 4.12 illustrates the five causes with the highest rank in group 5 (Project characteristics related factors) from contractor participated with UNRWA and contractor who participate with other clients. The result shows that both contractors gave attention to the factor “Number of floors required” and "Type of clay needed" as the highest rank in project group. The factor “Area of the land “ranks as the forth position in this group. In this group the result shows that the contractors participated with UNRWA and with other client are agreed on the ranking this factor according to their believe which approved the agreeableness between contractor and owner on this issues.

On the other hand, from previous Table 4.12 the result shows that both contractors disagree over the "Area of the buildings" factor; where contractors participated with UNRWA rank this factor as the ninth position and contractor who participated with other clients rank this factor as the third positions. Maybe the contractor who participated with other clients consider this factor of more value than the contractor participated with UNRWA because, in most cases, the contractor participated with UNRWA always not faces the problem in sites because all mud building UNRWA project was constructed in small area.

Table 4.13 Lowest factors affecting mud building in construction projects

No.	Lowest factors in project characteristic factor group	Participated with UNRWA			With Other Clients		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank
9	Landscaping required in the projects	3.00	0.60	**12**	2.87	0.57	**12**
10	Type of contract to be used	2.30	0.46	**13**	2.40	0.48	**13**

Table 4.13 illustrates the last rank factor in group 5 " Project characteristics related factors " from contractor participated with UNRWA and with other client point of view. This means that Landscaping required in the projects and Type of contract to be used are considered as the lowest factors affecting in mud building for this group and the agreeability between both contractors regarding these factors as the lowest rank. This proved that these two factors can be considered as the lowest factors affecting mud building for Project characteristics group. These results are not matched with Rodriguez et al. (2002) who studied from economical point of economic issues of mud construction the land identification and requirements.

4.1.3.6 Ranking of most ten factors affecting mud building from point view of all respondents

Table 4.14 shows that all respondents ranked "Unwillingness of people to built their houses with mud" in the first position. This result reflects the effect of this factor on use mud building. The second factor ranked by all respondents was "Need high maintenance" And all respondent ranked number of floors required. in the third position

Table 4.14 illustrate that both contractor ranked need intensive labor, weather conditions, poor in resistance to weather conditions, unavailability of skills (shortage of skilled labors), weak resistance to earthquake, number of skilled labors that contractor have , non-government agencies to encourage construction with mud, type of clay needed were the most important factors that affect in mud building projects. The most important factors of mud building as shown in Table 4.14 was discussed and analyzed in the previous paragraphs at this chapter.

Table 4.14 most ten factors affecting mud building from point view of all respondents

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
27	Weak resistance to earthquake	3.939	0.933	0.788	**4**	4.400	0.828	0.880	**4**	4.083	0.919	0.817	**9**
28	Poor in resistance to weather conditions	4.121	1.083	0.824	**3**	4.667	0.817	0.933	**1**	4.292	1.031	0.858	**6**
29	Need high maintenance	4.273	0.944	0.855	**1**	4.600	0.828	0.920	**2**	4.375	0.914	0.875	**2**
30	Need intensive labor	4.182	1.044	0.836	**2**	4.600	0.507	0.920	**2**	4.313	0.926	0.863	**4**
3	Unavailability of skills (shortage of skilled labors)	4.091	1.182	0.818	**1**	4.533	0.516	0.907	**1**	4.229	1.036	0.846	**7**
11	Number of skilled labors that contractor have	4.030	1.045	0.806	**3**	4.200	0.414	0.840	**5**	4.083	0.895	0.817	**9**
12	Experience of subcontractor with the contractor	4.091	0.980	0.818	**1**	4.333	0.488	0.867	**2**	4.167	0.859	0.833	**8**
2	Weather conditions	4.273	0.801	0.855	**2**	4.400	0.737	0.880	**2**	4.313	0.776	0.863	**4**
5	Unwillingness of people to built their houses with mud	4.394	1.059	0.879	**1**	4.800	0.414	0.960	**1**	4.521	0.922	0.904	**1**
6	Non-government agencies to encourage construction with mud.	4.061	0.748	0.812	**3**	4.067	0.884	0.813	**3**	4.063	0.783	0.813	**10**
5	Number of floors required	4.333	1.058	0.867	**1**	4.400	0.737	0.880	**1**	4.354	0.956	0.871	**3**
6	Type of clay needed	4.030	0.847	0.806	**2**	4.133	0.516	0.827	**2**	4.063	0.755	0.813	**10**

4.1.3.7 Groups affecting mud building in construction projects

Table 4.15 shows the rank of 5 groups that influencing mud building at construction projects in Gaza Strip, according to the viewpoints of both contractors.

Table 4.15 Groups affecting mud building in construction projects

No.	Group/ Factor	Participated with UNRWA			With Other Clients			Total		
		Mean	R.I.I	Rank	Mean	R.I.I	Rank	Mean	R.I.I	Rank
1	Client related factors	3.04	0.61	**5**	3.26	0.65	**5**	3.11	0.62	**5**
2	Design and consultant related factors	3.219	0.64	**3**	3.63	0.73	**2**	3.35	0.67	**3**
3	Contractor related factors	3.10	0.62	**4**	3.54	0.71	**3**	3.24	0.65	**4**
4	External Environmental factors	3.37	0.67	**2**	3.54	0.71	**3**	3.42	0.68	**2**
5	Project characteristics related factors	3.46	0.69	**1**	3.69	0.74	**1**	3.53	0.71	**1**

4.1.3.7.1 Client related factors

Referring to Table 4.15, the group of “Client related factors" was ranked in the fifth position by contractor participated with UNRWA and contractor who participate with other clients with R.I.I (62.0%). As shown in Table 4.1 Out of a total of 13 factors of Client related factors; there are no factors that are included in the top ten most important factors that affecting mud building; both contractor agree this group have minimum effect on use mud building.

4.1.3.7.2 Design and consultant related factors

Referring to Table 4.15, the group of Design and consultant related factors was ranked in the third position by contractor participated with UNRWA and contractor who participate with other clients with R.I.I (67.0%). As shown in Table 4.2 Out of a total of 30 factors of Design and consultant related factors; there are four factors that are included in the top ten most important factors that affecting mud building; these include weak

resistance to earthquake, poor in resistance to weather conditions, need high maintenance, and need intensive labor.

4.1.3.7.3 Contractor related factors

The groups of Contractor related factors were ranked in the fourth position with importance index (R.I.I = 65%) by both contractor as shown in Table 4.15 referred to in Table 4.5 out of a total of 16 factors Contractor related factors, there are three factors that include the top ten most important factors affecting mud building. These include unavailability of skills (shortage of skilled labors) was ranked seventh among the top ten factors, number of skilled labors that contractor have was ranked ninth among the top ten factors, and experience of subcontractor with the contractor was ranked in eight among the top ten factors.

4.1.3.7.4 External Environmental factors

The groups of external factor affecting mud building were ranked in the second position with importance index (R.I.I = 68%) by contractor participated with UNRWA and contractor who participated with other clients in Table 4.15 Referred to Table 4.8. From a total of 9 factors of external factor, there is three factors which includes the top ten most important factors that affecting mud building. These include Weather conditions, Unwillingness of people to build their houses with mud, and Non-government agencies to encourage construction with mud.

4.1.3.7.5 Project characteristics related factors

The groups of " Project characteristics related factors " were ranked in the first position with importance index (R.I.I = 71%) by contractor participated with UNRWA and contractor who participate with other clients as shown in Table 4.15 Referring to Table 4.11 From a total of 13 factors of Project characteristics related factors, there is two factors which includes the top ten most important factors that affecting mud building. This includes number of floors required, and type of clay needed.

4.1.3.8 Hypotheses Testing

4.1.3.8.1 Testing the correlation between groups

This section discusses the relationship between the different groups of mud building factors. The Pearson Correlation Test was conducted to find out the different agreements and disagreement for both contractor participated with UNRWA, and contractors participate with other clients. This test is based on assuming a null hypothesis (Ho) of the existence of no significant relationship between the different groups of mud building factors. The null hypothesis (Ho) is rejected if they obtained significance is less than $\alpha = 0.05$. The following section discusses the perceptions of both contractor participated with UNRWA, and contractors participate with other clients through tables that are symmetric around a diagonal axis.

4.1.3.8.2 Correlation between groups affecting in mud building

Table 4.16 presents the Pearson correlation coefficient between all groups affecting in mud building. As shown in Tables 4.16 most of the P-Values were below $\alpha = 0.05$, which means the rejection of (Ho). This means the existence of a significant relationship between the most groups, while the correlation coefficient between client related factors and external environmental factors equals to 0.253 with P-value (Sig.) = 0.082. The P-value is greater than the level of significance, $\alpha = 0.05$, so there is no significant relationship between client related factors and external environmental factors.

Table 4.16 Correlation between groups affecting in mud building

		Client	Design and consultant	Contractor	External Environmental	Project characteristics
Client	Pearson Correlation	1	.481	.488	.253	.437
	Sig. (2–tailed)		.001	.000	.082	.002
	N	48	48	48	48	48
Design and consultant	Pearson Correlation	.481	1	.713	.481	.408
	Sig. (2–tailed)	.001		.000	.001	.004
	N	48	48	48	48	48
Contractor	Pearson Correlation	.488	.713	1	.414	.325
	Sig. (2–tailed)	.000	.000		.003	.024
	N	48	48	48	48	48
External Environmental	Pearson Correlation	.253	.481	.414	1	.336
	Sig. (2–tailed)	.082	.001	.003		.020
	N	48	48	48	48	48
Project characteristics	Pearson Correlation	.437	.408	.325	.336	1
	Sig. (2–tailed)	.002	.004	.024	.020	
	N	48	48	48	48	48

Correlation is significant at the 0.05 level (2-tailed)

4.1.3.8. 3 The agreement between contractors who participated with UNRWA, and who participated with other clients regard factors affecting in mud building

This section will discuss the difference between contractor participated with UNRWA, and contractors participated with other clients regarding the different groups of mud building groups. The independent samples t-test was used to test the difference in the implied means. The null hypothesis (Ho) for this test assumes the existence of no difference between the contractor participated with UNRWA, and contractors participate with other clients perceptions, for a significance level of $\alpha = 0.05$. The null hypothesis (Ho) is rejected if the P-Value is less than α.

Table 4.17 illustrates that, after applying independent samples t-test for the factors affecting in mud building with mean values implied by both contractors participated with

UNRWA, and contractors participate with other clients. The P value as shown in Table 4.17 is greater than the level of significance, α = 0.05, so there is no significant differences between contractor participated with UNRWA and contractors participate with other clients for three groups and exist significance in "Contractor related factors", "Design and consultant related factors" groups. For this groups the P-value is less than the level of significance, α = 0.05, so there is differences in the agreement between contractor participated with UNRWA, and contractors participate with other clients in this groups.

Table 4.17: Comparing between contractors participated with UNRWA and contractors participate with other clients for main groups affecting in mud building.

		Mean	Std. Deviation	t value	F value	P value
Client related factors	Participated with UNRWA	3.0396	.59495	−1.146	1.054	.258
	Participated with other clients	3.2615	.67862	−1.090		.286
Design and consultant related factors	Participated with UNRWA	3.2192	.71283	−2.004	2.708	.051
	Participated with other clients	3.6311	.51923	−2.255		.03
Contractor related factors	Participated with UNRWA	3.1042	.58289	−2.727	7.130	.009
	Participated with other clients	3.5417	.30861	−3.391		.001
External Environmental factors	Participated with UNRWA	3.3670	.65528	−.862	.005	.393
	Participated with other clients	3.5407	.62975	−.875		.389
Project characteristics related factors	Participated with UNRWA	3.4592	.62773	−1.252	1.512	.217
	Participated with other clients	3.6872	.47192	−1.393		.172

The results obtained from Table 4.17 illustrated that all score means are ranged within (3.03 to 3.68). Such range of score mean and results could be returned to the following reasons;

1. The attitudes of the participants are relatively close to the moderate agreement (neither strongly agree nor disagree) (close to 3). This means that the participants are still not strongly aware of the mud building importance and concepts.

2. As the concept is relatively new. Many techniques and methods are still not known in the construction industry which creates this vagueness in the perception trends.

3. The challenges and barriers to apply this construction method and materials are relatively high due to the cultural resistance and unavailability of skilled labors injected in this process.

4. This is the first time for all participants in this study to be asked about their attitudes; barriers that face them, acceptance about the mud building practice. To our knowledge this research is the first one in the Gaza Strip.

Statistically, the P value shown in Table 4.18 for the factors within all groups are higher than 0.05 ($\alpha = 0.05$ P critical) except within the "Contractor related factors", and" Design and consultant related factors" groups. This means that the agreement trends between the participants regarding the challenges affecting mud building is appeared within the contractors participated with UNRWA and outside UNRWA.

4.1.4 Benefits/successes obtained of construction Mud building

The respondents were asked regarding their points of view about benefits/successes obtained of construction mud building. Tables 4.18, show the statistical results including important index (R.I.I).

Table 4.18 shows that both contractor rank “Earth construction promotes local culture and heritage“ in the first position with (R.I.I =79.2%) as the most benefits obtained of construction mud building. This means that shape of a building plan, usually related to many cultural, historical, and urban planning traditions Al Dir’iyah became a large city and an amazing example of earthen architecture. This result matched with Zami and Lee (2008) who showed that earth construction promotes local culture and heritage and others important issues in the community.

Also from previous Table 4.18 the result shows that the contractor participated with UNRWA and contractor who participated with other clients disagree over the “Earth construction promotes local culture and heritage” factor, where contractors participated with UNRWA rank this benefit as the first position and contractor who participated with other clients rank this benefit as the third position. Maybe the contractors participated with UNRWA respondents consider this benefit of more value than the other contractor because, in most cases, the UNRWA always concerted in the Earth construction promotes local culture and heritage in sites.

Table 4.18 shows that contractor participated with UNRWA rank "Design and high aesthetical value" in the second position with (R.I.I = 77.9) as the most benefits obtained of construction mud building. The result shows the contractor participated with UNRWA and contractor who participated with other clients disagree over the “Design and high aesthetical value" benefit, where contractors participated with UNRWA rank this benefit as the second position and contractor who participate with other clients rank this benefit as the first position. These results introduced by Ramage et al. (2010) strengthen the fact that training new people in the mud building environment overall stages as specially design process will improve all the system.

Table 4.18 shows that both contractor rank "Saves energy" and “Local job creation opportunity“ In the third position with (R.I.I = 76.3) as the most benefits obtained of construction mud building. Material used in mud building which are with good thermal properties and the compositions of them in which the walls and the slabs

are thick; these properties gives the result of low thermal transmittance which means thermal comfort inside the buildings. It balances and improves indoor air humidity and temperature which ensures thermal comfort and internal temperature in mud brick houses was 5-6 lower than the external temperature. The other benefit of mud is local job creation opportunity refer to the work in mud building is often heavy so the process of its construction is labor-intensive and generates further more employment through the simultaneous production of building material, so earth construction is regarded as a local job creation opportunity. These results are combatable with Zami and Lee (2008), Arumala and Gondal (2008) and Kundoo (2008) who illustrated that building by mud material (clay materials) have many advantageous implications. The economic sustainability means creation of new markets and opportunities for growth of sales; cost reduction through efficiency improvements and reduced energy, and raw materials use; and creation of additional added value. Using locally available low energy materials and helping the money to remain in the local economy by increasing the labor component of the building cost, and by creating value addition in both, the structure as well as the products.

Also from previous Table 4.18 the result shows the contractors participated with UNRWA and contractor who participate with other clients disagree over the “Saves energy" benefit, where contractors participated with UNRWA rank this benefit as the fifth position and contractor who participate with other clients rank this benefits as the first position. Maybe the contractors participated with other client respondents consider this benefit of more value than the other contractor in most cases.

Meanwhile, the contractors participated with UNRWA projects does not believe that the goal of mud building is save of energy mainly in house Shelter for the Homeless, but contractor who participate with other clients such as Hotels, restaurants, and other interested with energy conservation in the mud construction.

