Ain Shams University
Egypt

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Germany

An Evaluation of the Usage of Environmentally Friendly Bricks for Housing in Egypt

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

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Disclaimer

This dissertation is submitted to Ain Shams University (ASU) and University of Stuttgart - Faculty of Architecture and Urban Planning (USTUTT) for the degree of Integrated Urbanism and Sustainable Design (IUSD), in accordance to IUSD-ASU regulations.

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Malek Amr El-Hamawy

Signature

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Abstract

Sustainability, environmentally friendly, energy-saving, and other terms became popularly acquainted with the construction field lately. However, the usage of these terms became a kind of a classy trend more than actually having the will to build with the goal of achieving them. Researchers have been trying to make it easier for builders to achieve their financial goals while saving the environment. Unfortunately, most of the researchers' recommendations and guidelines when it comes to choosing masonry, are either depending on unpopular building materials or financial comparisons that do not cover the whole building process.

This research is aiming towards finding a common ground between the stakeholders in the housing sector and the solutions proposed for solving the energy and the environmental issues related to building in Egypt. This research is not intended to be a guideline for builders but a clarification for the practicality of changing the building behavior and the criteria of choosing the building materials. The focus will be mainly on masonry as an outer envelope of skeleton concrete structures.

The aim of the study should be achieved by assessing the types of masonry in the Egyptian market and investigating the market's behavior when it comes to choosing the building materials. This assessment would be through grading the bricks according to their manufacturing environmental impact. Investigating the market's behavior should happen through interviews with the stakeholders of the housing projects. Starting with architects since they are the ones recommending and specifying the materials used in the building process.

The research concludes with a list of recommendations that would include all the stakeholders in the building sector. These recommendations should be based on the study of the stakeholders' behavior and preferences.

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Abbreviations

U-value	Thermal transmittance
EREC	Egyptian Residential Energy Code
HBRC	Housing and Building National Research Center
MOHUUC	Ministry of Housing, Utilities and Urban Communities
NUCA	New Urban Communities Authority
GPRS	The Green Pyramid Rating System
EGBC	The Egyptian Green Building Council
GHG	Greenhouse gas
ILO	International Labour Organization

"As an engineer, as long as I have the ability and the means to comfort people, God will never forgive me for deliberately raising the heat inside the house 17 degrees Celsius."

Hassan Fathy

Chapter One: Introduction

Chapter One: Introduction

A rapid increase in the number of residential housing projects has been taking place in Egypt for about ten years, now. This expansion in building is even expected to increase in the upcoming years due to the increasing population, which consequently leads to an increase in demand for residential housing.

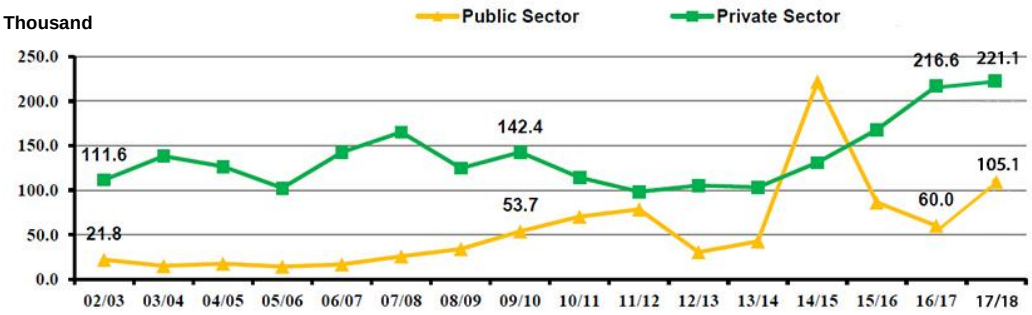


Figure 1: Dwelling units built-in urban by sector (2002/2003-2017/2018). (Source: Ministry of Housing)

Meanwhile, Egypt is facing an energy crisis due to the increase in consumption. This energy crisis led to an inflation in the prices of energy, which increases the economic pressure on the government and the individuals. According to the ministry of electricity, the amount of electricity sold on the fiscal year 17/18 reached 131148 GWH, more than 50% of this amount was for residential purposes only. (MOE annual report, 17/18) The percentage is even higher than the global contribution of the building sector –

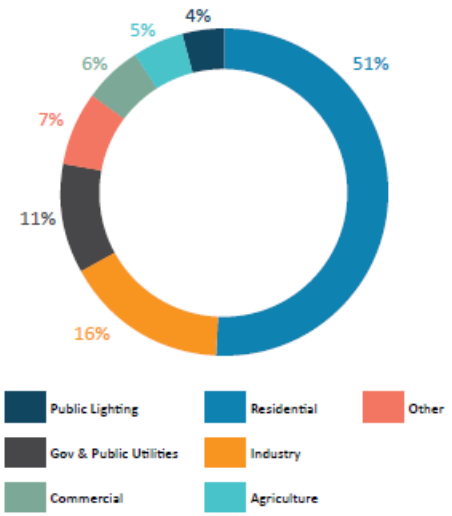


Figure 2: Energy Sold according to purpose. (Source: Ministry of Electricity)

including all building types- which is 40% of the total energy consumption and about one-third of the greenhouse emissions globally. Yet these percentages have a great potential to be significantly reduced at a lower cost.

Nevertheless, Egypt is also facing an environmental crisis which became so obvious after Cairo has been ranked as one of the most polluted cities in the world in 2018 (Whittaker-Wood, 2020) Mentioning the harmful emissions, the CO2 emissions reached 209 M ton/year in the latest statistics provided by CPMAS for the year 2016/2017. (CPMAS, 2020) This proves how the building sector has a great role in the increase of energy consumption and harmful emissions. Mostly the exterior walls which are -according to studies-, one of the most heat penetrating elements of a building. (Mahmoud A. Hassan, 2015) (Mohamed M. Mahdy, 2013)

According to a survey among almost 1500 apartments in three governorates in Egypt, the energy efficiency problem in the existing building context was revealed. The survey showed that all the surveyed buildings suffered from a poor thermal performance. It showed that 80% of the investigated samples used at least one air conditioner to overcome the inefficiency of the building. The envelopes of these buildings were described as being of low airtightness, walls were non-insulated, and no shading treatment. (Shady G Attia, 2011) These numbers indicate the severity of the energy performance of (residential) buildings in Egypt.

A brief history of the development of usage of building materials in Egypt

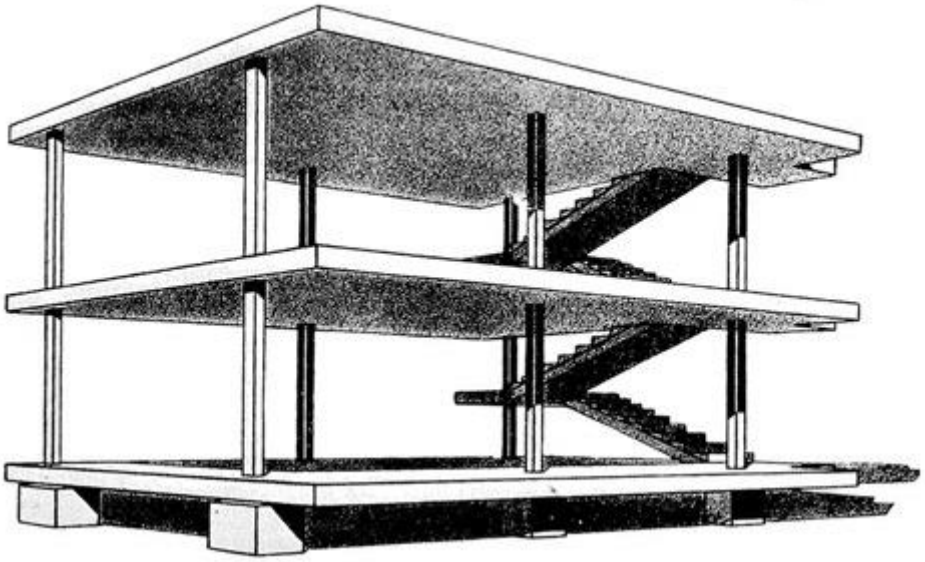


Figure 3: Perspective view of the Dom-ino system, 1914. (Source: Dezeen.com)

In Autumn 1914 Le Corbusier introduced the Maison Dom-ino, which perhaps represented "The first case in architectural history of a house designed as an open system". Today, we are only too aware that most homes on our planet are built without architects. If you go to the suburbs of Cairo, you'll find they are made up of thousands of medium-hight concrete frames, filled in with clay blocks. However, do not expect much difference if you go to one of the new classy neighborhoods, still the same building concept but with more expenses on other aspects of the building (e.g. aesthetic). As Pier Vittorio Aureli, the organizer of the symposium dedicated to Corb's idea in 2014, "the Dom-ino has become an ever-present ghost in the contemporary city – it seems to be everywhere." (McGuirk, 2020)

Since the ancient Egyptians and until nearly 100 years ago, the building construction in Egypt depended on the bearing walls system using earth materials (stone, mud bricks, lime bricks, etc.). This usage of earth materials

was very adaptive to the climate of Egypt in addition to the huge density of the exterior walls, both provided a great deal of thermal insulation.