On the other hand Table 4.18 shows that both contractor rank "Earth construction is economically beneficial”, in the last position in this group the result shows that the contractor participated with UNRWA and contractor who participate with other clients

are agreed on the ranking this benefit according to their believe which approved the agreeableness between contractor and owner on this issues. The main advantage of adobe is that the raw materials are locally available. It is observed that in many areas, the locally available resources have governed the use of the following constituent materials for walls. Mud produced from the soil excavated from the building site it eliminates transportation costs and the tools needed in this construction type are not many: shovels, baskets, hoes, pliers, spatulas, etc which are cheap. These results are combatable with Kundoo (2008) and Zami and Lee (2008) who summarized the advantages of earth construction in urban housing such as Earth construction is economically beneficial.

Table 4.18 Benefits/successes obtained of construction mud building

No.	Group/ Factor	Participated with UNRWA				With other clients				Total			
		Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank	Mean	std	R.I.I	Rank
	Benefits/successes obtained of construction Mud building												
1	Earth construction is economically Beneficial.	2.091	1.308	0.418	**12**	1.867	0.916	0.373	**12**	2.021	1.194	0.404	**12**
2	Requires simple tools and less skilled labor	3.576	1.251	0.715	**6**	3.467	0.990	0.693	**9**	3.542	1.166	0.708	**7**
3	Encourages self-help construction	3.303	1.24	0.661	**10**	3.067	1.335	0.613	**10**	3.229	1.259	0.646	**10**
4	Suitable for very strong and secured structure	2.424	1.120	0.485	**11**	2.400	1.502	0.480	**11**	2.417	1.285	0.483	**11**
5	Saves energy	3.606	1.273	0.721	**5**	4.267	0.799	0.853	**1**	3.813	1.179	0.763	**3**
6	Balances and improves indoor air humidity and temperature which ensures thermal Comfort.	3.636	1.246	0.727	**4**	3.867	0.990	0.773	**5**	3.708	1.166	0.742	**5**
7	Local job creation opportunity.	3.727	1.126	0.745	**2**	4.000	1.000	0.800	**4**	3.813	1.085	0.763	**3**
8	Environmentally sustainable.	3.515	1.121	0.703	**7**	3.667	1.047	0.733	**7**	3.562	1.090	0.712	**6**
9	Wall (loam) absorbs pollutants.	3.394	0.998	0.679	**9**	3.800	0.862	0.760	**6**	3.521	0.967	0.704	**9**
10	Design and high aesthetical value.	3.727	1.098	0.745	**2**	4.267	0.704	0.853	**1**	3.896	1.016	0.779	**2**
11	Earth building provides noise control.	3.485	1.121	0.697	**8**	3.667	1.047	0.733	**7**	3.542	1.091	0.708	**7**
12	Earth construction promotes local culture and heritage	3.909	0.879	0.782	**1**	4.067	0.884	0.813	**3**	3.958	0.874	0.792	**1**
	Total	**3.366**		**0.673**		**3.534**		**0.706**		**3.419**		**0.684**	

4.2 Structured interview

In this structured interview, fourteen contractors out of sixteen one were participated in this research. Four main questions were prepared to obtain detailed information about the mud building practices and the challenges in the construction industry in the Gaza Strip.

Structured interviews are similar to written questionnaires in that they utilize a set of fixed questions with fixed response categories covering a specific area or topic. They work well when the goals of the needs analysis are clear. The questions can only be constructed after the needs analyst knows something about the performance problem or business opportunity. Structured interview questions are concise and singularly address the issue at hand. Depending upon the desired depth and degree of information being sought, structured interviews normally last no longer than fifteen to twenty minutes (McClelland, 1995).

4.2.1 Results of Structured interview

Figure 4.17 shows that all of the contactors participated in this interview were first, second class and third class categories. This was done to obtain high level of accuracy to these results as these categories are higher practiced than low categories in mud buildings.

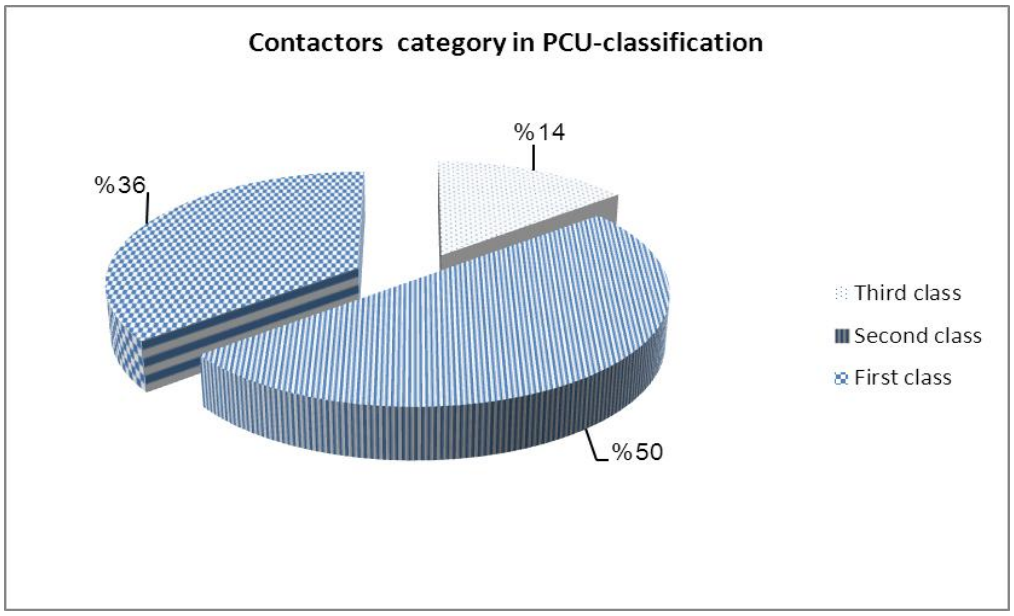

Figure 4.17: Contactors category in pcu-classification

Figure 4.18 shows that the majority (57%) of the contactors participated in this interview were building and infrastructure categories. The other field of works was distributed over all other participants. This diversity gives good results output.

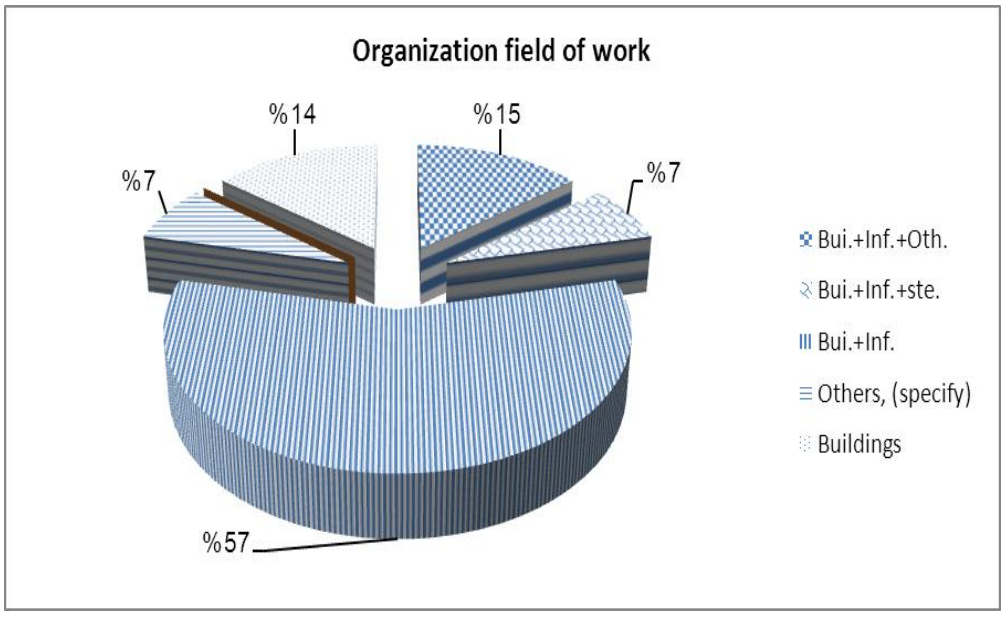

Figure 4.18: Illustrated that the majority of the targeted companies

The results shown in Figure 4.19 illustrated that the majority of the targeted companies in this interview have in average more than 11 persons. While a low category has more than 30 persons. This reflects that the majority is medium companies in the Gaza Strip.

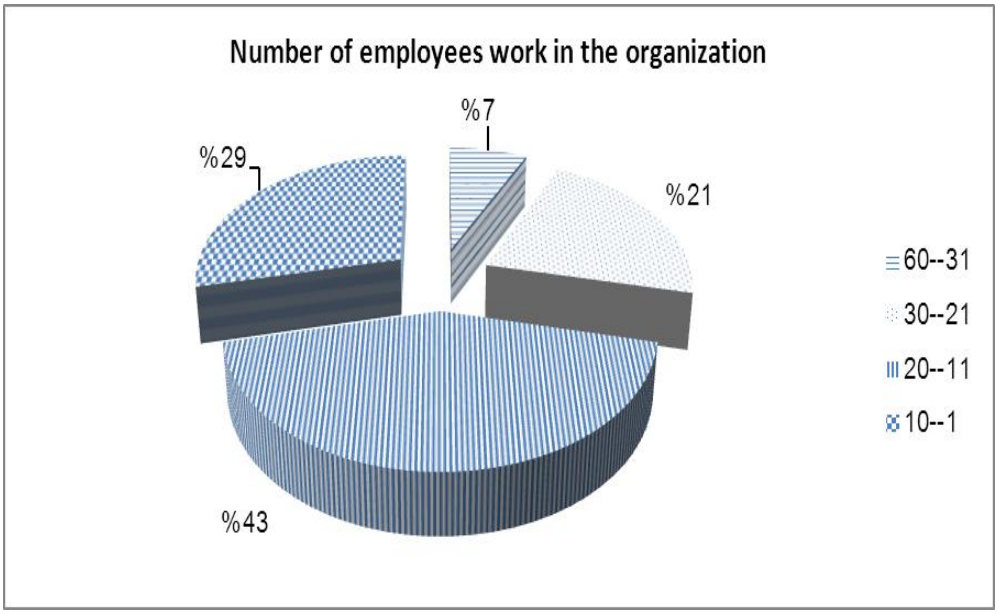

Figure 4.19: Number of employees work in the company

The results shown in Figure 4.20 illustrated that the majority of the targeted persons in this research was project managers. This gives the results more credibility and strength of the obtained results.

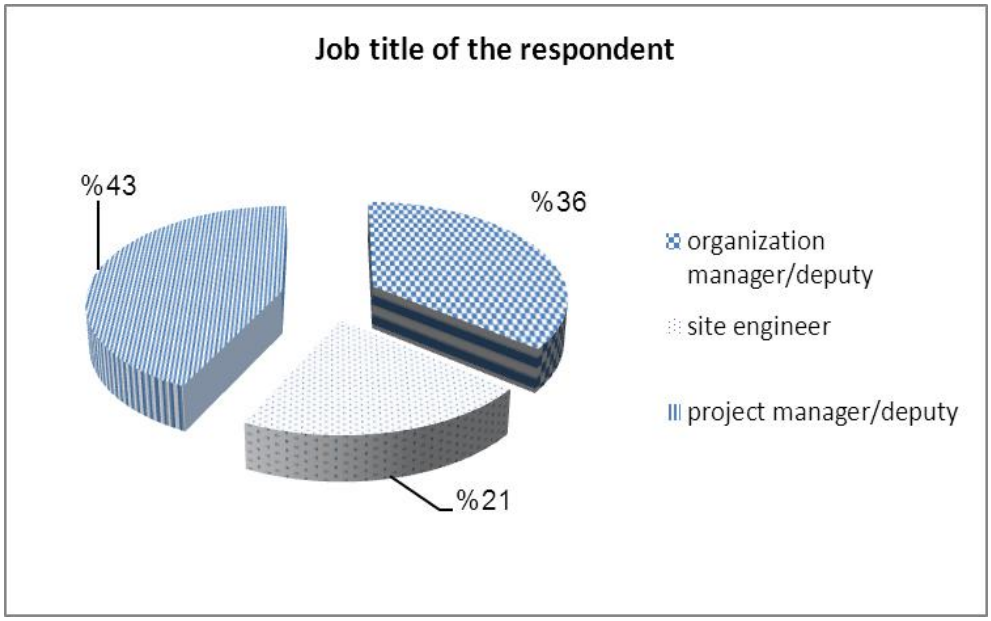

Figure 4.20: Job title of the respondent

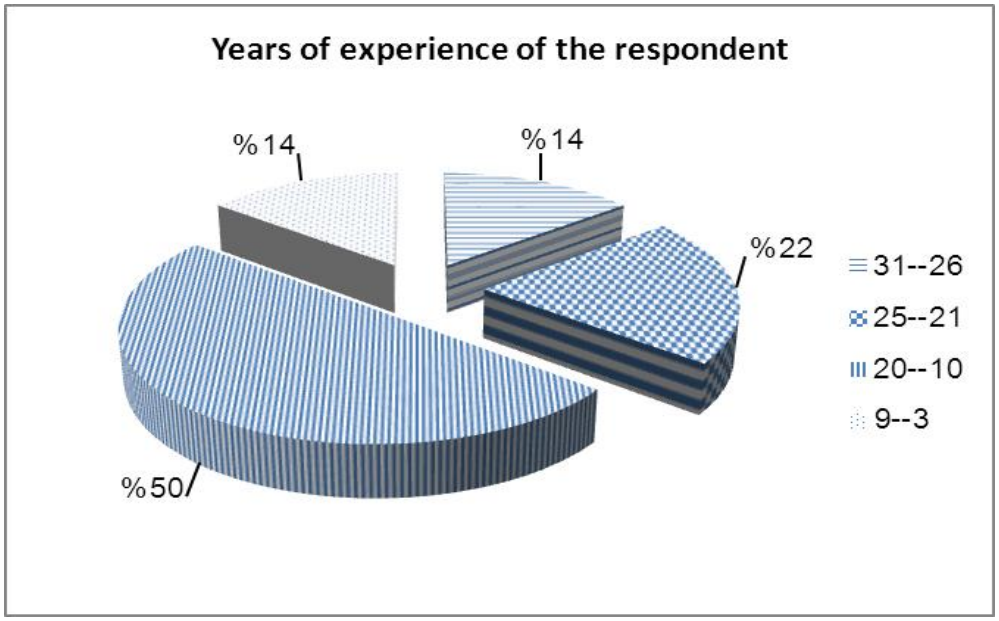

Figure 4.21: Years of experience of the respondent

The results shown in Figure 4.21 illustrates that the majority of the respondents have experience more than 10 years. Such results give good indicators and out come to our research.

Figure 4.22 shows that the majority of the executed projects in the last ten years were ranged from 2-5 million dollars. This range is relatively moderate.