Unfortunately, this thermal insulation in our buildings is not available now due to many reasons. Mainly, the total change in the way of building to concrete skeleton structures, which means that the exterior walls became just an element of exterior covering, not a thick dense isolating structural element as before. It started with, the worldwide culture change towards urbanism and industrialization, which supported the modern techniques of building and minimalism. Later on, the villages where the traditional building methods were most common, they were affected in this mean by the socioeconomic changes in the community.

After the migration of many Egyptians to work in the Gulf countries and achieving a good wealth that allowed them to build concrete houses in their villages instead of their old mud houses. Consequently, this became a sign of wealth and showing off. Also the 'Agriculture reclamation law' in the 1950s that gave each peasant a small piece of agricultural land. After generations, this piece of land was divided between many heirs and became too small to be of agricultural benefit. Accordingly, and with the increase of prices of lands available for building, the land was used to build a family house rather than agriculture-although that was prohibited, the houses were built informally-. This could have been only achieved through vertical extension, through concrete structures.

Moreover, with the construction of the 'high dam' in 1965, the natural yearly renewal of the soil due to the flood was not possible anymore. This made the fertilized agricultural land the only source for mud which is the main element in the production of red fire bricks. Accordingly, the government prohibited the use of mud of agricultural lands in the 1980s and this type of bricks was replaced with more artificial bricks.

Reaching our time being, the building revolution is still expanding and the aim of saving as much as possible of the building's expenses is prevailing. Unfortunately, this led to the prevailing of some building materials that may not be compatible with the climatic conditions of Egypt, regardless of the future environmental and economic impact of this saving.

Despite all these socio-economical changes, some non-environmentally harmful bricks remained available in the market. In addition to other materials that were researched and proved their efficiency but are not manufactured on an industrial scale. However, the building process is mainly depending on only one kind of bricks although other manufacturers are claiming to be having products of more economical and environmental efficiencies. Using materials that have a minimized environmental impact; earth materials, for example, always cause less environmental impact than using manufactured materials. It, therefore, cuts down on energy consumption, leading to less use of natural resources that cause climate change, such as oil and gas.

Bricks: Between craftsmanship revivalism and Modern Techniques

The utilization of block as a structure material for masonry work dates as far back as 7500 BC, so does the craftsmanship of masonry. Today, non-standardized brickwork surfaces can be planned to utilize parametric design instruments and embodied with the assistance of mechanized fabrication tools. These automated machines, nonetheless, are not generally available, particularly in developing nations where manual labor, local materials, and ordinary techniques are favored. (Elena Vazquez, 2018) However, some initiatives in developing countries such as Iran and India investigates the potential that bricks can offer by using parametric architecture utilizing a little more than the traditional construction techniques.

Figure 5: A locally built house in India featuring dancing brick walls. (Source: archdaily.com)

In Egypt, the usage of bricks as an external decorative material is found in different buildings following different architecture schools. It can be observed in old luxurious residential buildings at downtown dating back to the 19th century. Educational institutes built later; the building of the department of architecture at Ain Shams University as an example. Recently a mosque project in Suhag city of upper Egypt was highly praised for the beautiful formations made with Egyptian-made light bricks using local materials. But unfortunately, the usage of bricks as an aesthetic material is declining in Egypt, not mentioning the absence of modern parametric forms.

Figure 4: Basuna Mosque dome, Suhag. (Source: archdaily.com)

Observation and Research Problem

A- Observation

The author had worked in the field of construction for more than two years and through this period, the problem was formulated. After observing many different residential projects on different scales and different spending capabilities, it was noticed that the building process is almost the same. Although it is clear for all the stakeholders of the project that the building will be suffering from a thermal insulation problem, there is not any attempt to solve this problem. On the other hand, the only effort and spending is done in the process of solving the effects of this problem, for example: having the building ready with the needed electricity loads for fully air-conditioning the spaces, to overcome the weak thermal insulation.

B-Research Problem

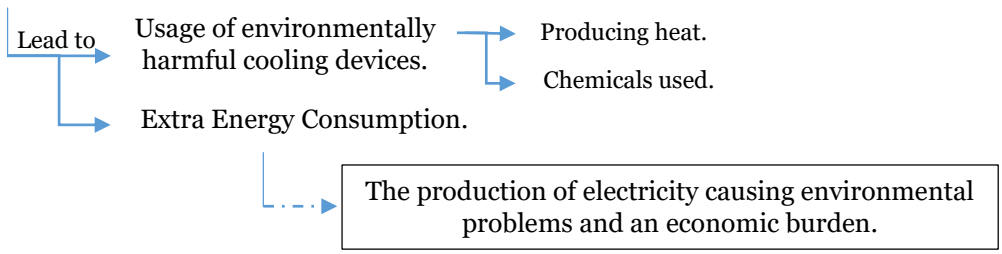
Besides the previously mentioned energy, economic, and environmental problems Egypt is a developing country that needs to make use of the most economical and efficient means in every aspect. Unfortunately, this perspective is almost totally neglected in the construction sector. Although some countries including Arabian countries are already enforcing laws on newly built buildings' energy consumption, there are not any guidelines or codes that are being enforced in this mean in Egypt.

However, Red bricks are the most commonly used in the interior and the exterior buildings’ walls, although that according to some studies they have the worst impact on the environment (Ahmed Abdelmonteleb, 2014) The lack of efficient thermal insulation leads to the usage of artificial cooling devices. These devices are environmentally harmful in means of either the heat they produce which contributes to global warming or the energy lost in the process of reaching thermal comfort. More specifically, the electric energy which is generated from fossil fuels. In addition to the operating costs which cause an economic burden on the users' scale and the government's subsidy for the

energy sector. It is believed that (the current and future) increase in the real estate while maintaining the same building habits will affect the increase of energy consumption and the environmental issues.

Accordingly, the behavior of the market when it comes to choosing the bricks should be questioned. Accompanied by data regarding the whole residential construction process and the role of the bricks in it. Then studying more, the criteria set by the users for choosing and preferring a type of brick. Reaching the possibility of modification of the attitude of the consumers when it comes to choosing the building materials and the positive or negative impacts of that.

The mostly used building methods



Research Objectives

This research aims to discuss the environmental impacts of the usage of different types of masonry blocks for building the exterior walls of residential buildings. However, the research is limited to the bricks that are commercially available in the local market in Cairo governorate. Bricks will be graded, including but not limited to, not including any severely environmentally harmful materials or processes during their manufacturing process. The research is planned to have a housing example in Cairo for discussion.
The bricks market in Egypt has many different types of bricks, with different blocks sizes. But for some reason, the building market is acting in a certain way when it comes to choosing the building materials. The research should investigate the attitude of the market and what is needed to be done to improve this attitude.

Research Questions

The research questions could be summarized in the general question:
'Why are some types and thicknesses of bricks prevailing, although they are not the most efficient?'

Answering this question would require finding answers for the following questions:

- How does the construction of modern residential buildings go generally?
- The percentage of structural materials (concrete) to covering materials (bricks) in a residential building?
- What are mostly used types of bricks and for what are they used for?
- What are the specifications of each type?
- Why is a certain type the most prevailing?
- What are the true (ignored) costs of using this type?
- If a certain brick type replaced another in its market share, what will be the impact?

Literature review

The issue of the relation between the current building strategies and the available local alternatives are plenty. But most of these studies are limited to the possibility of the revivalism of the ancient building materials, or the invention of new natural building materials that are -unfortunately- not available in the local markets. Although, these studies proved that the tested materials have better characteristics than the most commonly used nowadays, the unavailability in the markets and the absence of enough tests on the newly

studied materials mainly, prevented any change in the construction process. Nevertheless, the studies that assessed the commercially available bricks have not studied the issue entirely but were mostly limited to only one aspect. For example the economy of the operating cost of using a certain material but ignoring other aspects such as the environmental impact or the material density.

This study is expected to provide an assessment of the available blocks in the local markets in terms of environmental impacts. Accordingly, this study should act as a common ground between the demand of the market for construction materials, the environmental challenges, and the availability of materials. This should happen by introducing a new definition of money-saving in residential buildings with a different perspective, than the currently followed. Providing a kind of a materials recommendation guide in the field of construction that should mainly benefit the developers and the users with the ranking of the choices they have.

Hypothesis to be tested

As mentioned previously, 'Red bricks' are the most currently used type of bricks for residential buildings in Egypt, especially in cities. Although, the data sheets provided by the manufacturers of the other types of blocks, claim that they are more efficient in terms of thermal insulation. Nevertheless, it is also claimed that some other types are lighter in weight, which eventually means a less amount of structure concrete, accordingly saving money (Systems, 2020). If an exchange in the amount of usage of each block type was made, prioritizing them according to the environmental impact of each material, what may be the impact of this exchange on the other aspects of the building process?