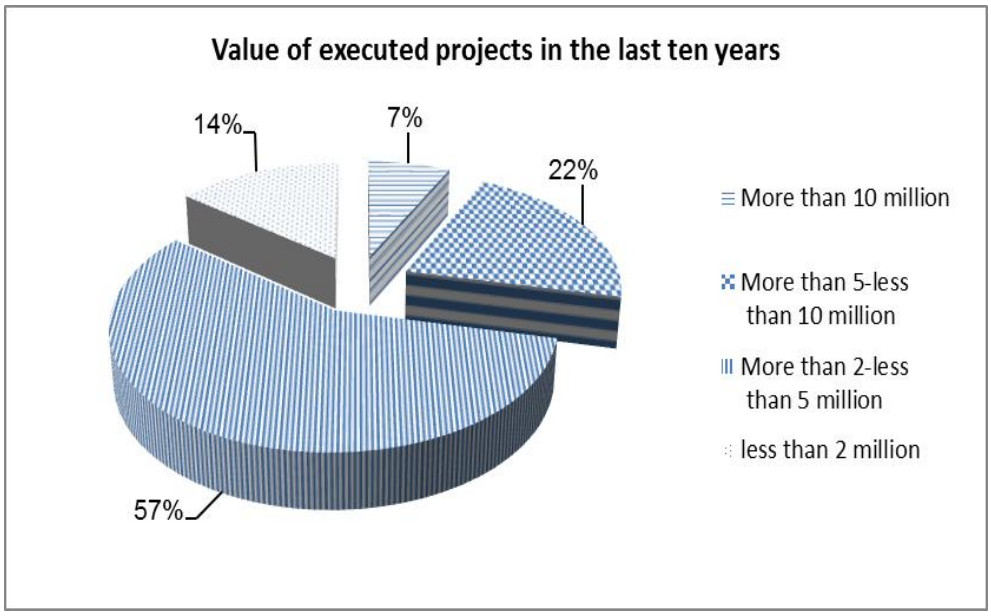

Figure 4.22: Value of executed projects in the last ten years

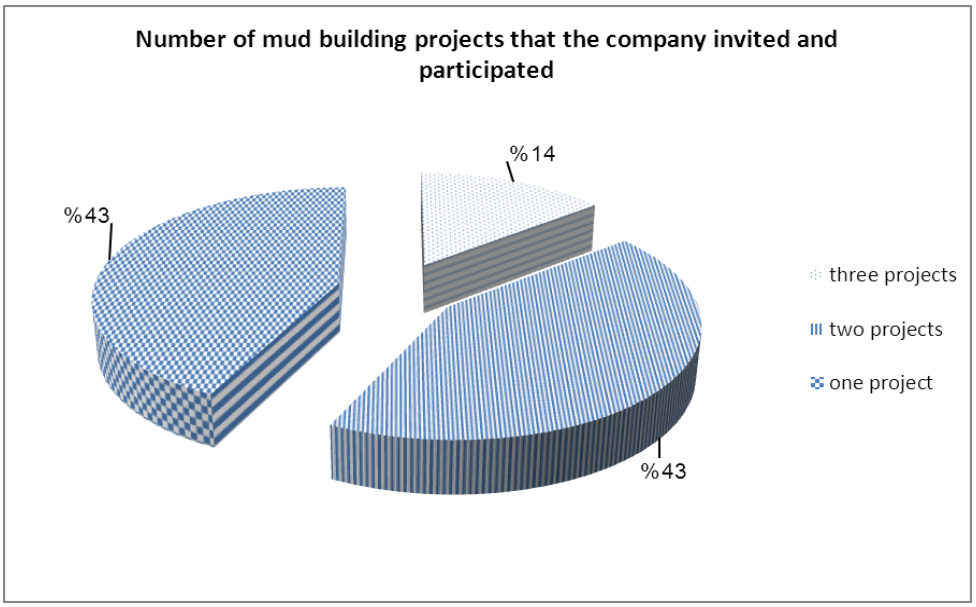

Figure 4.23: Number of mud building projects that the company invited and participated in

Figure 4.23 shows that the majority of the interviewed companies invited to participate in two projects. This is relatively low and indicates that the number of mud buildings is relatively low in the Gaza Strip.

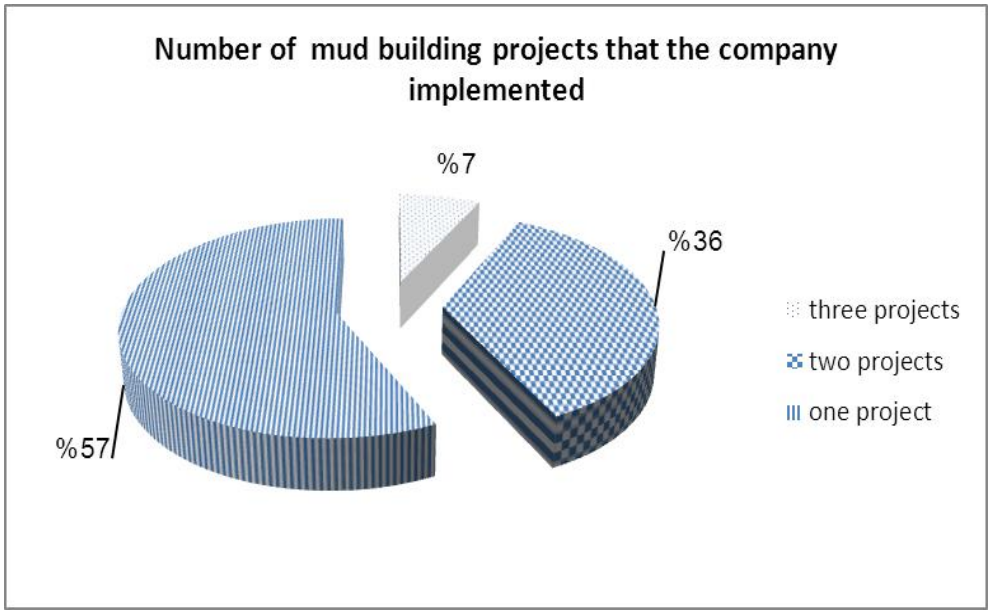

Figure 4.24: Number of mud building projects that the company implemented

Figure 4.24 show that the majority of the interviewed companies implemented one projects. This is relatively low and indicates that about 50% of the participation was positively obtained in the mud buildings in the Gaza Strip.

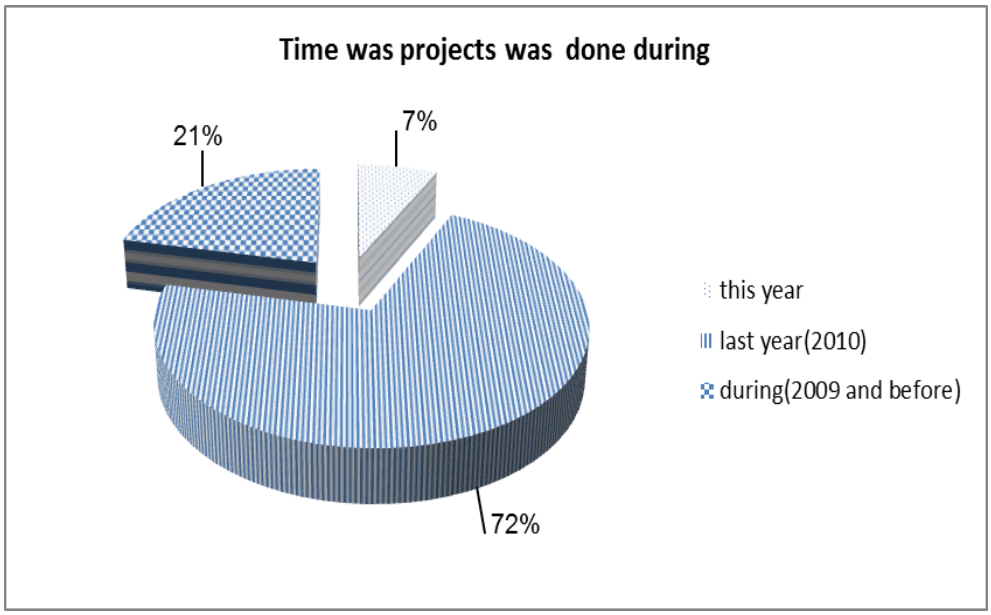

Figure 4.25: The participation in mud building projects was done during

Figure 4.25 shows that the majority of the interviewed companies participated in year (2010) this reflects that the revaluation of mud building started with a short period and nearly finished at the same year.

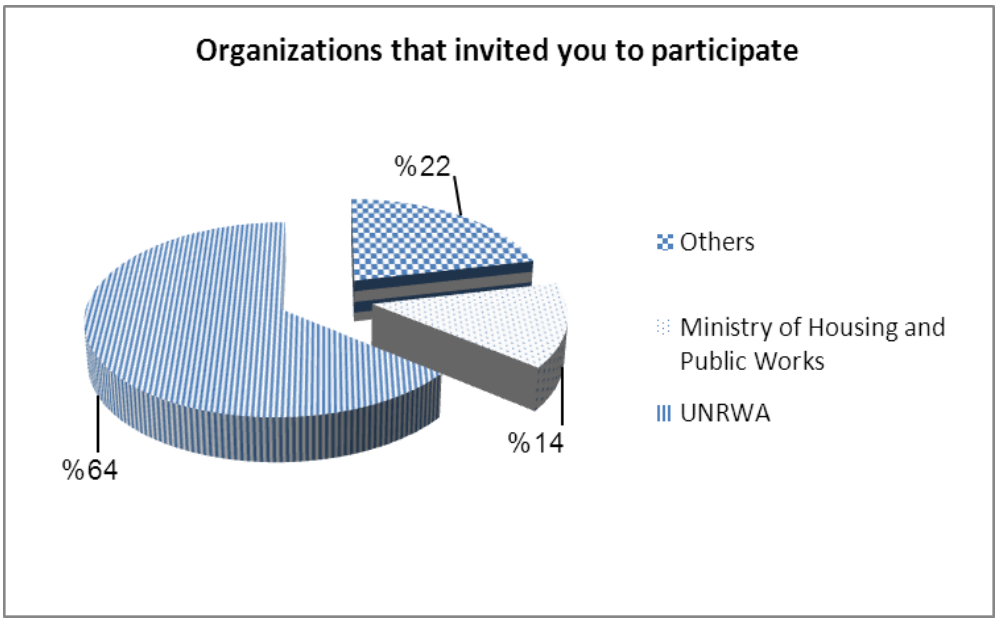

Figure 4.26: Organizations that invited you to participate

Figure 4.26 show that the majority of the interviewed companies stated that they were invited by UNRWA. In the other side, the local community (NGO's) participates in the mud building practices with about 22%.

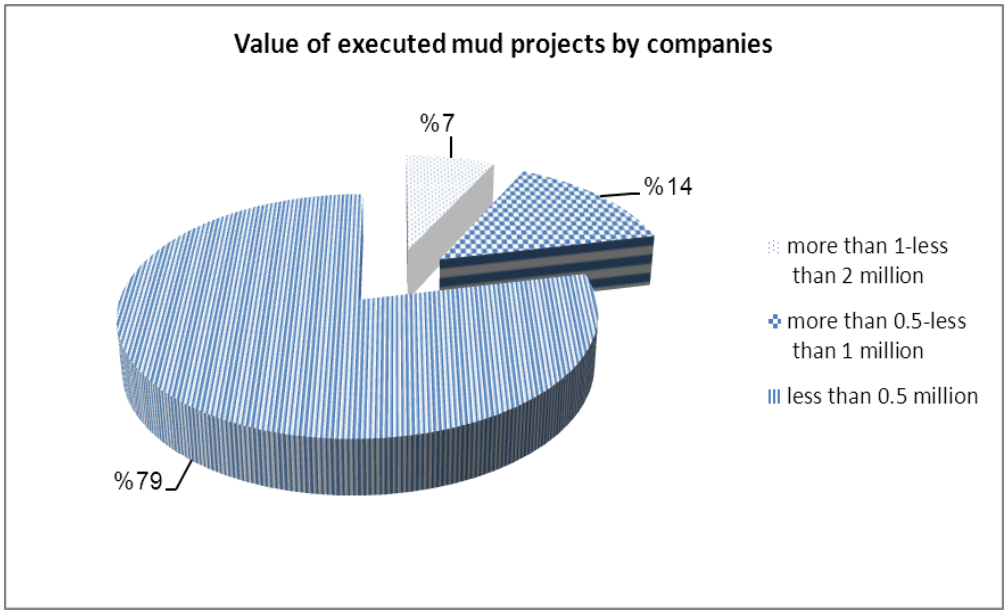

Figure 4.27: Value of executed mud projects by companies

In figure 4.27 the results introduced by the respondents showed that the average financial value of the mud building is less than 0.5 Million Dollars. This means that the costs of this type of building are show that the majority of the interviewed companies stated that they were invited by UNRWA.

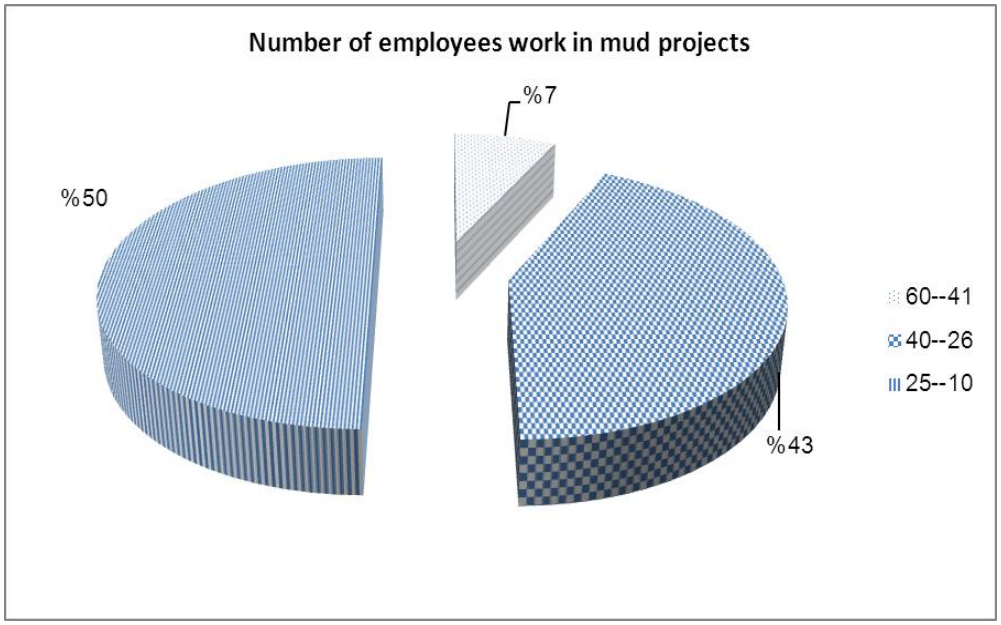

Figure 4.28: Number of employees worked in Mud project

The results introduced by the respondents in Figure 4.28 showed that the average number of employees worked in mud building was ranged between (10-25 parsons) while 7% of the respondents showed that the range is around (41-60 persons).

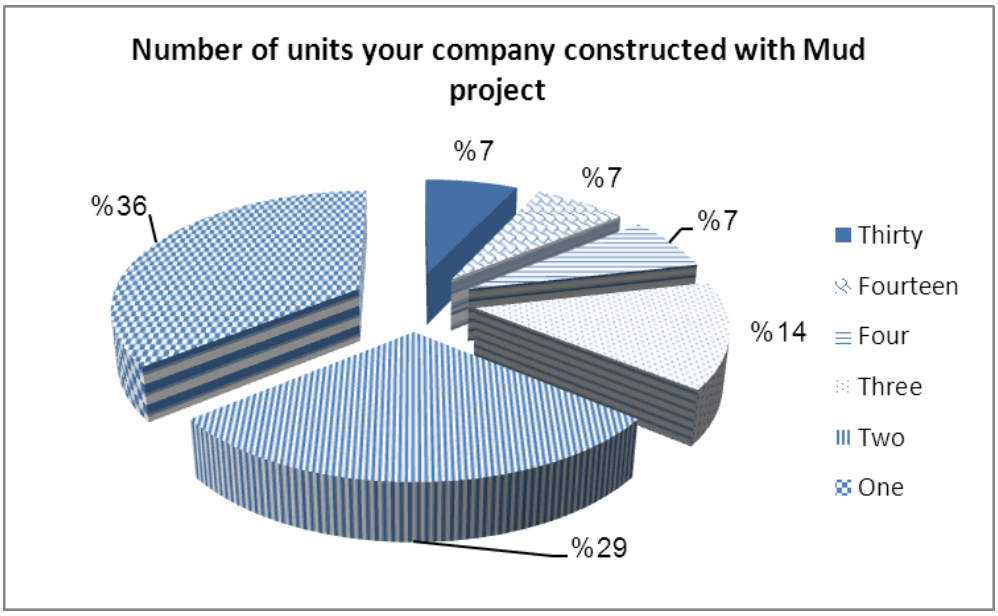

Figure 4.29: Number of units your company constructed with mud project

The results in figure 4.29 showed that the number of units that companies constructed with mud, range of units is about one to two building units. This is relatively realist and logic in compare with the other results.

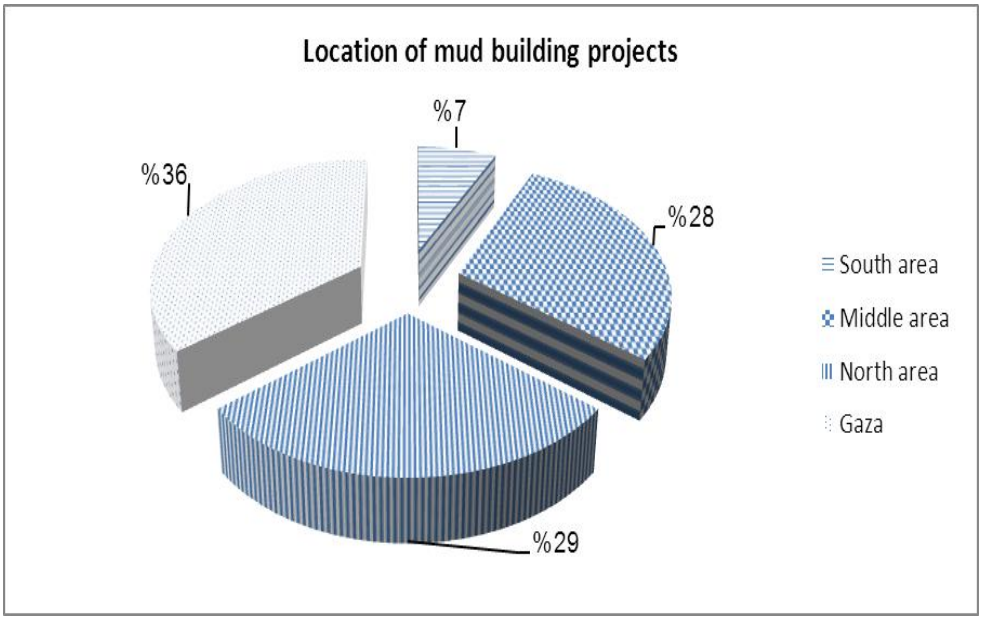

Figure 4.30: Location of mud building projects you implemented

The results in figure 4.30 showed that most of the mud building was distributed in Gaza strip although the south area was the least one in its share. The

Gaza and north area has the highest share as the destroyed shelters were the highest in the hot areas like (Azbet Abed Rabbo and other areas)

Table 4:19 Type of techniques used in mud building projects

Type of techniques used in Mud building projects	CEB	CSEB	Adobe	Rammed earth
No. of company's	1	12	4	0
Frequency	5.88	70.59	23.53	0.00

The results introduced in Table 4.19 illustrate that the most used type was CSEB. This is relatively logic as this type is the strongest one as the cement is a part in this type.

4.2.2 Analysis results of Structured Interview

4.2.2 .1 Question 1: What were the main challenges that face you as a contractor in the mud building practice?

Fourteen contractors' respondent for this question shows difference opinions, where the majority of contractors answered that the main challenges that face contractors in using mud building are investigated.

It shown that (13) of the respondents say limited skills and scientific expertise to those working in construction in the mud as well as the lack of workers that work in mud's buildings as the most challenges that face contractors in using mud building. The (8) of contractors' respondent for this question shows presence of one plant for the manufacture of bricks used in construction, (9) of the respondent faced lack of quality of mud material, (9) of the respondent say the construction with clay materials are related to bad impact of weather conditions, (7) of the respondent say mud building needed large place for bricks-and to dry, (4) of the respondent faced slow implementation, (9) of the respondent faced high cost of buildings with clay, (11) of the respondent faced difficulties in the implementation of the domes,(2) of the respondent faced flight engineers working in construction with mud's buildings

because of fear of shouldering the responsibility, (3) of the respondent faced draining of agricultural land, (6) of the respondent faced less of land in the Gaza Strip and the construction of mud's buildings needs to be large areas due to construction of horizontal, (6) of the respondent faced difficulty of establishments the electrical and mechanical works in the walls of mud's buildings, (5) of the respondent faced Psychological condition unacceptable to the population because of the belief that this buildings system is regressive and suggests a cultural case, (3) of the respondent faced lack of necessary equipment to construct mud's buildings, (7) of the respondent said limited construction of mud's buildings on the residential units that are small, (10) of the respondent faced mud's building depends mainly on the political decision, (3) of the respondent faced difficulty in pricing tenders for the mud's buildings construction, (2) of the respondent said that mud's buildings need to continuous maintenance in regular time, (2) of the respondent faced lack experienced workers, (6) of the respondent said that building with clay is weak and cant build multi-storey buildings, and (4) of the respondent faced difficulty of understanding the drawing and their accurately implementation as the most challenges that face contractors in the mud building practice.

From these results it, can be concluded that the needs for skilled labors and the needs to political support and considerations in the country are considered the critical factors affecting the mud building practices. Theses results are matched with the questionnaire's results and other researchers as well like Arumala and Gondal (2008) and Rodriguez et. al, (2002) who showed the important of experience in all stages of constructing mud building projects. Kundoo (2008) and Harris (2010) explained that building with mud brick or block in particular, requires little or no specialist skills. The process is labor-intensive.

4.2.2.2 Question 2: What was the main mistake or errors you observed during the work and the reason for these errors?

The number of contractor respondents according to main mistake or errors they observed during the work and the reason for these errors are investigated.

It is shown that (4) out of fourteen (14) of the respondent said that here is no steel reinforcement in the ground beams, which may cause a cracks and settlements in the mud's buildings because of the soil type, (5) of the respondent said that non-regularity of dimensions of the implementation of the domes, causing the cracks and water leakage, (5) of the respondent said that the implementation of the domes using caliper and this does not guarantee the regularity sizes domes, (8) of the respondent said that increasing the use of cement at high rates in the brick industry because of the lack of full knowledge of building systems with mud, (4) of the respondent said that high financial costs because of the complexities of the designs used and lack of development and attempts to get new models or sample to build with mud, (5) of the respondent said that the inability of laboratories to give the real value of the loads and the bearing capacity of clay bricks, (3) of the respondent said that non-plastering domes from the inside and not from with mortar from outside brick during construction and not after the completion of construction, (3) of the respondent said that use unsuitable mortar that is not appropriate in the construction of mud's building due to lack of proper tests, (2) of the respondent said that use clay in the foundations because there is high humidity in the soil, (1) of the respondent say cracks templates used in the manufacture of clay blocks because of the quality of used mud's, (2) of the respondent said that, repetition of the experiments used to implement the technology because of lack of previous experience. (2) of the respondent said that causing some pain for workers, especially in the back and feet due to heavy reliance on the human element at work, (5) of the respondent said that failure to ensure that age of the mud's buildings for a long time because of moisture and this needs to isolate the work of the buildings and maintenance.

From these results it can be concluded that many mistakes and non-conventional processes were done by the designers of mud building. No existence of steel reinforcement in the ground beams, which may cause a cracks and settlements in

the mud's buildings because of the soil and using the cement without any experimental tests that can be generalized to all companies work in this practices, no deep studies and feedback about the mud building process were recorded as crucial points that are in need to be solved by the clients and designers. All these are in line with the importance of the designers experience in this field. These results matched with Ramage et al. (2010) who stressed to the strengthen and training new people in the mud building environment overall stages as specially design process will improve all the system.

4.2.2.3 Question 3: Did you innovate or used any new technique to facilitate the building with mud materials? If yes please explain.

Contractors' respondent for this question shows difference opinions, technique to facilitate the building with mud materials are investigated. It is shown that (4) out of (14) of the respondent using new techniques, such as manufacture templates for the construction of fixed domes from which to build the dome and dismantled immediately after the end of construction, (2) of the respondent using new techniques, such as construction works of the floor of mud's buildings (volts and domes) of pure clay without iron or wooden bridges, (4) of the respondent filling the mortar by every stone on the construction unit, which gave aesthetic form during construction, (2) of the respondent using steel reinforcement to strengthen mud's buildings and this increases the bearing construction in emergency circumstances such as earthquakes and bombings, (2) of the respondent using manufacture of paint to the surface of floor about oils with Alkrkar powder to paint ceilings and protect it from dew and moisture, (3) of the respondent work of a distinctive architecture and a new forms with mud, (4) of the respondent used plastering domes and painted with isolated materials, (1) of the respondent using new techniques, such as construction with pure sand, (2) of the respondent increase the size of the pressure in the brick industry using the interlock factory mechanisms has given effective results.

From these results it can be concluded that many innovative issues by the contractors were introduced that provide valuable benefit to the construction industry

in the Gaza Strip such as manufacture templates for the domes of buildings, using materials to protect the roofs and others.

4.2.2 .4 Question 4: The most benefits you and other parties gained from these types of projects

The number of contractor's respondent according to the most benefits that the contractors gained from constructing mud building are investigated. It is shown that (12) out of (14) of the respondent said that increase expertise in mud's building systems, especially the construction of mud's as it is a new system, (11) of the respondent said that knowledge of the properties of mud's and construction equipment and materials needed for that and proportions of mix materials are used, (7) of the respondent said that discrimination and the ability to design mud's buildings with architectural features and a high environment properties, (5) of the respondent said that knowledge of equipment and construction materials of mud's buildings and availability, (11) of the respondent said that financial benefit through profit in the implementation of projects, (12) of the respondent said that the presence of staff with high experience in the field of construction companies in the mud's buildings as the most benefits for using mud building.

The majority of contractors answered that the most benefits to other parties gained from mud building are investigated .It is shown that (11) out of (14) of the respondent said that running large numbers of workers helped in partially pushing the economy, (10) of the respondent said that there is increase the experience of workers that works in the construction of mud's buildings, (8) of the respondent said that mud building contributed to solve the housing problems especially after last war, (7) of the respondent said that creating new job opportunities for contractors and engineers working in construction, (9) of the respondent said economic benefit because most of the components of the work are locally, (8) of the respondent said reduce unemployment of workers in the construction of mud's buildings, (8) of the respondent said that this construction is useful in areas of the eastern border of the Gaza Strip to fill the largest area of land in front of the occupation, (2) of the respondent said mud buildings are very useful in ventilation and keeping the heat and lack of moisture, (9) of the respondent said improving the experience efficiency of the

workers works in mud building, (10) of the respondent said challenge of the blockade of the Gaza Strip as the most benefits to other parties attitude from mud building.

Finally ,it can be concluded that many benefits are introduced in mud building practices such as new experiences in this area, ability to innovate, new opportunities to workers, solve the accommodations problems for the homeless people and other important issues.

5 ANALYTICAL CASE STUDY

5.1 Mud Building Practices in the Gaza Strip - UNRWA case study

5.1.1 Introduction

More than 15% of refugee housing stock in Gaza was destroyed or damaged during Israel assault on Gaza in December 2008 – January 2009. Approximately 12,000 refugees lost their homes, while the homes of a further 235,000 were damaged. 2,300 refugee shelters were destroyed or damaged beyond repair, with another 1,700 sustaining major damages and 43,000 sustaining minor damage. Even before the last Israeli assault many houses were destroyed or damaged by the Israelis. UNRWA estimates that between September 2000 and December 2008, 3,411 refugee shelters were destroyed or damaged beyond repair and a further 7,934 damaged. To date the Agency has completed the reconstruction of 1,029 shelters and the repair of 5,145 (UNRWA Report, 2010)

Since June 2007 the imposition of a strict blockade has prevented the entry into Gaza of construction materials and thus prevents any large scale reconstruction efforts. Small quantities of materials available at high prices on the local market have allowed some individual families to rebuild their homes. The needs to construct new alternative building of the reinforced concrete building was becoming necessity rather than just new building approach.

5.1.2 The objectives of the case study

The objective of this research-case study is to evaluate the implementation of the mud building in the Gaza Strip, UNRWA as case study. This contribution is expected to add valuable benefits for all parties operating in the construction industry.

5.1.3 Case of UNRWA

United Nations relief and work agency (UNRWA) Gaza Field has recently adopted a unique engineering solution to address the challenge of providing emergency shelter in an environment where most ordinary building materials are unavailable. Through close cooperation with the International Labour Organization (ILO) and the local private sector and after successive pilot projects and comprehensive feasibility studies, UNRWA has identified an opportunity to use natural raw materials readily available in the Strip to construct as many as 5,000 Compressed Earth Block (CEB) shelters. These CEB shelters are built in a specific structural manner, technically known as the "bearing walls with arches and domes system". Unlike in more conventional construction, shelters constructed using this technique do not require steel reinforcement bars or concrete. CEB shelters are constructed from locally-manufactured Compressed Stabilized Earth Bricks (CSEBs). Proportions vary slightly, but the typical makeup is 15% Gravel, 50% Sand, 20 Clay, 15% Silt. 5% cement is added to the total mass to increase stability of weight-bearing components.

CEB shelters have been thoroughly tested by UNRWA engineers to meet the comprehensive strength requirements established by the International Labour Organization of 3 N/mm2 or 30 kg/cm2. Wet compressive strength, absorption, abrasion and erosion tests carried out by UNRWA have also shown CEB shelters to be sufficiently resistant to water. Materials used to construct the CEB shelters are plentiful in Gaza and the construction of a limited number has absolutely no impact on agricultural land, as the material is taken from quarries, not arable land. CEB technology is environmentally friendly insofar as the construction materials require no

industrial processing and very little transport to be produced and brought on site. The shelters should also be more thermally efficient than normal buildings, thereby lessening heating related cost and carbon emissions. The figure 5.3, 5.4 illustrates the architectural and structural design of the CEB shelters.

There are two models of the one-story CEB-Shelters; the first one (designated as S1) has a total built area of 60 m2 for families of fewer than eight persons and consists of two rooms, a kitchen and a toilet. The second one (designated as S2) has a total built area of 80 m2 for families of eight or more persons and consists of three rooms, a kitchen and a toilet (UNRWA Report, 2010).

Based on pilot projects implemented by local private sectors in coordination with UNRWA and International Labour Organization (ILO), the typical duration required for constructing a CEB shelter ranges from 40 days to two months. However, this relatively short time period is dependent on the availability of skilled workers who will be responsible not only for building the shelters but also for producing the building blocks (CEBs) and the associated binding materials. Accordingly, and as there are limited numbers of construction workers available locally who have the required experience, it will be necessary to provide training for civil engineers and labourers in parallel to the implementation of the project. For this reason, a period of six-months is a projected to complete the project (UNRWA Report, 2010).

5.1.4 Methodology of the study

Data Files analysis was conducted in this project to find out the techniques used in this projects in constructing 20 CSEB shelters that was implemented by UNRWA in 2010. The data was obtained from the reports and documents filed by the contractors who completed these projects. For the privacy purposes the names of these contractors were not mentioned in this research as the main purpose is to obtain the facts and information which provide a valuable research contribution. The filing

system provided by the contractor illustrated that this project was advertised on August 2010 with a tender closing date on September 2010.

The project (20 shelters) consisted of 2 CSEB shelters in Jabalia, 10 Gaza, 6 Nusirate and 2 Khan Younis area. The models used and the techniques applied will be illustrated in the following section.

5.1.5 Number of Projects implemented by UNRWA

The tender documents for project 36/2010 illustrated that, there are three packages of mud buildings were advertised and implemented. These projects started in 2010. The first package includes 6 shelters at Middle area; the second package includes 19 shelters over all Gaza Strip while the third package was to construct 20 CSEB overall Gaza Strip. Since that date of tendering the last package (20 CSEB shelters) no more units (till now) is tendered. This may reflect an indicator that in the existence of construction materials (cement, steel reinforcement) the needs for these types are becoming not essential for the revival.

5.1.6 Project details, features and information

The case that will be illustrated in our research is related to construct 20 CSEB shelters. The duration planned to implement this project was 16 weeks. The average cost for each unit was US $ 18,000.0 Based on the drawings attached for this project (Tender 36/2010) the Proportions vary slightly, but the typical makeup is 15% Gravel, 50% Sand, 20 Clay, 15% Silt. 3-8% cement is added to the total mass to increase stability of weight-bearing components. Figure 5.1 shows the architectural distribution of model (1) of the CSEB shelters. This model includes two bid rooms, one kitchen and one bath room. The average area for this building is 60 m^2.