So this research is aiming to study the buying decisions of the market, that does not make the supposedly more efficient materials the most prevailing.

Research Methodology

The research depends on a qualitative approach to collect data and analyze it. Visits to the brick production sites (factories) take place to observe the production process and rate it from being environmentally friendly. In addition to, interviews that take place with different stakeholders to have extensive responses, which is believed to be the best method that suits this topic and leads to collecting richer information. Secondary data sources are also essential, especially for materials' technical qualitative data and statistics.

Research structure

Chapter one: Introduction: This chapter discusses the Background of the research, its historical background, the research's problem, objectives, questions, and methodology.

Chapter two: Data Gathering: The field of residential construction in Egypt: The chapter explains the process of construction and its relation with the bricks as an outer envelope. Linking them with the housing sectors in Egypt and the environmental properties associated with the bricks. This is based on answering the research questions as well as an overview of the current construction techniques.

Chapter three: Data Analysis: The Market's Behavior: In this chapter, an analysis of the actors' decisions when choosing the types of bricks should take place. This analysis should include social acceptance, economic feasibility, and all the aspects related to the usage of different materials based on the stakeholders' perspective. The previous users who used these materials and the stakeholders of the building process should be included in the analysis process. This will clarify all the 'ignored costs' (either financial or others) that direct the market actors and were missing in previous studies on this concern.

Chapter four: Discussion and Recommendations: In this chapter, the findings and results of the research will be discussed, suggesting a group of recommendations that would improve the competitiveness of environmentally friendly bricks in the building industry.

Conclusion of chapter one:

This chapter started by explaining the increase in residential projects and two major problems facing Egypt and their relation to the research topic issue. Followed by a historical background explaining how did the topic issue evolve until the current time. The observation included the view of the topic from the perspective of a stakeholder in the field of residential construction (the researcher). That paved the way for the research problem and objectives that were simplified in the research questions. Before concluding the hypothesis, the literature review was essential to simplify the previous similar researches and to clarify the difference between the objectives of this research and the previous researches. The hypothesis was then concluded based on the previously stated problem.

Chapter Two: Data Gathering: The field of residential construction in Egypt

Chapter Two: Data Gathering: The field of residential construction in Egypt

This chapter is concerned with connecting the residential building process and its relation with the bricks used in this process. This should lead to explaining the housing typologies in Egypt and specifying an example for discussion. In addition to, grading the environmentally friendly bricks that would be the focus of the study and the Egyptian thermal comfort zone will be reviewed too.

Housing structures in Egypt

In order to study the existing construction process of housing in Egypt, a classification had to be done according to the type of structures. This classification is only concerned with the type of structural systems, which are classified into two types: Bearing Wall system with thermal mass and Reinforced concrete skeleton system with masonry.

Bearing Wall system

After the industrial revolution, the world started to act in a more industrialized way and with a rapid desire for modernization. Due to this change in the world, some local building materials were not able to cope with this quick transformation and were gradually replaced with more industrialized building materials and building systems. Clay bricks and concrete skeleton structures may be considered nowadays in Egypt, a result of this transformation in the building sector after replacing the traditional bearing wall system which was lasting since the ancient Egyptians era.

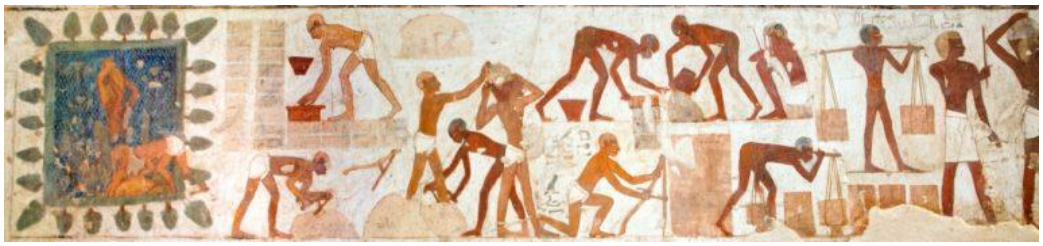


Figure 6: Brick making in ancient Egypt. (Source: biblicalarchaeology.org)

The bearing walls depends on transferring the load of the floors and the roofs in addition to its own weight through the walls to the foundations of the building. Such walls are usually thicker towards the base, where maximum weight accumulates. (Britannica, 2020) In Egypt, the bearing walls were usually made of bricks manufactured from the local materials available in the building area. Since the walls had to have a definite thickness (usually minimum 25cm) to be able to carry and transfer the loads, and in addition to using the local materials, this provided a very suitable thermal insulation that matched the temperature in Egypt. Also, the building process did not require any type of machinery, which eased the building process in remote and poor areas.

On the other hand, building multi-story buildings was not easy using this building system and the thick walls of the building decreased the interior spaces for living. Adding to this the long time needed for a building to be built in this rapidly moving industrialized world. All of these were reasons, besides the world's movement towards modernization for the abundance of using this system for housing in Egypt.

Concrete skeleton system

Concrete frame structures are perhaps the most well-known kind of building internationally. This system consists of slabs which are the flat planes that humans walk on, columns which are the vertical elements transferring the load to the foundations, and beams that are the horizontal elements connecting the columns. (Anon., 2020)

Figure 7: Concrete skeleton building

The prevailing of concrete structures was due to many reasons. Starting with its relatively cheap price and long life requiring few maintenances. It has a strong compression force and can be easily shaped before hardening. Besides its ability to carry an unlimited number of stories while wasting the minimum area from the building's spaces. (Anon., 2020) In addition to that, the usage of concrete allows having an almost unlimited area of openings in the building's outer envelope which is limited when using the bearing walls system, due to the structural loads of the walls.

However, concrete harms the environment, since it needs cement which produces an enormous amount of CO_2 during its production. Contrary to the bearing walls system where the structural system and the outer envelope of the building are incubated together, the Reinforced concrete system does not provide any outer envelope to the building. This makes the building vulnerable to the absence of thermal mass or wall insulation if the masonry was intended only to be used as an outer envelope (cover) for the building. The process of the skeleton structural system does not have any effect on the choosing of the bricks

types used, except for the weight of the bricks, which may affect the structural calculations and consequently the initial cost of the structure.

This study will be concerned with the Reinforced concrete structure system only, which is currently the major type of structure for housing in Egypt.

Comparing the amount of structural elements to the building envelope on an elevation of a typical residential building, it shows that the percentage of structural elements (beams, slabs, columns) do not exceed 35 % of the elevations. Also, to calculate the exact area of the outer envelope dependent on the masonry, windows and openings should be excluded. This shows that the percentage of facades covered only by masonry is about 60% of the total area of the facades. Thick concrete structural elements provide insulation for less than 35% of the elevation, while most of the heat escapes to the interior spaces through the remaining 65%.

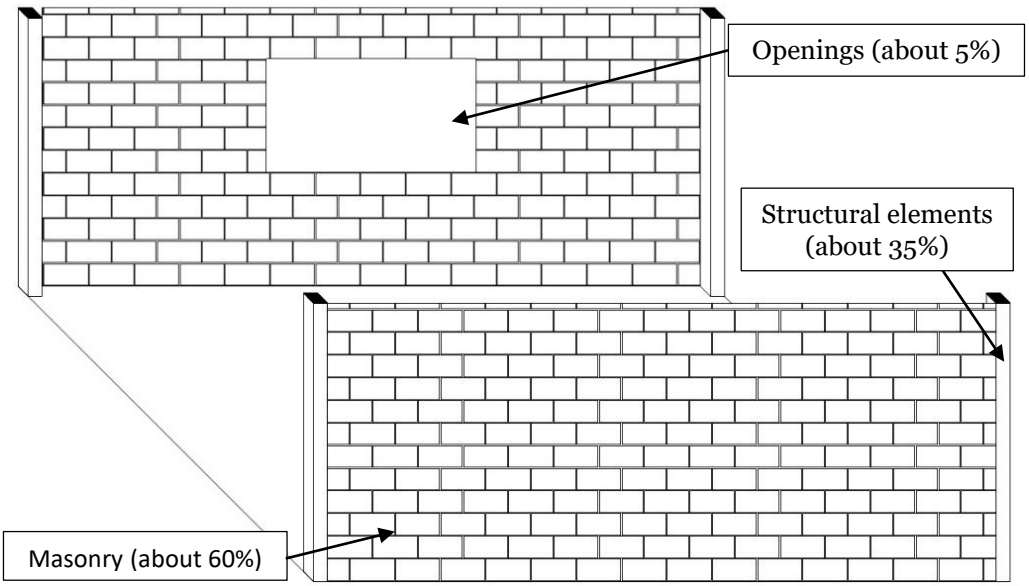


Figure 8: Housing construction and envelope materials. (Source: Author)

Housing types and categories

The main housing suppliers in Egypt are divided into three sectors:

1- The public sector including cooperative housing (under various programs and agencies as monitored by MOHUUC).

Starting the year 1982 a major housing policy shift was introduced which resulted in the production of 1.26 million units over the whole 23 years 1982-2005. Social housing built during these periods were produced by four main providers:

Figure 9: Public housing built in the early 1990s. (Source: 'Egypt Housing Profile' report)

- **Governorate housing:** the highest number of units produced of the government housing.
- **Housing cooperatives:** the second most important type of government housing.
- **Housing by NUCA:** produced 20% of the government housing over the 1982-2005 period, which all were located in new towns.
- **Miscellaneous**: Other executing agencies had the least contribution of the government housing.

The social housing adopted a new policy since this time that the produced units were sold to beneficiaries under monthly installments over 20 to 40 years.

2- The formal private sector (recorded through building permits).

Formal private sector housing accounted for almost 25% of total housing units' production in the urban areas over the 1996- 2006 period. The number amounted to 3.38 million units over the period from 1982 through mid-2014,

with an average production of about 110,000 units (from mid-2009 to mid-2014).

Figure 10: Formal private housing at various stages of completion (Source: 'Egypt Housing Profile' report)

How is the housing production done by the formal private sector in urban Egypt? Production is carried out by (1) corporates of large developers who produce compounds and housing estates. (2) smaller developers that construct one or several buildings at a time, and (3) individuals who construct only a single building. Production by individuals is common in subdivided plots provided by the government in new towns. All formal private developers need a registered contractor to carry out the construction and consulting engineers to design and supervise the construction. For individuals, a registered architect is needed to do the drawings since a building permit is required and most probably individuals will employ an unregistered contractor (although this is not required by law).

As it is well known, most of the units produced by the private sector target the high end of the housing market. In the new towns, housing units built by individuals or private developers will typically range in area from 150 to 350 m^2, smaller units are relatively rare.

3- The informal private sector (unrecorded and assumed to be all other housing production).

Figure 11: Informal housing under construction in Giza (Source: 'Egypt Housing Profile' report)

Informal housing produces at least two-thirds of all urban housing in Egypt, the production process is quite different from that of the private formal sector. Most of the informal buildings are managed by a single-family or an individual. For small informal buildings design is either made by an informal “ahli” contractor, by a local master mason, or by a local engineer/architect. The construction process is very well known locally; the norms of construction, design parameters, and structural requirements. Building permits are not obtained. The norm is progressive building. Normally the building is constructed as single floor at a time or by construction phases, starting with foundations and RC frame and slab, followed by brick infill, then doors and windows and interior finishing and utilities. The building owner was likely to supervise and manage the construction process himself in the past, hiring skilled or unskilled workers and purchasing and collecting the required building materials. It is now more likely, at least in Cairo, that the owner contracts the building process out to a local contractor. (David Sims, 2016)

Bricks usage in the housing types:

The public sector

From the previous categorization, it is obvious that the public sector housing is intended to provide housing at a low budget and produce the maximum amount of units for those of a limited income. Besides that, the public sector usually includes a bureaucratic multiplicity of providers, which makes any suggested change in the building process resisted and hard to execute. A real change in this sector would require the interfere of those in charge, who believe in the urgency of reducing the harmful environmental impacts and the energy consumption of the construction sector. These buildings usually used red bricks for outer walls, but lately, they are using cement blocks, due to the deformations that happen to red bricks due to firing.

The informal private sector

However, the informal private sector which does not follow any official building regulations and is managed by individuals is hard to change too. As it is obvious in all Cairo's informal residential constructions (due to the absence of finishing materials), the external walls are built of 12cm red bricks. The target is always towards choosing the cheapest materials to cut the building expenses as much as possible and provide units at a relatively cheap price. Also, since the building process is mostly not supervised by architects who would understand and suggest an unorthodox modification in the building process, no investment in the building, in the long run, would be easily understood. Especially that those informal buildings became nowadays very vulnerable to demolishing by the government, which made the property owners very eager to finish building and sell the units as fast as possible more than anything else.

A change in this building sector would require the provision of a cheaper type of brick that provides better environmental properties. If an environmental change was applied to this housing sector only, the impact will be obvious, as it occupies about 70% of the housing units in Egypt.

The formal private sector

On the other hand, the formal private sector is mostly expected to be more flexible for a suggested change. The types of bricks used in this housing sector are various according to who is carrying out the building's production. For projects held by large real estate corporates, there is a probability that the project consultant specifies different types of blocks other than red bricks, for example, hollow cement bricks or light white bricks. Reputable developers are willing to keep the reputation of their projects even if this would increase the building cost but it will be repaid later by the client.

Smaller developers that construct less number of buildings at a time are more focused on gaining the most profit. Consequently, they favor a 12cm red brick as a building envelope. Such developers are targeting high-end clients but mostly within a tight budget and a lower price than real state developers. Since the outer walls insulation properties are not yet recognized by the clients as an added value, so cutting the masonry expenses is considered the right economic decision for the developers.

Individuals who construct single units for their personal use are usually using 12 or 25cm thick wall of red bricks although, they would benefit directly from a long term investment in their residence. Being guided by architects who should be recommending the best solutions, out of their knowledge.

The latter case of individuals constructing their private sector seems to have the most potential of a change, this will be even explained more after interviewing the property owners. Even experimenting with newly invented bricks (by offering some incentives) would be mostly possible through individuals.

The area urbanism; New Cairo City

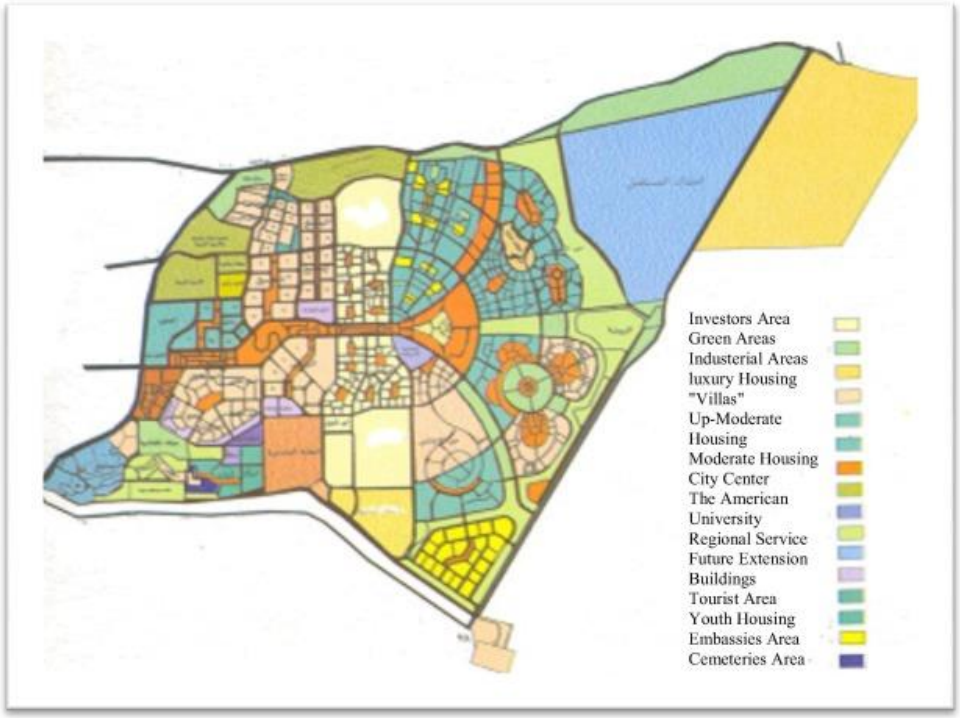


Figure 12: New Cairo city general plan, (Source: HBRC Journal)

Due to Egypt's policy of establishing the new cities that was adapted for national aims. New Cairo was established by presidential decree (191/2000) as one of the second generation cities. The city is characterized by its practical developed location. It was made the focus of real estate investment, for the economy and investment politics of the Egyptian government at this time. Although, this had negative effects on sustainability.

General plan

The city of New Cairo is situated in the eastern part of Cairo on the ring road and lies in the zone between Cairo El Ain El Sokhna desert road and Cairo-Suez desert road. The area of the city reached 70 thousand acres in total, this area is a built-up area consisting of (Residential areas - services - industrial - tourism and recreation).

Housing sector

The total number of land plots is 46346 (villas- buildings – Families). This number of plots resulted in 69764 housing units, 34034 units of them were implemented by New Urban Communities Authority, and the remaining 35730 implemented by the private sector (NUCA, 2020). The real estate in New Cairo depended on investing in the residential development that was only through the housing sector, focusing entirely on luxury housing (villas).