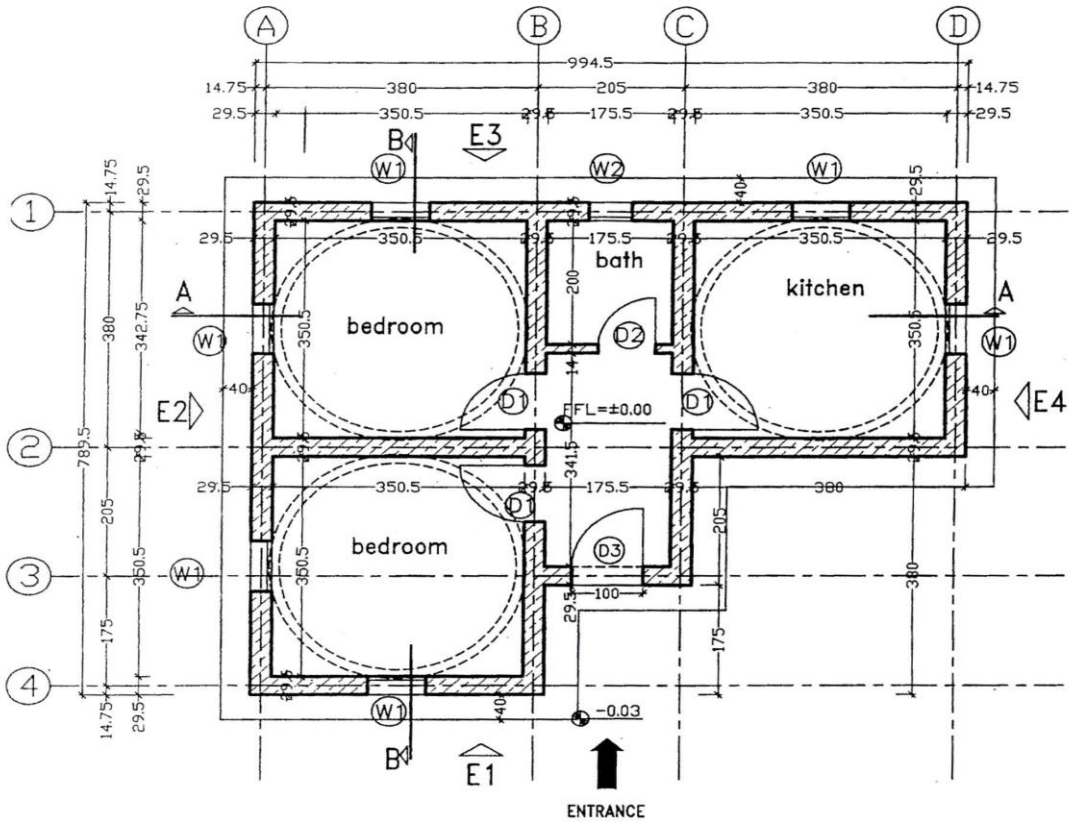

Figure 5.1: Architectural distribution of model (1) [Source: UNRWA drawing –tender 36-2010]

In Figure 5.2 the section showing the construction of foundation and wall was illustrated. The foundation was poured as plain concrete B200 kg/cm². The constructed walls used CSEB blocks with a strength 60kg/cm². the dimensions of the blocks used was 29.5 X 14 X 9cm as shown in the detailed section (Figure 5.2)

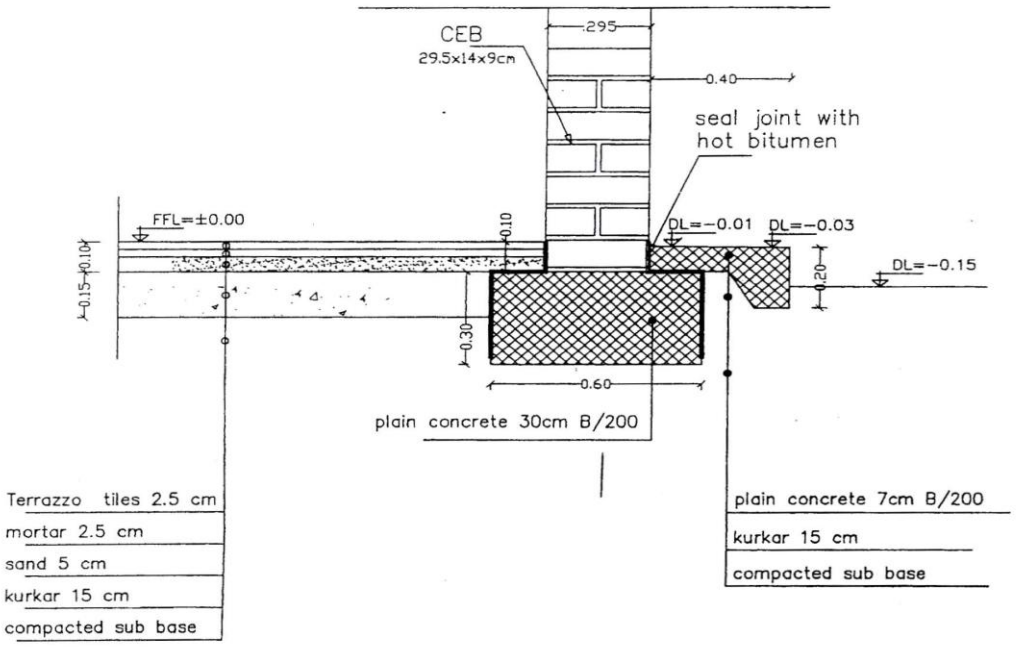

Figure 5.2: Section of connection between foundation and wall Source: [UNRWA drawing –tender 36-2010]

The slopes and the top views of the building is illustrated in Figure 5.3, besides a cross section shows the detailed structural and architectural details is introduced in Figure 5.4

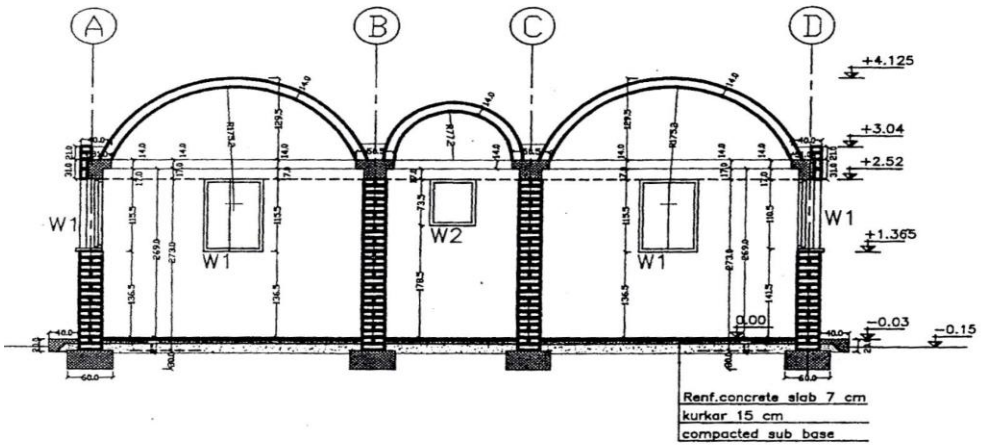

Figure 5.4: Detailed section of structural and architectural details

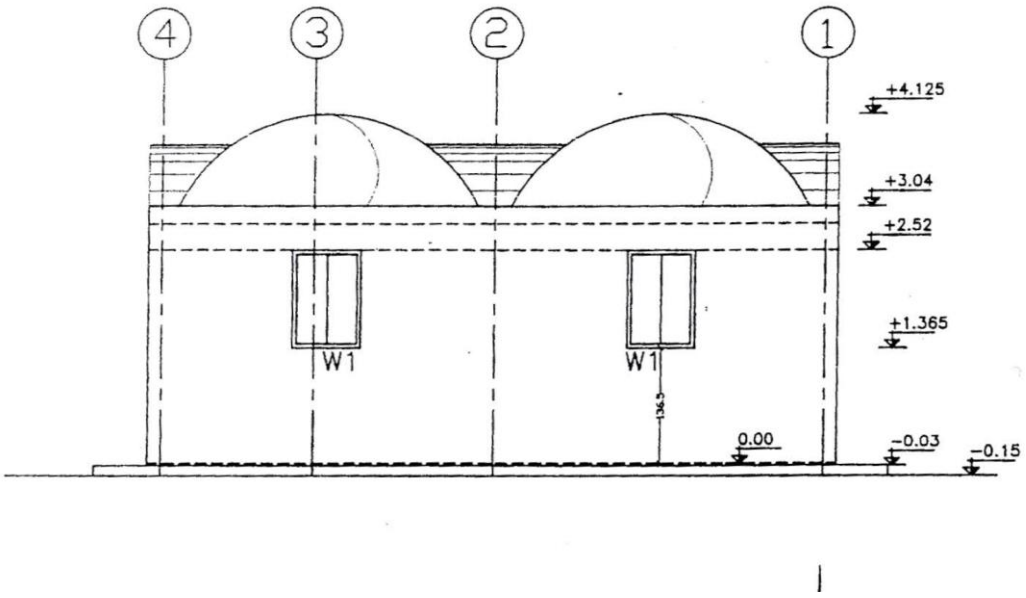

Figure 5.3: Detailed section of structural and architectural details

5.1.7 Photos taken during the implementation of 20 CSEB shelters- Middle area

In this part, the researcher was lucky to visit some of the sites that were implemented during his research. A field survey to these building illustrated the steps taken during the construction works since the foundation works till constructing the doms. Figure 5.5 illustrates the walls with the CSEB.

Figure 5.5: Illustrates building the walls with the CSEB (Taken by the researcher, 2011)

In Figure 5.6 the researcher (left in the photo) during his visit to one of the projects during the implementation stage.

Figure 5.6: Illustrates building the walls with the CSEB (Taken by the researcher, 2011)

The electrical connections in the walls are shown clearly in Figure 5.7, while Figure 5.8 and Figure 5.9 illustrate the final shape and features of the building after its completion.

Figure 5.7: Electrical connections in the walls

Figure 5.8: External electrical connections in the building

Figure 5.9: The mud building after completion (Ready to be handed to the beneficiaries)

5.2 Mud Building Practices in the Gaza Strip-Government building case study

5.2.1 Introduction

The closure of border crossings, especially Al-Montar (Karni) crossing, has seriously impacted the economy of the Gaza Strip, and the private sector is at the edge of collapse due to the ban imposed on importation and exportation. At least 85% of factories have been forced to stop their production and the remaining 15% were forced to decrease their productive capacity to less than the half due to lack for raw materials. As a consequence, the production capacity of the Gaza Strip has decreased by at least 80%. Many employers have been forced to dismiss workers, which has increased the levels of unemployment. Additionally, at least 35,000 out of approximately 42,000 construction workers have lost their jobs due to lack of raw construction materials, which has led to the suspension of many construction projects (PCHR, 2007).

People in Gaza Strip already face difficulties deriving from the effects of an Israel siege, that conned over 4 years, and which has engendered humanitarian crisis across all sectors of Palestinian society. This situation has reached an even more

height emergency condition since early 2009, following Israel's Operation Cast Lead. That attack caused thousands of victims and ongoing suffering which can be measured in terms of physical injuries and homelessness.

5.2.2 The objectives of the case study (Ministry of Public Works and Housing)

The objective of this research-case study is to evaluate implementing of the mud building in the Gaza Strip, Ministry of Public Works and Housing as case study. This contribution is expected to add valuable benefits for all parties operating in the construction industry.

There is no large-size projects supervised by governmental bodies fully, but some projects are encouraged by some ministries or supported financially.

5.2.3 Policy mechanism for reconstruction (MPWH, 2011)

1. Interests of the resident and putting them above all else.
2. Justice in compensation so that the amount of compensation commensurate with the value of losses.
3. The parent is to build residential units on the same land that was built upon.
4. Reliance on local labors at all stages of reconstruction as possible.
5. Coordination of efforts among all parties and full flexibility in dealing with everyone.
6. Promote the participation of the private sector and all civil society institutions.
7. Work to ensure the greatest possible benefit of offices and companies.
8. Benefit from what has happened to correct any irregularities and organizational planning as possible.
9. The participation of all relevant parties in decision-making.

5.2.4 Areas of work in the Ministry of Public Works and Housing (MPWH, 2011)

1. Inventory of losses and damage to public facilities, private and major road networks.
2. Assessment of buildings which constitute a danger to people's lives and to decide on their construction.
3. Strengthening of buildings that need to strengthen the structural and the completion of the demolition of buildings that have been decided to repaired.
4. Begin repairing partial damages.
5. Find alternatives to reconstruction in the siege.
6. Develop plans to be rebuilt after the siege.

5.2.5 Classification of losses (MPWH, 2011)

After the recent war in the Gaza Strip, the Ministry of Public Works and Housing divided the damage and losses into different categories.

1. Housing units totally destroyed.
2. Partially damaged housing units.

Table 5.1: Distribution of damage to the governorates of the Gaza Strip (MPWH, 2011)

Governorate	Full damage	Partial damage
Rafah	500	6325
Khan Younis	350	4850
Central Province	210	4990
Gaza	970	10934
North Province	1410	21140
losses during previous attacks and invasions	1450	-
Total	**4890**	**48239**

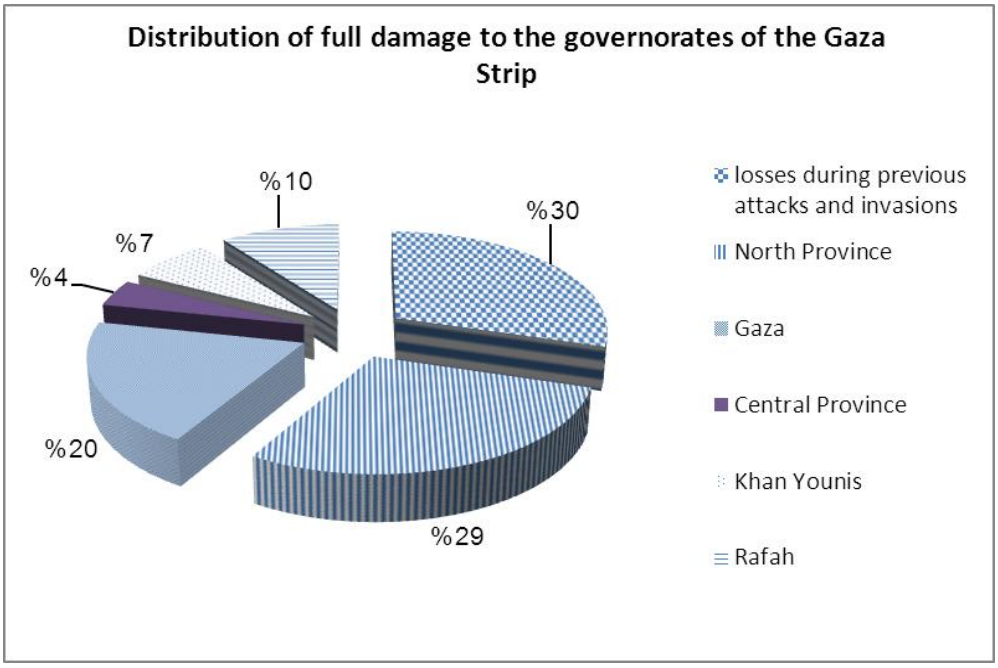

Figure 5.10: Distribution of full damage to the governorates of the Gaza Strip

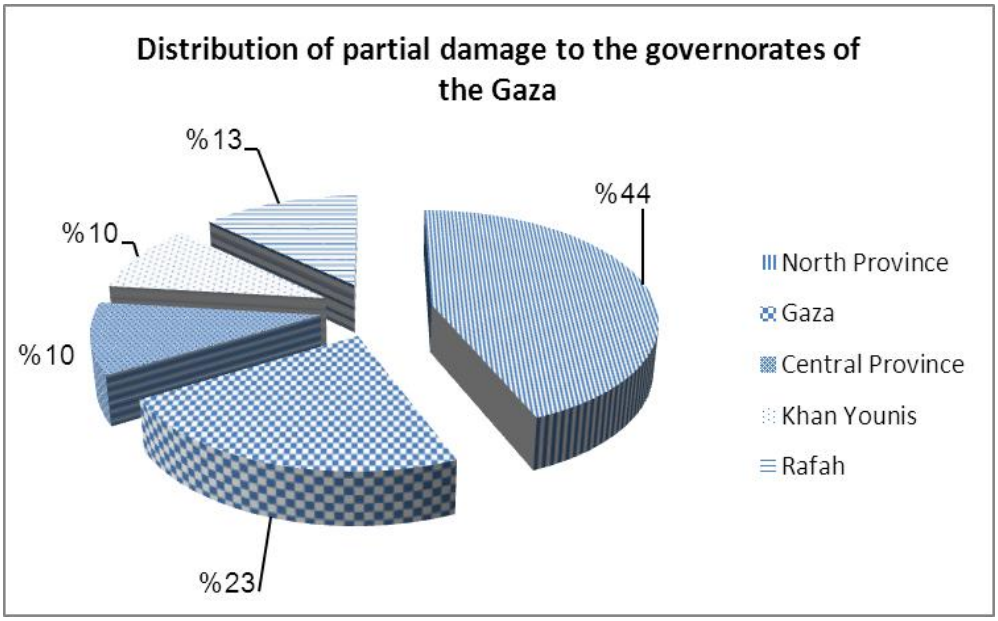

Figure 5.11: Distribution of partial damage to the governorates of the Gaza Strip