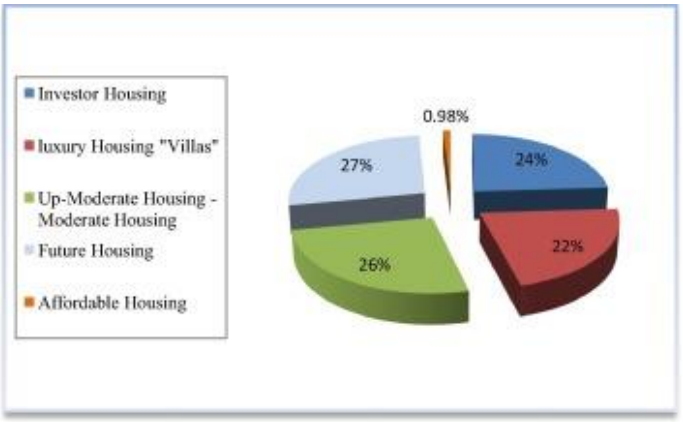


Figure 13: Housing types, approximate ratios according to the general plan. (Source: HBRC Journal)

New Cairo is a city that billions of Egyptian pounds were invested in and still being invested in it through luxurious housing. This indicates that if a slight increase in the initial cost of the buildings was needed, it would still be affordable for the property owner, or a change in the usage of certain building materials should be understandable. Not mentioning that this change would be an investment in the long run. Choosing New Cairo in particular as the urban setting for the study was due to continuous real estate development in the city. Besides being a formal area, which obliges the property owner to hire an architect for the design phase. The architect should understand more than the owner about the importance of having an adequate building envelope, and if hired for the construction supervision too, the architect may lead him to the best solutions.

Unfortunately, although all of the previously mentioned potentials in this area, sustainability, and energy conversation were totally neglected by the government in this real estate hub. A lavish lifestyle that would lead to high

energy consumption should have been expected in such a luxurious housing. This could have been reduced by forcing some energy reduction techniques starting with having an adequate building envelope.

Housing model

To carry out the study, a model of a typical residential building in one of Cairo's new residential settlements (the 5th settlement) was employed. The residential building is of a floor area of around 300 m^2 and a total area of around 1200 m^2. Consisting of a basement, ground, first, second floors, and a room on the roof with at least a 5 meters gap separating it from a neighboring building. The structural system is a concrete skeleton system and the roof is of the hollow block system. This housing unit can be divided internally into several units or one large unit, however, this will not affect the exterior walls (the building's envelope).

More detailed information concerning the unit, such as; orientation, wind direction, etc. was not mentioned since this is an abstract description of the area urbanism and a housing model to be used for later discussion with the stakeholders.

External walls Types and specifications

The specifications of the available types of walls used in the housing building sector are presented in (Table 1). The bricks types mentioned in (table 1) were chosen according to a field survey between building materials' merchants. The field survey took place in one of the new settlements in Cairo's area (the 5th settlement). The goal of this survey was to collect quantitative data concerning the types of bricks available in the market for residential buildings. The bricks density is according to the average density of the brick mentioned in the (Egyptian code for calculating loads and forces in construction and building works, 2008). For the U-factor, the (Specifications of thermal insulation work items) issued by the Egyptian ministry of housing were used as the reference.

The light white brick was the only type with a U-factor absent from the (specifications of the thermal insulation) accordingly, the value was obtained from (Delta block) company data sheet (Systems, 2020).

Wall (brick) type	Thickness cm	Density Kg/m^3	U-factor $W/m^2\ ^oC$
Solid cement brick	12.5	2000	3.56
Hollow cement brick	25	1600	2.97
Light white brick	25	500	0.43
Solid sand brick	12.5	1850	3.87
Solid red (clay) brick	12.5	1700	3.27
Hollow red (clay) brick	12.5	1350	2.57
Hollow red (clay) brick	25	1350	1.67

Table 1: Bricks types and specifications.

The table compares the physical characteristics of the building materials, in terms of Thickness, density, and U-value. The bricks types mainly consist of 4 materials: Cement, Sand, Limestone, and clay.

Note that the Half red brick wall and Full red brick wall are the most used types of external walls, this is mainly due to their low initial cost and other factors that would be investigated later through the research.

It is a fact that the lower the u-value of a material, the more it isolates heat which would lead to a more economical operating cost. The U-value alone has been used as an indicator in many studies to promote the usage of different types of bricks. Comparing the high block price to the low operating cost and considering it as an investment in the long run. But most of the studies ignored the return of the investment in small residential units such as villas, although

they have been increasing lately, which may affect the buying decisions. The high or low density may affect the structural loads and accordingly affect the initial cost of the building positively or negatively. Mentioning the initial cost, it has to include the price of special labors or tools needed for building the walls leading to a higher initial cost.

Environmentally Friendly bricks: A Multi-Criteria Analysis

" Environmentally friendly building materials are those that make optimal use of resources, produce minimum waste and are safe for the environment and people " (Rousseau, 2012)

The term environmentally friendly is a sustainability and marketing term that has been used lately to refer to products or materials of reduced or no harm to the ecosystems or the environment. However, an Environmentally friendly building material increases the energy used efficiency and decreases the effect on human well-being and the surrounding environment.

European Bank for Reconstruction and Development (EBRD)

"The European Bank for Reconstruction and Development is a worldwide financial organization established in 1991, as a multilateral formative venture bank". The bank expanded to support development in more than 30 countries from Central Europe to Central Asia including Egypt. The EBRD had assured, to commit over 40 percent of its financing to green projects by 2020. (Anon., 2020)

The EBRD guideline was chosen for this study as the bank focuses on investment in developing countries and is focusing in Egypt on supporting Egypt’s efforts in diversifying its energy efficiency investments across sectors. Besides having a detailed guideline for the environmental impact of the manufacturing process of bricks (EBRD, 2020).

EBRD Environmental and Social Guideline: Manufacture of Bricks

This guideline is designed to focus on the nature of environmental and social risks associated with existing operations of the manufacture of bricks. It is not an exhaustive list of environmental and social risks.
Explaining in the following table the environmental and social risks present in brick manufacturing as an overview divided into 4 categories.

(This table and the following process description was provided in EBRD environmental and social guideline)

E&S Risk Category Key Risks	**Environment**  Impact on natural environment	**Health and Safety**  Impact on health or safety of employees	**Labor**  Impact on workplace conditions and the treatment of employees	**Community**  Impact on the health and safety, livelihoods, and environment of the community and wider public
Air emissions	√	√		√
Noise	√	√	√	√
Water Use	√			√
Wastewater	√			
Biodiversity	√			

Solid Waste	√			√
Energy Use	√			
PCBs/ Asbestos		√		
Hazardous Materials	√	√	√	
Machine and Electrical Safety		√		
Manual Handling		√	√	
Slips, Trips and Falls		√		
Temperature Exposure		√		
Confined Space		√		
Labor and Working Conditions			√	
Community Relations				√

Table 2: social and environmental risks in brick manufacturing, (Source: EBRD)

*This guideline does not cover the resulting transport to wholesalers, manufacturers or clients. Block producing sites are in some cases utilized for landfilling of waste after the clay is extracted. This note does not cover the landfilling process.

Air emissions: Emissions to air happen from the utilization of ovens to fire bricks. Emissions emerge from both the consuming of fuel to produce heat and from the impact of heat on the materials.

Noise: Public/environmental wellbeing and disturbance issues related with noise can emerge from production activities and may affect neighboring areas.

Water Use: Water is used in the brick production process and evaporates into the environment as steam. No harmful emissions are expected from this evaporation however there could be limited increases in air temperature.

Wastewater: Wastewater is released from brick manufacture process. Contaminated wastewater presents a pollution hazard whenever permitted to enter a watercourse without satisfactory treatment.

Biodiversity: Advancement of a new brick cutting site for material extraction, or extension of a current one may adversely affect biodiversity through effects on landscape, habitats and wildlife.

Solid Waste: The brick manufacturing process itself creates minimal waste material other than bundling waste and used chemical compartments. Brick offcuts may likewise emerge and are classified as waste.

Energy Use: Brick manufacture is energy-intensive because of the high temperatures needed. Usually, the energy source for the ovens is natural gas. As a substitute sawdust or waste tires can be used as a fuel.

PCBs/Asbestos: PCBs are some substances which are good electrical insulators. Normally, PCBs might be available as constituents of hydraulic oils or dielectric liquids in electrical switchgear, transformers and fluorescent light starters.

Hazardous Materials: Unsafe materials utilized in the block manufacturing industry may incorporate fuels, oils, glazing agents, solvents and so on. Bad storage or handling of these substances might be a source of contamination or health hazard (to individuals, environments, soil or water assets).

Machine and Electrical Safety: In a bustling manufacturing condition, it is not unexpected to have injuries where individuals interact with gear or machinery.

Manual Handling: Lifting, tedious work and posture injuries happen because of lifting and conveying heavy or abnormal molded things, for example, products, items and solid wastes.

Slips, Trips and Falls: Slips and falls are regular events in brick manufacturing situations and can cause numerous injuries. Usually these are because of uneven ground, wet/oily floors from oil and different spillages and poor housekeeping.

Temperature Exposure: Ovens working at high temperatures can increase the temperature of the workplace which can cause heat stress.

Confined Space: Brick manufacturing plants contain vessels, for example, tanks and pits which may require interference of staff during cleaning and maintenance. Entry to closed spaces without powerful administration and control can cause suffocation.

Labor and Working Conditions: Brick manufacturing activities may use casual and provisional workers. Worker accommodation standards, especially for impermanent/casual workers may not meet the standard required for permanent workers.

Community Relations: Having good relations with the neighboring societies reduces the problems of objections on the manufacturing activities (Development, 2014).

Assessing the local bricks

Key Risk/Brick Type	Hollow cement bricks	Solid cement bricks	Sand bricks	Red bricks	Light white brick
Air Emissions				√	
Noise					
Water Use					
Wastewater					
Biodiversity					
Solid Waste				√	
Energy Use				√	
PCBs/Asbestos					
Hazardous Materials				√	
Machine and Electrical Safety				√	
Manual Handling	√	√	√	√	
Slips, Trips and Falls				√	
Temperature Exposure				√	
Confined Space					
Labor and Working Conditions	√	√	√	√	
Community Relations					

Table 3: Bricks types and key risks according to EBRD criteria. (Source: Author)

The previously mentioned grading of the bricks manufacturing (table 3) will be explained according to the manufacturing process and its environmentally friendly properties. This phase of assessment will be concerned with the manufacturing process of the bricks. Visits to the different types of bricks factories in different areas were conducted. The manufacturing process was witnessed, recorded, and discussed with the managers and workers.

1- Cement Blocks

The manufacturing of cement blocks consists of a mixture of powdered Portland cement, sand, water, and gravel. This concrete mixture is molded inside a machine to produce the light gray block and gives it its rough texture and high strength (Anon., 2020) The molding machine is either automatically operating and producing the bricks, or each of its functions is controlled directly by a worker –named half automatic-. The bricks are molded inside forms and compressed inside the machine then left to sun dry for about 24 hours before they are ready for usage. The same process applies to hollow and solid cement bricks.

Figure 14: Front; Cement bricks stalked for sun drying, behind; Dried bricks ready for transfer. (Source: Author)

Cement has many negative environmental impacts that are represented in its production process, which ranked it as the third producer of (manmade) CO_2 in the world (greenspec, 2020). However, for grading the brick according to the criteria adopted in this study the issues of the manufacturing are the labor conditions, for not all the workers are working under permanent contracts. The workers are also sometimes involved in manual handling and stalking of the bricks although the dependency of most of the process on mechanized activities.

2- Sand Blocks

Figure 15: Colored Sand Blocks. (Source: (Anupoju, 2020))

Sand Blocks or rose blocks are the commercial names for Calcium silicate bricks, that are made of sand and lime. The block consists of a high amount of clean sand 88-92% plus 8-12% of calcium lime. Clean water should be added to this mixture in addition to pigment to give color. The manufacturing process consists of molding the mixture into bricks applying mechanical pressure to the bricks. The final stage is placing the bricks in the autoclave chamber exposing them to steam and heat (Anupoju, 2020). This process is free from any environmentally harmful materials or processes, only for the usual usage of energy. Labors are also involved in manual handling and are not provided with safety tools, besides not working under permanent contracts.

3- Light White Blocks

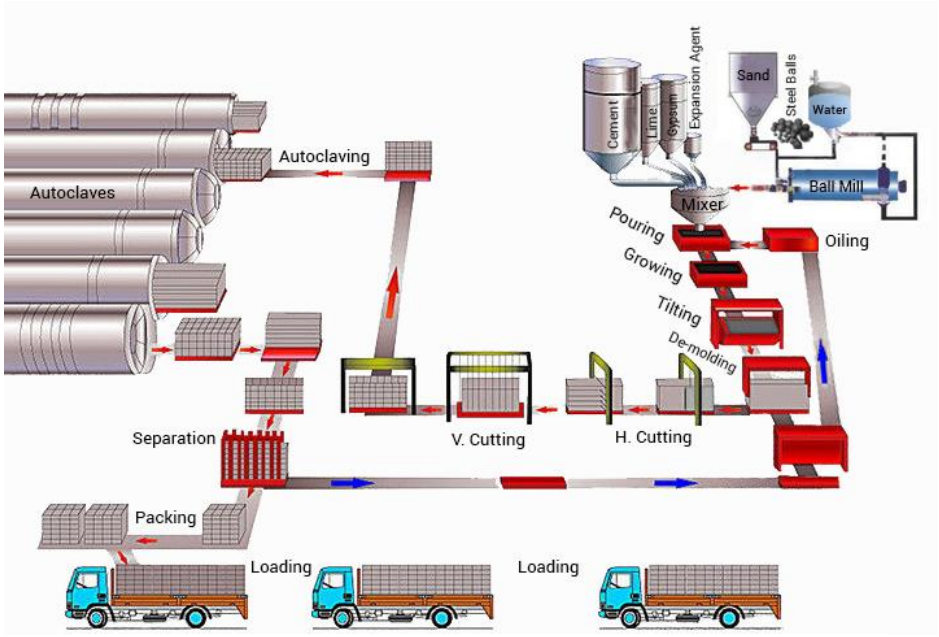


Figure 16: The manufacturing cycle of light weight bricks. (Source: plenaegypt.com)

This type of bricks depends on a technology known world white as (AAC), however, known in the Egyptian market as 'Light White Block' due to its physical characteristics. The production process includes the usage of the following raw materials: sand, cement, lime, gypsum, and water. The process starts with sand grinding with water in large grinding mills. All the raw materials are added with an expansion agent to become a homogenized slurry, which is then cast into large metal molds. The molds are then transferred to increase in volume 'swells', creating the compound structure that creates the brick's specifications. Once the mixture is hardened sufficiently, it is then cut into different sizes. Lastly, the blocks are exposed to high heat and pressure to generate the block's strength (Egypt, 2020). According to the manufacturing sources provided by the manufacturer, the production cycle is automated and depends on electricity as the energy source (Ltd, 2018). The production takes place in an industrial area, and the process is supervised by a quality control department that monitors the whole production process.

4- Clay Blocks

The mud-brick molding started during the ancient Egyptians time, the engravings indicating the cycle of the bricks casting show the significance of the in industry. The casting of the Mudbrick was a typical traditional cycle, either in the desert, where desert clay is the primary material or in the Delta, where mud from the Nile sedimentation was utilized.

Figure 17: Adobe making, Tomb of Queen Hatshepsut. (Source: Auroville Earth Institute)

Later, with the technology of burning the bricks for better physical properties appeared, many brick factories were established on the river banks. Making use of the sediments(mud) from the Nile valley. Until the use of the mud from the agricultural land was prohibited in the 1980s. (El-Kabbany, 2013)

Nowadays, clay brick is mainly consisting of a clay mixture in addition to sand, lime, Iron oxide, and magnesium. The manufacturing process starts with clay preparation which is through crushing the clay particles and then mixing the clay well. The next step is the Molding of the clay which can happen in different ways, differing on the amount of moisture needed. After molding, the drying process takes place through sun drying for about ten days. Lastly, the firing process which is exposing the bricks gradually to a very high heat (reaching 900 ^{o}C) (Khattab, 2020) The process includes very high heat, which may have negative environmental impacts if it is depending on fossil fuel burning, which is, unfortunately, the case in red (clay) bricks manufacturing in Egypt. Accordingly, red brick

Figure 18: Clay brick firing causing continues smoke. (Source: The author)

factories are among Egypt's most air polluting industries, likewise cement factories. The majority of the brick factories depend on diesel-burning for the firing process while others depend on natural gas, both cause air pollution and excessive energy use. Due to the presence in an industrial area, there are not any issues related to noise or community relations. Water is used only during the first stage of clay mixing without any wastewater. There are no issues related to biodiversity during the manufacturing of the brick however, it is unknown if the clay extraction process in the desert has any negative effects. If the unfired bricks were exposed to water (rain or other reasons), the molded bricks are no longer usable and turn into solid wastes. The firing process is the most dangerous, since workers stand on highly stacked piles of bricks that may lead to slip and fall, besides being exposed to very high heat. The firing machines and pipes are not well isolated which causes oil leakage and threatens the safety conditions of the workers. The laborers are not working under permanent contracts but are paid on weekly basis.

It is important to mention that clay blocks are one of the most important materials used in building since it is used in the construction of 80% of the buildings. However, 99% of the clay blocks factories are 'traditional' besides that 45% of the production does not match the standard specifications. (Elmosalamy, 2017)

The physical specifications and characteristics showed the superiority of the light white bricks in terms of thermal insulation and density. The manufacturing assessment too ranked this brick as the best environmentally, after being the only type not having any environmental issues related to its production process. On the other hand, red bricks were the worst in terms of environmental impact. Also, when it came to the U-factor of the mostly used red brick did not show superior insulating characteristics. The actors' opinions should clarify more the preference of the market and if there any other factors that direct the markets' decisions.