5.2.6 Features of construction industry in Palestine and Gaza strip

The Gaza Strip was part of the British mandate of Palestine before 1948 and was captured by Israel from Egypt in the 1967 war. The Gaza Strip is approximately

360 square kilometers in area. It has an 11km land border with Egypt and a 51km land border with Israel. Its land borders and 40km coastline are under Israeli control (see Figure 5.12). The Gaza Strip is entirely surrounded on land by an Israeli-controlled security fence. Three-quarters of Gazans are refugees expelled from what is now called Israel in the 1948 war, or their descendants. The Palestinian population in the Gaza Strip is growing rapidly, at over a rate of 4% per year; half of the population is under age 15. Before the outbreak of the al-Aqsa Intifada in September 2000, the Gazan economy was valued at approximately $US 1 billion. The service sector is the largest part in the economy, followed by agriculture. Approximately 24,000 Gazans who used to work in Israel are now unable to reach their jobs due to Israeli border closures (PCHR, 2003)

The Ministry of Public Works and Housing inventory of all the large and small damage resulting from the attacks of the occupation during the last War, The Zionist enemy launched brutal war on Gaza, this war began at 27th of December 2009, and continued for 22 days. As a result of this war 3,500 housing units were totally demolished and 16,500 citizens lost their homes. Till now, no real construction has taken place due to the blockade on the Gaza strip. Gazans look for alternatives in order to construct the demolished units despite the blockade.

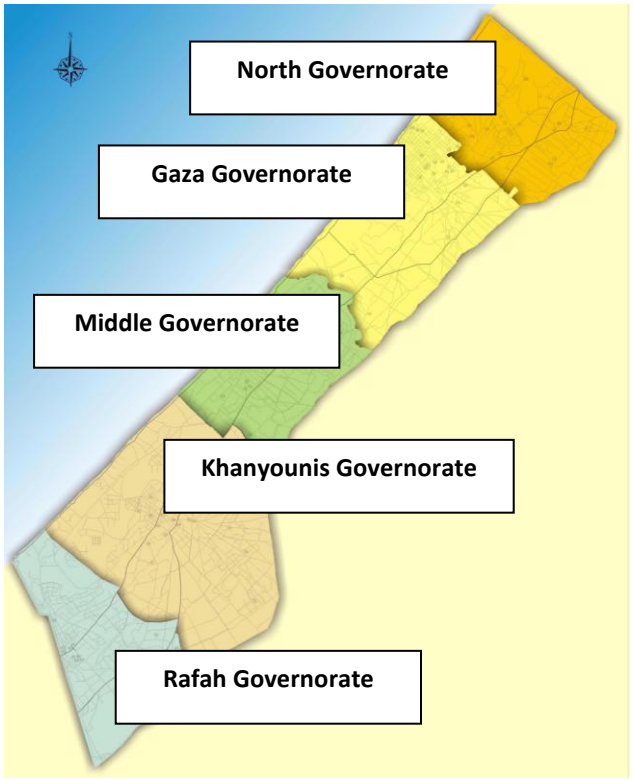

Figure 5.12: Gaza Strip Map

Because of the unjust siege on the Gaza Strip and the lack of basic building materials, the government cannot build or re-constructing the demolished housing units.

5.2.7 Alternatives form Ministry of Public Works and Housing inventory (MPWH, 2011)

1. Building with mud bricks technology.

2. Buy apartments for the affected families.

3. Providing caravans instead of tents for the affected families.

4. Provide cash compensation to the affected families.

5. Construct core units.

Ministry of Public Works and Housing discussed each alternative, and concluded the following MPWH, (2011):

5.2.7.1 Buy apartments for the affected families

This alternative is complicated, it may record limited success but in any case not sufficient. Before the war construction was stopped because of blockade, so currently we need more than 60,000 housing units due to the natural growth demand only, this makes the housing sector crisis complicated.

5.2.7.2 Providing caravans instead of tents for the affected families:

Is considered a temporary solution as a transitional period while getting a permanent home, but even this solution is not available in Gaza, because of the blockade.

5.2.7.3 Provide cash compensation to the affected families:

This alternative have many disadvantages such as: Many of the affected will use compensation in things other than reconstruction because building materials are not available in reasonable prices. Also many families may move their homes to other places; so many important regions might be evacuated.

5.2.7.4 Building with mud

Building with mud needs higher cost of the unit compare with concrete, the construction is considered a temporary need cost to remove after that, this add to the cost of new construction, which will be built as it has to be instead (non-horizontal or vertical expansion). Building mud is by people rejected, in addition building with mud wasted natural wealth.

5.2.7.5 Construct core units.

The damage survey conducted by Ministry of Public Works and Housing showed that about 1,000 units from the 3,500 demolished units consist of one floor, and their foundations designed to extend vertically up to 3 or 5 floors. Some of these one floor units have temporary roofs from asbestos or corrugated metal sheets. On the other hand, these units have small areas before destruction so they don't require large amount of materials for reconstruction. "This information led us to think with reasonable alternative which is core units approach".

This is led to think about building with a Core Unit system so that the construction would be a part of the floor plan of the building scalable horizontally and vertically expansion when needed and when the building material is available, it is appropriate at this stage to accommodate the families who lost their home, without the need to leave home when they start with the expansion, figures 5.13, 5.14 illustrated first and second phases of the core unit system MPWH, (2011).

Figure 5.13: The first phase of the Core Unit

Figure 5.14: The Second phase of the Core Unit

5.2.8 Evaluation of alternatives:

Table 5.2: Evaluation of alternatives

	Caravans	Buy Apartments	Mud construction	Core Unit:
Cost	Low	High	Medium	Medium
Expansion	Non-expansion	Non-expansion	Non-expansion	Scalable
Popular acceptance	Low	Average	Low	High
Permanence	Not Available	Not Available	A temporary solution	Lasting solution
Evaluation	Bad	Bad	Good	Excellent

The Ministry of Public Works and Housing after studying the four options, they preferred to use the model of Core Unit construction system, Table 5.2 illustrated evaluations of alternatives MPWH, (2011).

5.2.9 Police center in Beit Lahiya case study detail

Challenge to the Israeli siege on the Gaza Strip, some government Agencies has encouraged building with mud to some of the buildings; we studied a model police center in Beit Lahiya, as a case study.

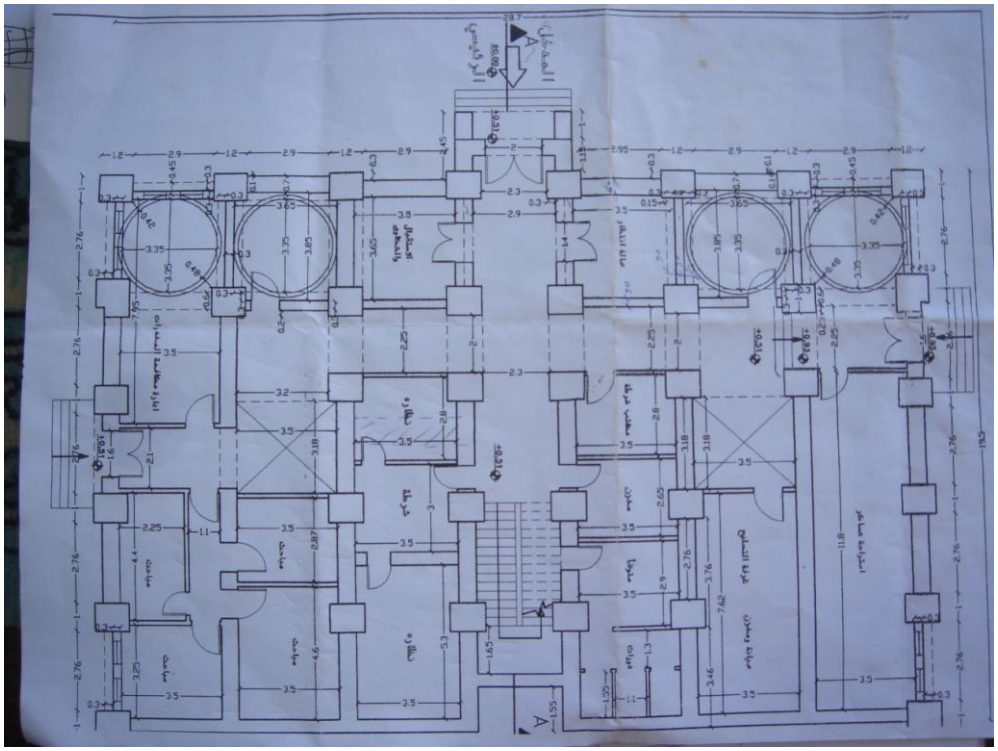

Figure 5.15: Architectural distribution of Police center in Beit Lahiya

In Figure 5.15 The architectural distribution of Police center in Beit Lahiya showing the construction of foundation and wall was illustrated. The constructed walls used adobe blocks. The dimensions of the blocks used was 20 X 12 X 35cm as shown in the Figures 5.17, 5.18.

Figure 5.16: Picture of the implementation of some of domes and arches

Figure 5.17: Image of blocks manufacture used in the Police center in Beit Lahiya

The slopes and the side views of the building is illustrated in Figure 5.16, manufacture of blocks used in the Police center in Beit Lahiya is illustrated in Figure 5.17.

Figure 5.18: The slopes and the side views of the building

The researcher was unlucky to visit Police center in Beit Lahiya that has been implemented before the start of his study. A field survey to these building were done during the study of mud building practice, the illustrated steps taken during the construction works since the foundation works till constructing the domes. Figure 5.19 illustrates the walls with the adobe; Information was collected for these parts of searching in difficulty through the supervisors' engineers of the project, and through personal interviews with relevant projects.

Figure 5.19: Illustrates Install mesh on the bottom of the wall to protect it from moisture (Taken by the researcher, 2011)

In Figure 5.20 the researcher (Central in the photo) during his visit to Police center in Beit Lahiya after the implementation stages.

Figure 5.20: Illustrates Police center in Beit Lahiya the walls with the adobe (Taken by the researcher, 2011)

The electrical connections in the walls are shown clearly in Figure 5.21, Figure 5.22 illustrated internal plumbing connections in the building, while Figure 5.23 illustrate the final shape and features of the building after its completion.

Figure 5.21: Electrical connections in the walls (Taken by the researcher, 2011)

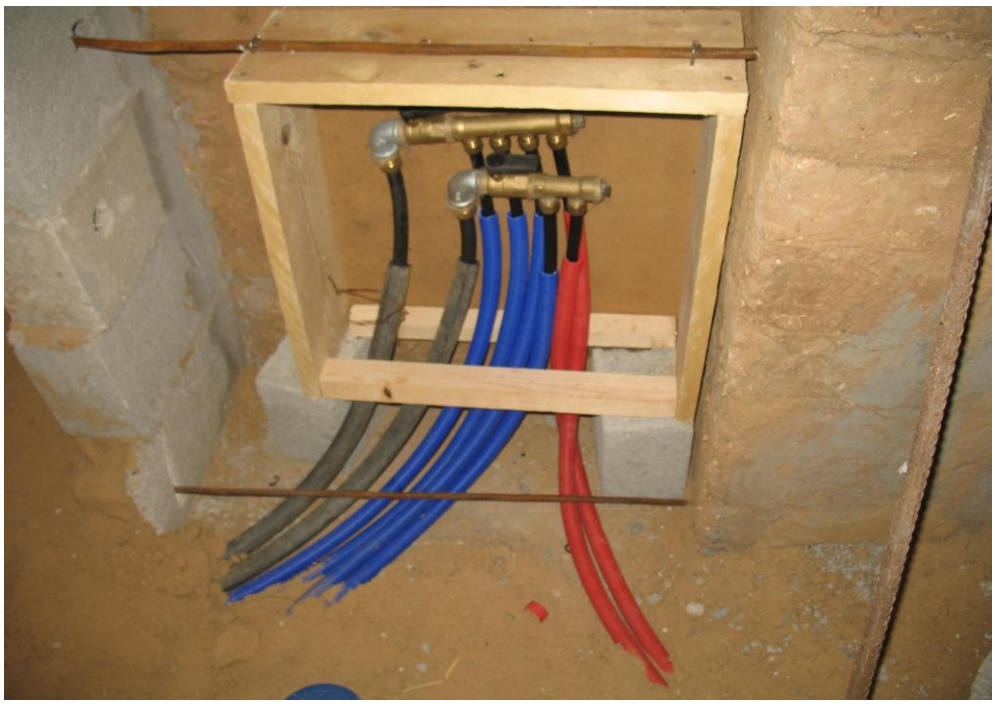

Figure 5.22: Internal Plumbing connections in the building (Taken by the researcher, 2011)

Figure 5.23: The mud building after completion (Ready to be handed to the beneficiaries)

5.2.10 Conclusions and recommendations

Out of these cases, it can be concluded that the construction with Mud building was existed with a certain period of time where no construction materials were available in the local market due to imposed siege on Gaza Strip. As the flow of construction life revived a gain, such alternative does not become crucial and critical. It is recommended from this research is to build such models (clay or mud building) to create green areas and to sustain the cultural heritage in our country Such as museums, restaurants and various tourist centers.

Through the study of the previous cases, it is clear that the use of mud in construction projects is very limited and came to defy the blockade at Gaza Strip, the political decision was important in supporting such projects in the beginning of the siege, and notes that there are many obstacles limiting the spread of these techniques, such that high costs and lack of expertise in this field, and the unwillingness of people to build their houses using this method.

We believe that the construction of mud in the Gaza Strip is not successful to a great extent, especially at the government level, we find that some of the projects

collapsed during construction because of the lack of experience in implementation, Some of these buildings are not used because of the lack of suitability to residents or because of the risk and it needs continuous maintenance, which corresponds with results of many presenting researches.

The challenges that face contractors in using mud building are lack of experience of workers, needs of political support, weather condition, lack of workers that work in mud's buildings, lack of quality of mud material, difficulties in the implementation of the domes, Construction of mud's buildings needs large areas due to horizontal construction, difficulty of understanding the drawing and their accurate implementation.

Some benefits of mud buildings are: local job creation opportunity, earth construction is economically beneficial, labor-intensive, save energy and raw materials are locally available.

Finally, it was founded diversity in the mud construction techniques used in the Gaza Strip, the most of the buildings through the UNRWA implementing is CEB While the most of the buildings implementing by government-backed institutions are adobe techniques.

6 CONCLUSIONS AND RECOMMENDATIONS

This chapter includes the conclusions and recommendations to improve and enhance the construction industry in the Gaza Strip and Palestine through a practical investigation of the applicability to use mud materials in the construction industry in the Gaza Strip. This will be achieved through sub objective. The first objective of this study was to review mud building system, the second objective was to evaluate challenges of constructing mud building in the Gaza Strip, the third one was to investigate the techniques used in mud building practices and the fourth one was to evaluate failure/success of implementing the mud building in the Gaza Strip, UNRWA and government building as case study while the last one was to identify the practical benefits of constructing mud building and its applicability in the Gaza Strip

6.1 Conclusion

6.1.1 Conclusions from questionnaire

The study findings of the first group (Client related factors) indicated that "Client culture and attitudes" and "Inadequate experience of client's staff in the design and supervision" and "Client previous experience in such work" was shown as a most barriers and challenges towards the adoptability of mud building practices. These have been the highest factors resulting in this field by both contractors participated with UNRWA, and contractors participated with other clients points of view. The results indicated that there is high level of agreement between the

contractor participated with UNRWA, and contractors participated with other clients regarding these factors which can be considered as a critical factors affecting mud building in construction projects.