Thermal comfort

Thermal comfort is the state of mind in which the human being is satisfied and active in the thermal environment surrounding him. According to the Health and Safety Executive UK, there are six factors affecting thermal comfort distributed between environmental and personal factors. Four of these factors are reliant on environmental factors, which are: Air temperature, Radiant temperature, Air velocity, and Humidity while the other two reliant on personal factors are: Metabolic heat and Clothing insulation (Executive, 2020)

Thermal Comfort in Egypt

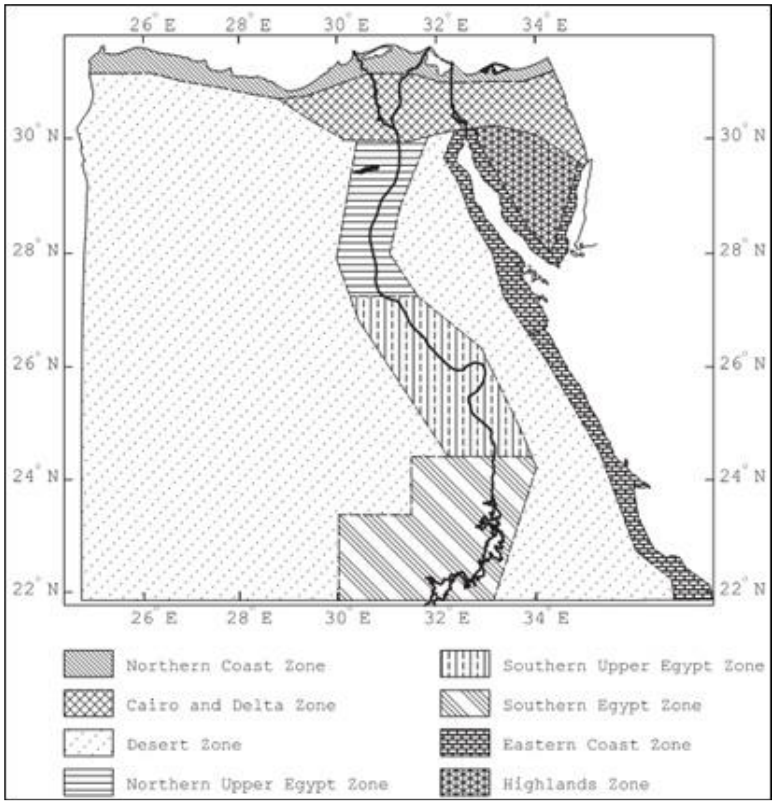


Figure 19: Egypt's eight climatic zones classification map according to the Egyptian Residential Energy Code. (Source: (Barakat, 2017))

Egypt is a huge nation having various weather conditions extending from amazingly hot conditions in the desert areas, for example, the Western Desert, to cold conditions in Mountain St. Catherine in Sinai. In any case, the general

weather of Egypt is portrayed by being hot dry weather with extremely high sun oriented radiation intensity almost all year. (Barakat, 2017) It's essential here to mention that global warming has a considerable part in expanding the dry zones everywhere in the world over the previous fifty years.

There is now a grow in temperature profile allover Egypt over the previous 10 years. This part of climate change makes the issue more difficult in Egypt in light of the fact that the majority of the structures are not very good insulated. That raises the energy consumed to reach thermal comfort to a significant degree. Several surveys conducted in the Egyptian context found out that power use is notably overwhelmed by the seasonal utilization of air conditioners. Buildings in Egypt are described by low degrees of insulation which causes low indoor air quality and a very poor thermal performance. Diminishing the electricity use will reflect immediately on energy consumption, which cannot be reached without resolving the thermal inefficiency issue. The wall material and the construction type are the elements that influence the thermal transmittance. From the material perspective, the wall could be built from various bricks types and thicknesses each with various thermal masses. (ALBADRY, 2016)

Conclusion of chapter two:

Egypt was one of the pioneering nations in the brick industry since the Ancient Egyptians. Until now, it is still a local industry contributing to the national economy and providing thousands of job opportunities. Unfortunately, nowadays due to the modern structure systems, bricks' importance became underestimated. Although, the housing sector includes three different sectors with different stakeholders. The environmental impact of the most used and produced type of bricks (red bricks) is strongly harmful to the environment, harming the health of millions of Egyptians. Also, not paying attention to the importance of passively obtaining the thermal comfort zone in our residence, leads to indirect harm to the environment and a continuous financial exhaustion.

Chapter Three: Analysis: The Market's Behavior

Chapter Three: Analysis: The Market's Behavior

After studying the types of bricks commonly available in the Egyptian market, in an attempt to study their relationship with being environmentally friendly. While explaining the housing sectors that will be used for comparison and analysis. In this chapter, an analysis of the actors' decisions when choosing the types of bricks should take place. This analysis should include social acceptance, economic feasibility, and all the aspects related to the usage of different materials based on the stakeholders' perspective. The previous users who used these materials and the stakeholders of the building process should be included in the analysis process. This will clear all the 'ignored costs' (either financial or others) that direct the market actors and were missing in previous studies on this concern.

A value chain analysis for bricks as a building envelope:

Explaining the value chain analysis

The value chain is a strategic tool to recognize which activities are the most valuable and which ones can be improved to provide a competitive advantage. Defined as *"the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers"* (Kaplinsky, 2001). A value chain includes makers, processors, input providers, and consumers, and till the end product or service: such as a building component or material.

This strategy is derived from the business management field. The use of the 'Value Chain Analysis' in this research's topic is due to the desire to recognize all the activities and actors that are subject to improve the usage of environmental

bricks as an outer envelope for buildings in the housing sector. In addition to, the limitations confronting it, and the current opportunities, besides the value-added from the contribution of all fields of specialization. The necessary information is accumulated through a progression of semi-structured in-depth interviews with a chosen sample of interviewees who are the main actors engaged with the value chain. Every expert was approached to distinguish and clarify the activities wherein s/he is directly or indirectly engaged with during his/her practice and the relationship with other entities or actors. The topics relating to the value chain of brick masonry works incorporate construction laws and guidelines, workforce, training, innovative work, supplies and equipment, recognizing raw material, creation of building material or component(s), architectural and structural designs, advertising and marketing.

The purpose of using the tool of the value chain analysis:

- To realize the primary actors operating within the different activities, their roles and relationship links, and identify the missing activities that can contribute to the promotion of a material.
- To realize the unseized opportunities and the constraints that are holding back the change and development.
- To realize the market's behavior and trends.

Collection of data:

The data was collected using the following methods: interviews, field surveys, scientific researches, and reviews. Semi-structured in-depth interviews are depending on a flexible interview guide to suit each interviewee according to his understanding and background while maintaining focus on the interview's topic. The wording of the questions does not have to be the same for all interviewees. In-depth interview is a qualitative research procedure that includes conducting intensive interviews with few individuals to investigate their points of view on a specific thought, program, or circumstance (Boyce & Neale, 2006).

Identifying stakeholders:

The stakeholders in this study are all who are involved with the choosing of the type of masonry for a building. They were identified according to the process and the stages of building. A stakeholder may be affecting the buying decision or being affected by it at a certain time or both.

Activity	Actor
Structural calculations	Civil engineer
Building specifications	Architects/Consultants
Materials Production	Building Materials Producers
Materials research and specifications	HBRC
Financing	Building Owners
Use in Construction	Builders/ Contractors
Building codes and regulations	Ministry of Housing

Table 4: Activity vs Actors of the masonry building process.

Interviews were conducted with the following interviewees:

- Two consultant architects.
- One consultant civil engineer.
- Building (villa) owner.
- An expert from the national research institute (HBRC).
- A masonry builder/contractor.
- Three Building Materials Producers.

(The whole list of interviewees, field surveys, and site visits is indicated in Annex 1)

It is important to clarify that interviews are not the main focus of this study. Nevertheless, it is a secondary mean of collecting data for the research's topic, that is why the previously mentioned number of interviewees was sufficient for this study.

To value the importance of the opinion of each actor, a power/interest graph was drawn to identify the authority of each stakeholder in taking the buying decision. The graph is not intended to locate exactly the amount of power/interest each actor has, however it can be considered an indicator according to the reviews and interviews that are done by the author with the stakeholders.