The study finding from the second group (Design and consultant related factors) indicated that "Need high maintenance" in the first position and "Need intensive labor" has been ranked in the second position. These have been the highest factors resulting in this field by both contractor participated with UNRWA, and contractors participated with other clients. The result indicated that there is agreeability between the contractors participated with UNRWA, and contractors participated with other clients points of view regarding these factors which can be considered as a critical factors affecting mud building in construction projects. This indicates that the obtained result in the Gaza Strip is very close to what was found in the researches in other countries.

The study finding of the third group "Contractor related factors" indicated that "Unavailability of skills (Shortage of skilled labors)" in the first position, and "Experience of subcontractor with the contractors" in the second position. These have been the highest factors resulting in this field by both contractor participated with UNRWA, and contractors participated with other clients. The result indicate that there is agreeability between the contractors participated with UNRWA, and contractors participate with other clients points of view regarding these factors which can be considered as a critical factors affecting mud building in construction projects. It can be concluded that such mud building practices is on a very critical need for comprehensive planning and training before the beginning of such works. Acquiring skills in this work need a time which should be considered early.

The study finding of the fourth group "External Environmental factors" indicated that "Unwillingness of people to build their houses with mud" in the first position, and "Weather conditions" in the second position. These have been the highest factors resulting in this field by both contractor participated with UNRWA, and contractors participate with other clients. The result indicate that there is agreeability between the contractors participated with UNRWA, and contractors

participated with other clients points of view regarding these factors which can be considered as a critical factors affecting mud building in construction projects. This result indicates clearly the impact of cultural resistance for any new style or system. The results are still within the atmosphere of the outside attitudes.

The study finding of the fifth group “Project characteristics factors” indicated that “Number of floors required” in the first position, and “Type of clay needed” in the second position. These have been the highest factors resulting in this field by both contractor participated with UNRWA, and contractors participate with other clients. The result indicate that there is agreeability between the contractors participated with UNRWA, and contractors participated with other clients points of view regarding these factors which can be considered as a critical factors affecting mud building in construction projects. The study finding from questionnaire showed that the top ten factors affecting mud building practices by both contractors participated with UNRWA, and contractors participated with other clients point view are "Need intensive labor", "Weather conditions", "Poor in resistance to weather conditions", "Unavailability of skills (Shortage of skilled labors)", "Weak resistance to earthquake", "Number of skilled labors that contractor have", "Non-government agencies to encourage construction with mud", "Type of clay needed" were the most important factors that affect in mud building projects.

The study finding from questionnaire that "Project characteristics related factors" group has been ranked in the 1st position by both contractors participated with UNRWA, and contractors participated with other clients. Results also show that "External Environmental factors" group has been ranked in the 2nd position by contractors participated with UNRWA. Respondents contractors participate with other clients ranked the group of "Design and consultant related factors" as the 2nd position group. Out of this result it can be concluded that the project characteristics and type of project play the most important role in the participants acceptance and attitudes towards the acceptance or rejection. This is true in this case as the mud building projects in the Gaza Strip is considered a unique project.

The study finding from questionnaire that the most ten benefits obtained of construction mud building by both contractors participated with UNRWA, and contractors participated with other clients are "Earth construction promotes local culture and heritage" in the 1st poison, " Design and high aesthetical value" in the 2nd position, " Local job creation opportunity " in the 3rd position, "Saves energy" in the 3rd position, "Balances and improves indoor air humidity and temperature which ensures thermal Comfort" in the 5th position, " Environmentally sustainable" in the 6th position, " Requires simple tools and less skilled labor" in the 7th position, "Earth building provides noise control" in the 7th position, " Wall (loam) absorbs pollutants" in the 9th position ," Encourages self-help construction " in the 10th position.

Out of these results it can be concluded that reviving our heritage especially in the building style and architectural environment is still vital from participants attitudes and point of view. Although the mud building is friend to the environmental, the participants did not put this benefit in the first positions. it is believed that such benefit is considered in the highest rank as the world now is running to protect the environment.

Building with earth materials can be a way of helping with sustainable management of the Earth's resources. They can be put in place using simple machinery and human energy. Earth buildings avoid deforestation and pollution, and can achieve low energy costs throughout their lifetime – in the initial manufacture and construction, in used as homes, and eventually in their recycling back to the earth.
The study finding from questionnaire that mud building need high maintained because material used in construction is very light and not resistible for the outside natural changes such as sun, water and vegetation. Those usually cause cracks in the plaster allowing for water to penetrate, which causes weakness in structure by flushing out the mortar causing the falling after that.

The study finding that earth constructions require simple tools and less skilled labor. Building with mud bricks or blocks in particular, requires little or no specialist skills but it may refer to poor experience of the contractor in this area. Construction with mud building process is labor-intensive and generates further more employment through the simultaneous production of building material, and provides direct benefits

in upgrading the quality of life of those who couldn't have afforded a 'standard' house.

The study finding from questionnaire illustrate that there is no significant differences in the opinions between contractor participated with UNRWA and contractors participate with other clients for all group. The P value is greater than the level of significance, $\alpha = 0.05$ except "Contractor related factors", and "Design and consultant related factors" groups. This means that there is major agreement between the participants overall groups except contractor related group and design and consultant related factors group.

The study finding from questionnaire there is significant relationship between the most groups affecting building in mud with P-Values were below $\alpha = 0.05$, there is no significant relationship between Client related factors and External Environmental factors with P-value is greater than the level of significance, $\alpha = 0.05$.

6.1.2 Conclusions from structured interview

The study finding from structured interview that "limited skills to those working in construction in the mud", "lack of workers that work in mud's buildings", "lack of quality of mud material", "Bad impact of weather conditions", "Difficulties in the implementation of the domes", "Political decision" as the most challenges that face contractors in using mud building.

The study finding from structured interview that "There is no steel reinforcement in the ground beams, which may cause a cracks and settlements in the mud's buildings because of the soil types, "Non-regularity of dimensions of the implementation of the domes, causing the cracks and water leakage", "Implementation of the domes using caliper and this does not guarantee the regularity Sizes domes", "Increasing the use of cement at high rates in the brick industry because of the lack of full knowledge of building systems with mud", "Failure to ensure that age of the mud's buildings for a long time because of moisture and this needs to isolate the work of the buildings and maintenance", "No deep studies and feed back about the mud building process were recorded as crucial points that are in

need to be solved by the clients and designers" as the most mistake or errors contractor faced.

The study finding from structured interview that the most benefits that the contractor gained from constructing with mud building are "Increase expertise in mud's building systems, especially the construction of mud's as it is a new system", "Increase knowledge of the properties of mud's and construction equipment and materials needed for that and proportions of mix materials are used", "Financial benefit through profit in the implementation of projects", the presence of staff with high experience in the field of construction companies in the mud's buildings as the most benefits for using mud building.

The study finding from structured interview that the most benefits other parties gained from mud building are "Running large numbers of workers, this helped in partially in pushing the economy", "Increase the experience of workers that works in the construction of mud's buildings", "Contributing to solving the housing problems especially after last war", " Economic benefit through greater financial benefit to the economy because most of the components of the work are locally", "Reduce unemployment of workers in the construction of mud's buildings", "Improving the experience efficiency of the workers works in mud's building", and "The accommodations problems for the homeless people".

6.1.3 Comparison between the results questionnaire Structured interview results

The study findings show that the majority of the contractors (67% from questionnaire, 70.59% from structure interview) implemented CESB types which indicate the important of adding the stabilizers (like cement) to improve the housing conditions of the mud buildings. The agreement between the respondents of questionnaire and the results of structure interview improve the importance of this technique his is relatively logic as this type is the strongest one as the cement is a part in this type.

From the results obtained from questionnaire at this thesis, and compare it with the results obtained Structure interview, it's found that there are a real similarity of the most benefits that the contractors gained from constructing with mud building.

Structure interview and the respondents of questionnaire concentrate on some benefits, these benefits' are: local job creation opportunity, earth construction is economically beneficial, labor-intensive, save energy and raw materials are locally available.

The above agreement between the respondents of questionnaire and the results of structure interview prove the importance of these benefits' obtained from mud building.

Also there are real agreements between the result obtained from questionnaire and structure interview about the important factors that affecting in mud building these factors are: lack experience of workers, needs to political support, weather condition, lack of numbers that work in mud's buildings, lack of quality of mud material, difficulties in the implementation of the domes, mud's buildings need to continuous maintenance, construction of mud's buildings needs large areas due to construction of horizontal, difficulty of understanding the drawing and their accurately implementation. The above agreement between the respondents of questionnaire and structure interview proves the importance of these factors affecting in mud building construction.

6.2 Recommendation

Contractors are recommended to have qualified technical staff with appropriate experience of the mud building project in order to be able to follow the different technical and managerial aspects of the project. The staff will be more effective if it is consisted of enough numbers of engineers, technicians, and foremen. Because mud building need high experience to deal with natural earth material and making mud shape in beautiful architectural appearance and structural status.

Client are recommended to have experienced supervising staff who will control and monitor the process itself. Because training new people meant more breaking down and repairing of low quality work, more building waste, more loss of time and less aesthetic appeal.

Client are recommended to play a major role to embark mud building in the industry through building simple and healthy houses and not expensive homes to help refugees who homes were demolished as a result of the war.

CESB building system mud used by the UNRWA high cost due to the use of a high proportion of cement, as well as that used for the first time in the Gaza Strip in this way, so cost can be reduced by the factors affecting it are many.

Client are recommended to build with mud because it generating employment by giving unskilled labor opportunities to find work, while also providing jobs to the local potter whose lively hood is threatened by the plastics and metal industries that are replacing the products that potters used to provide.

Contractor are recommended to use suitable soil because in the compressed Earth Block (CEB) depends on its constituents that are sand, silt and clay proportions. And they recommended using CSEB that will minimize the cracks in the blocks and give strength.

Designer are recommended to make suitable improvements in design and technology, such as soil stabilizations, appropriate architecture, and improvement in structural techniques because mud building is prone to rain damage being extremely vulnerable to water.

The governments should support the culture heritage by using mud building materials and building in the Gaza Strip. This will lead to improve the urban planning and architectural attitudes in the Gaza strip Such as museums, restaurants and various tourist centers.

6.2.1 Further recommendations

I. it is recommended to conduct in more detailed study by reading the stockholders perceptions and attitudes about mud buildings.

II. As the majority of the researches show the weaknesses if mud building against resistance and weather conditions, it is recommended to prepare a comprehensive research how to improve the characteristics and behaviors in these two issues.

III- Find ways to examine the mud construction materials and methods adopted in local laboratories to test it, as well as the work of ratings and records of all the materials needed to build mud and all data related with it.

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QUESTIONNAIRE

Mud building practices in Construction Projects in the Gaza Strip

ممارسات البناء بالطين في مشاريع الانشاءات في قطاع غزة

تهدف هذه الدراسة إلي التحقق من مدى تطبيق استخدام الطين في صناعة الإنشاءات في قطاع غزة و للتعرف على الفوائد العملية للبناء في الطين ومدى تطبيقها في قطاع غزة و تقديم توصيات عملية من شأنها التغلب على العوائق في هذا المجال، وكذلك تقييم فشل أو نجاح تنفيذ البناء بالطين في قطاع غزة.

كل المعلومات الموجودة بها سوف تستخدم فقط لهدف للبحث الأكاديمي و ستكون خاصة و مع المحافظة على سريتها. تحليل البيانات لهذه الدراسة سوف يكون بمثابه تغذية راجعة لكل الأطراف العاملة في الصناعة الإنشائية بهدف الاستفادة منها في هذا المجال.

The aim of this research is:

1. To investigating the applicability of using mud materials in the construction industry in the Gaza strip.
2. To provide the practical recommendations that will overcome the barriers in this field.
3. To evaluate failure/success of implementing the mud building in the Gaza Strip.
4. To identify the practical benefits of constructing mud building and its applicability in the Gaza Strip.

The information used will be confidential and will be kept for study purposes only.

Researcher : Hamed Abu Ajwa

Supervisor : Dr. Nabil El Sawalhi

2011

Part 1: General information معلومات عامة

1. **Name of organization (اسم المؤسسة) اختياري:**.....
2. contactors category in PCU -classification تصنيف المقاول

□ 1ST	□ 2nd	□ 3rd	□ 4th	□ 5th

3. **Organization Field of work** طبيعة عمل المؤسسة

□ Buildings مباني	□ Infrastructure بنية تحتية
□ Steel Structures مباني حديد	□ Others, (specify) ..... أخرى (حدد)

4. **No. of employees work in the organization**: (.....) (عدد العاملين فى المؤسسة)
5. **Job title of the respondent:** طبيعة عمل الشخص المعني بتعبئة الإستبانة

□ Project manager/deputy مدير مشروع/ نائبه	□ Site engineer مهندس موقع
□ Organization manager/deputy مدير المؤسسة أو نائبه	□ Others,(specify) ..... أخرى (حدد)

6. **Years of experience of the respondent : (.....)** عدد سنوات خبرة الشخص المعني بتعبئة الإستبانة
7. **Value of executed projects in the last ten years** : (in million dollars) قيمة المشاريع المنفذة في العشر سنوات الأخيرة (بالمليون دولار)

□ less than 2 million أقل من 2 مليون	□ More than 2-less than 5 million أكثر من 2 وأقل من 5 مليون
□ More than 5-less than 10 million أقل من 10 و أكثر من 5	□ More than 10 million أكثر من 10 مليون

Part 2: Mud Building practice in Gaza البناء بالطين في غزة

8. **No. of mud building projects that the company invited and participated in ( )**

عدد مشاريع البناء بالطين التي تم دعوة الشركة بالمشاركة فيها ( )

9. **No. of mud building projects that the company implemented ( )**

عدد مشاريع البناء بالطين التي نفذتها الشركة ( )

10. **The participation in mud building projects was done during**

□ This Year	□ Last Year(2010)	□ During (2009 and before)

11. **Organizations that invited you to participate in Mud building projects**

المؤسسة التي قامت بدعوتكم لتنفيذ مشاريع البناء بالطين

□ UNRWA	□ UNDP
□ Ministry of Public Works and Housing	□ Others,……

12. **Value of executed mud projects by your company**: (Thousand dollars)

قيمة مشاريع البناء بالطين التي نفذتها الشركة

□ less than 0.5 million أقل من 0.5 مليون	□ More than 0.5-less than 1 million أقل من 1 مليون أكثر من 0.5
□ More than 1-less than 2 million أقل من 2 و أكثر من 1	□ More than 2 million أكثر من 2 مليون

13. **No. of employees worked in Mud project**: (…….) (عدد العمال الذين عملوا في مشاريع البناء بالطين)

14. **No. of units your company constructed with Mud project**: (…….)

(عدد الوحدات السكنية التي قامت الشركة بتنفيذها من مشاريع البناء بالطين)

15. **Location of Mud building projects you implemented**

(مكان الوحدات السكنية التي قامت الشركة بتنفيذها من مشاريع البناء بالطين)

□ Gaza غزة	□ North area في الشمال
□ Middle area المنطقة الوسطى	□ South area جنوب غزة

16. **Organization that you implemented Mud building projects for them was**

المؤسسة التي نفذتم مشاريع البناء بالطين لها

□ UNRWA	□ UNDP
□ Ministry of Public Works and Housing	□ Others,……

17. **Type of techniques used in Mud building projects** (You can use more than one)

نوع التقنية المواد والبناء المستخدم لتنفيذ مشاريع البناء بالطين

وهي تربة مكونة من الطين والرمل والحصى وتنخل وتجهز ثم توضع في قوالب وتضغط CEB □
باستخدام ماكينة ضغط خاصة بحيث يكون المحتوى المائي قليل.

نفس السابق لكن يضاف إلي المكونات أحد المضافان التي تحسن خصائص البلوك المصنع CSEB □
مثل الاسمنت أو الجير أو مواد أخرى.

ويصنع من تربة طينية يتم تحضيرها وعجنها لتصل إلي درجة اللدونة (**الطوب النيئ**) Adobe□
ويضاف إليها ألياف نباتية وتشكل باليد أو باستخدام قوالب لتترك حتى تجف في مستودعات خاصة أو
تحت أشعة الشمس.

وهي تربة تحتوي على نسب معينة من الطين والرمل والحصى وتصب بعد Rammed earth □
خلطها بالماء في قوالب أو شدات خشبية معدة مسبقاً بطريقة يدوية في مكان الإنشاء وعلى شكل طبقات
متتالية.

□ Others, please explain

……

……

……

……

Part 3: Challenges/factors affecting the use of mud building in the Gaza Strip

The following table shows a number of factors that may affect mud building in the construction projects. From your experience, please express your opinion on the importance of the following factors according to its impact on the construction projects in the Gaza strip. (Please tick the appropriate box).

في الجدول التالي عدد من العوامل المسببة لعوائق البناء بالطين في المشاريع الإنشائية ، فمن خلال خبرتك الرجاء التعبير عن رأيك حسب الأهمية للعوامل التالية طبقاً لمساهمتها في حدوث العوائق في المشاريع الإنشائية في قطاع غزة (الرجاء إملاء الفراغ المناسب).

	Group/ Factor	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
	G I: Client related factors	**عوامل تتعلق مرتبطة بالمالك**				
1	Client culture and attitudes. ثقافة المالك وتوجهاته.					
2	Client Budget. ميزانية المالك					
3	Client's financial problems مشاكل المالك المالية.					
4	Inadequate project objectives اكتشاف المالك نقص في أهداف المشروع					
5	Client previous experience in such work. خبرة المالك السابقة في البناء بالطين					

	Group/ Factor	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
6	Inadequate experience of client's staff in the design and supervision نقص خبرة موظفي المالك في التصميم والاشراف					
7	Weak coordination between the client and the local community ضعف التنسيق بين المالك والمؤسسات المحلية					
8	Weak coordination between the client and stakeholders "mis-needs assessment" ضعف التنسيق بين المالك و باقي المساهمين					
9	No existence of mud building code in the client عدم وجود قانون للبناء بالطين لدى المالك					
10	Budget allocated constraint القيود الموجودة على الموازنة					
11	Client financial capability القدرة المالية للمالك					
12	Interference of client in project requirements تدخل المالك في متطلبات المشروع					
13	Safety considerations by client اعتبارات السلامة من المالك					
	G II: Design and consultant related factors عوامل مرتبطة بالتصميم والاستشاري					
1	Difficulties in the design صعوبات في التصميم					
2	Different design models needed اختلاف نماذج التصميم المطلوبة					
2	Un-clarity of contract documents عدم وضوح وثائق العقد					
4	Un-clarity of drawings عدم وضوح المخططات					
5	Different site conditions اختلاف ظروف المشروع					
6	No technology used in the design stage عدم استخدام التقنيات في التصميم					
7	Lack of coordination among project parties نقص التنسيق بين أعضاء فريق المشروع.					
8	Complex design and technology تعقيدات التصميم الفنية					
9	Inadequate shop drawing details نقص المخططات التنفيذية و تفاصيلها					
10	Consultant's lack of judgment and experience نقص خبرة الاستشاري					
11	Lack of coordination between international and local designer and supervisor teams (large scale projects). نقص التنسيق بين المصمم الدولي و المحلي و أعضاء فريق الإشراف (وهذا يخص المشاريع الكبيرة)					
12	Not benefiting from international specification and global experiences (eg. Testing procedure). عدم الاستفادة من المواصفات والخبرات العالمية					
13	Lack of coordination between various design					

	Group/ Factor	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
	dispelances نقص التنسيق بين مختلف تناقضات التصميم					
14	Inadequate revision and feedback system through design process. عدم وجود نظام مراجعة وتغذية راجعة مناسب					
15	Lack of consultant's knowledge of available materials and equipment نقص معرفة الاستشاري بالمواد و المعدات المتاحة					
16	Inconsistency between drawings and site conditions. التناقض بين المخططات و ظروف الموقع					
17	Errors and omission of quantity estimation. أخطاء أو حذف في تقدير الكميات					
18	Omission of contract document items. حذف في بعض بنود و وثائق العقد					
19	Errors of cost estimation. أخطاء في تقدير الاسعار					
20	Insufficient site investigation. i.e. *(Materials needed, soil data, constraints,…)* نقص في فحص الموقع					
21	Consultant's lack of required data نقص المعلومات المطلوبة للاستشاري					
22	Ambiguous design details تفاصيل التصميم غامضة					
23	Noncompliance design with government regulations عدم مطابقة التصميم للقوانين الحكومية المحلية					
24	Noncompliance design with owner's requirementعدم مطابقة التصميم لمتطلبات المالك					
25	Lack of coordination between designer and client نقص فى التنسيق بين المصمم والمالك					
26	Change in specifications by consultant تغيير الاستشاري للموصفات					
27	Weak resistance to earthquake مقاومة ضعيفة للزلازل					
28	Poor in resistance to weather conditions مقاومة ضعيفة للعوامل المناخية					
29	Need high maintenance تحتاج صيانة عالية					
30	Need intensive labor تحتاج عمالة عالية					
	G III: Contractor related factors **عوامل مرتبطة بالمقاول**					
1	Lack of contractor's involvement in design. نقص اهتمام المقاول في التصميم					
2	Unavailability of equipment to implement the project. عدم توفر المعدات لتنفيذ المشروع					
3	Unavailability of skills (shortage of skilled labors)نقص مهارات العمال					
4	Contractor's financial difficulties الصعوبات المالية للمقاول					

	Group/ Factor	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
5	Unwillingness of contractors to construct such type of work عدم رغبة المقاول لتنفيذ مثل هذا العمل					
6	Location or place of the contractor مكان سكن المقاول					
7	Unfamiliarity of the contactor with the exact location of materials (earth materials- clay, sand, silt, etc) عدم معرفة المقاول بالمواد المحلية وأماكنها					
8	Lack of a specialized construction managers نقص المتخصصين في إدارة التشييد					
9	Poor (unclear) procurement process عدم وضوح عملية التوريد					
10	Poor experience of the Contractor in this area ضعف خبرة المقاول في هذا المجال					
11	Number of skilled labors that contractor have عدد العمال المهرة للمشروع					
12	Experience of subcontractor with the contractor خبرة مقاولين الباطن العاملين مع المقاول					
13	Misunderstanding of tender documents during cost estimation stage. عدم فهم وثائق العطاء خلال مرحلة تقدير التكلفة (التسعير)					
14	Unbalanced tender price due to closure. عدم اتزان أسعار العطاء المقدمة بسبب الاغلاقات					
15	Lack of the necessary documents to built mud نقص المستندات اللازمة للبناء بالطين					
16	Lack of construction materials and equipment spare parts due to Closure and siege نقص الاحتياط في الموارد الإنشائية و المعدات نتيجة لسياسة الحصار و الإغلاق					
	G IV: External Environmental factors عوامل خارجية أخرى					
1	Force Majeure					
2	Weather conditions الأحوال الجوية					
3	Change in government regulations تغيرات في القوانين الحكومية					
4	Change in economic conditions (inflation , currency change rate) التغيرات في الظروف المادية (التضخم و معدل صرف العملة)					
5	Unwillingness of people to built their houses with mud عدم رغبة الناس بناء بيوتهم بالطين					
6	Non-government agencies to encourage construction with mud. عدم تشجيع الجهات الحكومية للبناء بالطين					
7	Unforeseen problems مشاكل غير موقعة					
8	Cost inflation تكلفة التضخم					
9	stakeholders attitudes اهتمامات ذوي العلاقة					
	G V: Project characteristics related factors					

	Group/ Factor	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
1	Land allocation problems مشاكل في أرض الموقع					
2	area of the land مساحة الأرض					
3	Location الموقع					
4	Site condition ظروف الموقع					
5	Number of floors req., عدد الطوابق المطلوب					
6	Type of clay needed نوع الطين المطلوب					
7	Availability of materials توفر المواد الخام					
8	Value of project needed حاجة المشروع					
9	Landscaping required in the projects التخطيط المعماري حول المشروع					
10	Type of contract to be used نوع العقد					
11	Number of projects to be constructed at the same time عدد المشاريع المنفذة في نفس الوقت					
12	Distances between mud buildings المسافة بين المباني					
13	Area of the buildings مساحة المبنى					

Part 4: Benefits/successes obtained of construction Mud building

الفوائد / النجاحات التي تم الحصول عليها من البناء الطين بناء

	Benefits/success	Very high Impact	high Impact	Medium Impact	low Impact	Very low Impact
1	Earth construction is economically Beneficial. البناء بالطين موفر اقتصادياً					
2	Requires simple tools and less skilled labor يحتاج معدات بسيطة وعمالة غي ماهرة					
3	Encourages self-help construction تشجع الاعتماد على الذات					
4	Suitable for very strong and secured structure مناسبة لبناء قوي وأمن					
5	Saves energy موفر للطاقة					
6	Balances and improves indoor air humidity and temperature which ensures thermal Comfort. يحسن الارتياح الداخلي و والرطوبة الداخلية					
7	Local job creation opportunity. يخلق فرص عمل محلية					
8	Environmentally sustainable.استدامة بيئية					
9	Wall (loam) absorbs pollutants.يمتص الملوثات					
10	Design and high aesthetical value. القيمة الجمالية العالية					
11	Earth building provides noise control. يحد من نسبة الضوضاء					
12	Earth construction promotes local culture and heritage يعزز الثقافة المحلية والتراثية					

Thank You for Your Time and Support

Structured Interview with the companies implemented Mud Building in Gaza Strip

ممارسات البناء بالطين في مشاريع الإنشاءات في قطاع غزة

تهدف هذه الدراسة إلي التحقق من مدى تطبيق استخدام الطين في صناعة الإنشاءات في قطاع غزة و للتعرف على الفوائد العملية للبناء في الطين ومدى تطبيقها في قطاع غزة و تقديم توصيات عملية من شأنها التغلب على العوائق في هذا المجال، وكذلك تقييم فشل أو نجاح تنفيذ البناء بالطين في قطاع غزة.

كل المعلومات الموجودة بها سوف تستخدم فقط لهدف للبحث الأكاديمي و ستكون خاصة و مع المحافظة على سريتها. تحليل البيانات لهذه الدراسة سوف يكون بمثابة تغذية راجعة لكل الأطراف العاملة في الصناعة الإنشائية بهدف الاستفادة منها في هذا المجال.

The aim of this research is:

1. To investigating the applicability of using mud materials in the construction industry in the Gaza strip.
2. To provide the practical recommendations that will overcome the barriers in this field.
3. To evaluate failure/success of implementing the mud building in the Gaza Strip.
4. To identify the practical benefits of constructing mud building and its applicability in the Gaza Strip.

The information used will be confidential and will be kept for study purposes only.

Researcher : Hamed Abu Ajwa

Supervisor : Dr. Nabil El Sawalhi

2011

Part 1: General information معلومات عامة

1. **Name of organization (اسم المؤسسة) اختياري:**.....
2. contactors category in PCU -classification

□ 1ST	□ 2nd	□ 3rd	□ 4th	□ 5th

3. **Organization Field of work** طبيعة عمل المؤسسة

□ Buildings مباني	□ Infrastructure بنية تحتية
□ Steel Structures	□ Others, (specify) ..... أخرى (حدد)

4. **No. of employees work in the organization**: (.....) (عدد العاملين فى المؤسسة)
5. **Job title of the respondent:** طبيعة عمل الشخص المعني بتعبئة الإستبانة

□ Project manager/deputy مدير مشروع/ نائبه	□ Site engineer مهندس موقع
□ Organization manager/deputy مدير المؤسسة أو نائبه	□ Others,(specify) ..... أخرى (حدد)

6. **Years of experience of the respondent : (.....)** عدد سنوات خبرة الشخص المعني بتعبئة الإستبانة
7. **Value of executed projects in the last ten years** : (in million dollars) قيمة المشاريع المنفذة في العشر سنوات الأخيرة (بالمليون دولار)

□ less than 2 million أقل من 2 مليون	□ More than 2-less than 5 million أكثر من 2 وأقل من 5 مليون
□ Mire than 5-less than 10 million أقل من 10 و أكثر من 5	□ More than 10 million أكثر من 10 مليون

Part 2: Mud Building practice in Gaza البناء بالطين في غزة

8. **No of mud building projects that the company invited and participated in ( )**

( ) عدد مشاريع البناء بالطين التي تم دعوة الشركة بمشاركة فيها

9. **No of mud building projects that the company implemented( )**

( ) عدد مشاريع البناء بالطين التي نفذتها الشركة

10. **The participation in mud building projects was done during**

□ This Year	□ Last Year(2010)	□ During (2009 and before)

11. **Organizations that invited you to participate in Mud building projects**

المؤسسة التي قامت بدعوتكم لتنفيذ مشاريع البناء بالطين

□ UNRWA	□ UNDP
□ Ministry of Public Works and Housing	□ Others,……

12. **Value of executed mud projects by your company**: (Thousand dollars)
قيمة مشاريع البناء بالطين التي نفذتها الشركة

□ less than 0.5 million أقل من 0.5 مليون	□ More than 0.5-less than 1 million أقل من 1 مليون أكثر من 0.5
□ More than 1-less than 2 million 1 و أكثر من 2أقل من	□ More than 2 million أكثر من 2 مليون

13. **No. of employees work in Mud project**: (…….) (عدد العمال الذين عملوا في مشاريع البناء) بالطين)

14. **No. of units your company constructed with Mud project**: (…….)
(عدد الوحدات السكنية التي قامت الشركة بتنفيذها من مشاريع البناء بالطين)

15. **Location of Mud building projects you implemented**
(مكان الوحدات السكنية التي قامت الشركة بتنفيذها من مشاريع البناء بالطين)

□ Gaza غزة	□ North area في الشمال
□ Middle area المنطقة الوسطى	□ South area جنوب غزة

16. **Organization that you implemented Mud building projects for them was**
المؤسسة التي نفذتم مشاريع البناء بالطين لها

□ UNRWA	□ UNDP
□ Ministry of Public Works and Housing	□ Others,……

17. **Type of techniques used in Mud building projects** (You can use more than one)

نوع التقنية المواد والبناء المستخدم لتنفيذ مشاريع البناء بالطين

□ CEB وهي تربة مكونة من الطين والرمل والحصى وتنخل وتجهز ثم توضع في قوالب وتضغط باستخدام ماكينة ضغط خاصة بحيث يكون المحتوى المائي قليل.

□ CSEB نفس السابق لكن يضاف إلي المكونات أحد المضافان التي تحسن خصائص البلوك المصنع مثل الاسمنت أو الجير أو مواد أخرى.

ويصنع من تربة طينية يتم تحضيرها وعجنها لتصل إلي درجة اللدونة (**الطوب النيئ**) Adobe□
ويضاف إليها ألياف نباتية وتشكل باليد أو باستخدام قوالب لتترك حتى تجف في مستودعات خاصة أو تحت أشعة الشمس.

□ Rammed earth وهي تربة تحتوي على نسب معينة من الطين والرمل والحصى وتصب بعد خلطها بالماء في قوالب أو شدات خشبية معدة مسبقاً بطريقة يدوية في مكان الإنشاء وعلى شكل طبقات متتالية. Others, please explain

……

……

……

……

Part 3: Challenges/factors affecting the use of mud building in the Gaza Strip

3.1 What were the main challenges that face you as a contractor in the mud building practice?

3.2 What was the main mistake or errors you observed during the work and the reason for these errors?

3.3 did you innovate or used any new technique to facilitate the building with mud materials? If yes please explain.

3.4 The most benefits you and other parties gained from these types of projects

YOU:

OTHERS:

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