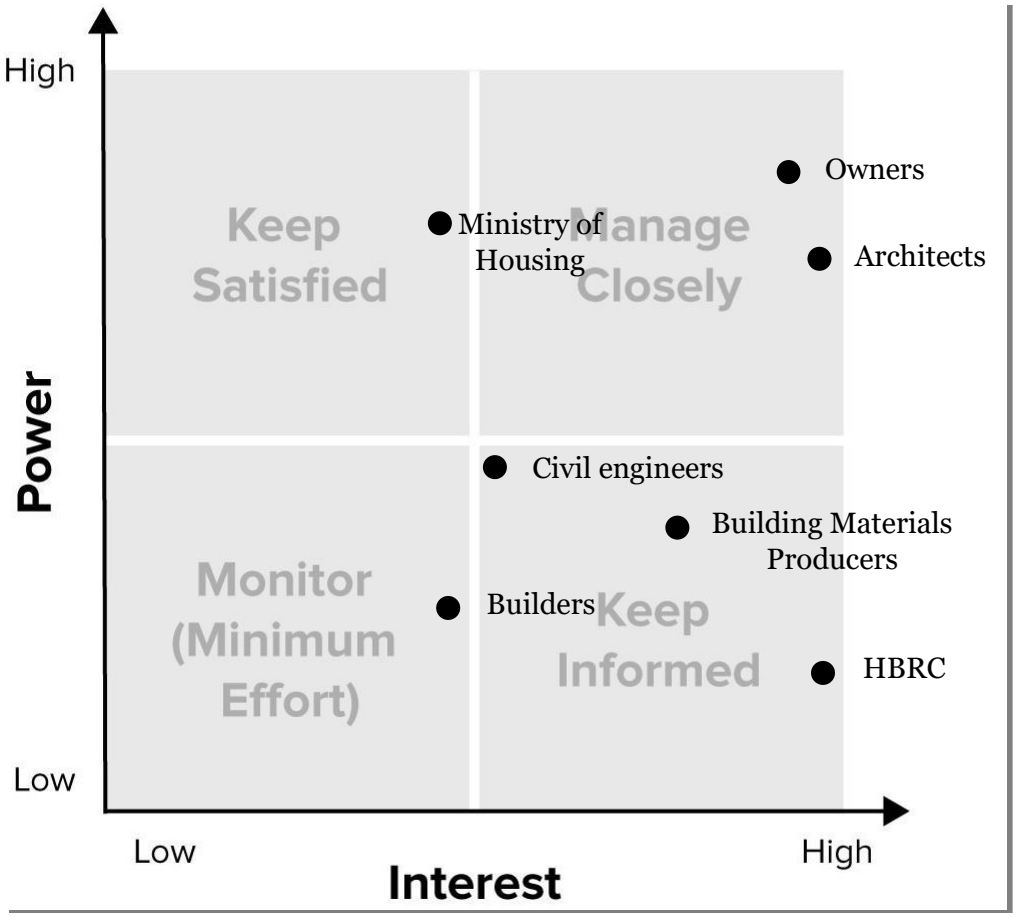


Table 5: Power to Interest of the actors.

The Role of each actor:

Consultant Architects

Architects are in fact are the most undertaken on the building process and all its actors. In Egypt, most of the architects would also work in contracting of small residential projects such as apartments or villas, which would be mostly of their design. In such a case, the architect is supervising the implementation of the building according to his specifications, however, if an external contractor is implementing his designs, abiding by the specifications is not guaranteed.

Contractors when handed a private project, they become the main deciders of the usage of building materials and specifications, according to the architects' opinion. Due to the ignorance of the property owner of the details of the building process, the contractor substitutes any building material with the easiest to use, the cheapest, and the most available in the market. Supported by the owner's desire to save as much as possible of the building's expenses. Contrary to the case of mega projects, where the consultant's specifications must be implemented by the contracting company and the construction is supervised by a project manager.

When consultant architects were asked about what do they think about the most commonly used types of bricks and the variation in the market, it was agreed that the red clay bricks (half bricks in particular) are the most widely used. This wide use is due to the cheap price, easy labor, presence of plenty of factories and providers, however, this had a setback on the quality of the bricks. Architects complained that the numerous traditional clay bricks factories (99% of red brick factories) led to a drop in the quality of the brick; the bricks are not well burnt which decreases its compression properties. Also, the dimensions of the bricks are not meeting the minimum specifications according to the Egyptian code which leads to the usage of extra finishing materials to cover the flaws caused.

Cement bricks although being more expensive than red bricks, are being used in most of the projects for the wet areas (kitchens and bathrooms) or areas below the zero level. Not mentioning that the cement bricks vary too in their quality and price according to their manufacturer, but again this is implemented depending on the specifications and the quality of the masonry works. However, the usage of a special material for the masonry (cement bricks) although being more expensive due to a certain need may indicate the acceptance of the users to pay more for what may benefit them more in the future.

Discussing the ecological effects of the bricks, it is known that most of the production of the red bricks depends on burning diesel in large furnaces which produces a great amount of smoke. When asked if they search for a more environmental alternative, it was obvious that this is not done beyond what is usually available in the market.

There was a consensus that the labor quality is low which constrains the usage of different types of materials and also prevents any attempt of development. One of the architects mentioned that he used hollow cement bricks in wall building in a project in one of the gulf countries. This type of brick, although being available in the Egyptian market but it is not usually used in wall building. For it needs a high level of craftsmanship -to keep the wall sturdy and decrease the brick waste- which is hard to find between the masonry workers in Egypt and when found the wage of the worker will be high compared to any other worker.

When being asked about lightweight bricks since they have the lowest u-value and are not environmentally harmful, none of the architects have used it before in private residential housing as the model proposed. Although it has not been widely examined before on such a scale of projects, it is mostly used for mega projects. This type of brick needs special tools for building and experience by the worker, which is usually missing as mentioned before.

Discussing the role of the property owner on the decision making, most of the clients accept the usage of a 25 cm red brick wall for the future benefit it provides (although having to pay almost the double). Nevertheless, this depends on the purpose of the property owner for the future use of his property. For example, if the property is intended to be sold after finished as an investment, the usage of a thicker wall or a heat isolating material will cost the owner more without any future benefit, especially that the majority of the buyers do not consider thermal insulation as an added value. Another factor that affects the decision of the architect and the owner when choosing the thickness of the walls, is the area of the rooms that will be deducted by the thicker walls.

Civil engineers

Although civil engineers are not usually the ones responsible for choosing the masonry type used for the building. But their role of calculating the building loads accordingly the cost of the building's structure is affected by the dead loads of the walls. By asking an expert consultant civil engineer about his role in choosing the bricks' type, it was obvious that it is not his role but sometimes the civil engineer has to switch roles if the architect is not aware enough of the consequences of choosing each type.

When asked about how usually does specifying a certain type of bricks decreases the structural costs of a residential unit such as the chosen housing model, he explained that specifying a certain type of brick does not decrease the structural costs in such a model but rather it may increase it. This is because some bricks types; sand brick as an example has a way higher density per m^3 than the usually used types. On the other hand, if a lighter type of brick was chosen, still the saving in the structural loads will be too little compared to the total cost of the building. Therefore, in such a model of a residential building, the interest in choosing the lightest brick type is almost neglected. Nevertheless, the saving of the usage of lighter bricks can be noticed if the area of the

residential building is starting from 4000-5000 m^2 although this model is not present in most of Cairo's new residential settlements.

It was obvious that contrary to what's is usually promoted to in some of the brick companies' advertisements or some researches that using lighter types of bricks will have a positive impact on the building's structure initial cost, the reality of implementing this in such a housing model is not fruitful.

Research and Development Institutes

After interviewing one of the professors specialized in the bricks industry in the (Housing and Building National Research Center), the following was concluded. There is indeed a gap between the research institutes and the industry of bricks manufacturing since the cement bricks are one of the most heat conductors but the manufacturing flow and cost matters are in control. Filling this gap is not a one process act but requires many things in different aspects of the process. There are several pieces of research on improving the bricks' specifications and even on new types of bricks but unfortunately, they are not industry implemented. Also, some companies produce unconventional types of bricks, and this is evident in the building and construction exhibitions and the directory issued by these exhibitions. Of course, they have some sales but are limited to the scale of construction companies or private sector contractors for distinguished or high-end projects. An example of improving the industry in Egypt is that (The Industry Modernization Authority) is undertaking a project to promote the clay brick industry with an international consulting office. There was a periodic evaluation system for bricks carried out by the Raw Materials Institute at the center, but it has been suspended for years and the institute is trying to return it. The center is now in the process of signing an agreement with the (Chamber of Building Materials Industry) to conduct tests and solve problems corresponding to its industries. As an opinion, the environmentally best brick type than the traditional types is the pumice sand brick, but its manufacture is currently reduced or scarce, and the best recently is the light white block (Delta Block).

Research papers and studies available on the Internet, in conference folders, and in scientific journals are the ones that can be referred to, to study the environmental impacts for every brick type. Inquiring about the thermal codes, it was clarified that there are energy codes specifying the thermal requirements for bricks that can be used in buildings. Such as the thermal resistance for the eight climatic zones in the Arab Republic of Egypt. Anyway, it is not guaranteed that these codes are being followed.

Master Builders/Masonry contractors

Master builders play the execution role of the wall building; their capabilities are a main factor in the type of materials to be used. Discussing the masonry work with one of the skilled masons who have worked in the field for about 20 years. He explained that all types of bricks apply the same building methodology and no special labor or extra equipment is needed. All the wall types do not need more than the bricks and the filling cement except for hollow cement blocks that need some extras such as a metal mesh. Due to the traditional methods of producing red bricks, the blocks are not always identical in size. This leads to having 2 different sides of the wall, named locally as (clean and dirty sides). The first side is coordinated aesthetically and vertically leveled, however, the other side cannot be leveled and the difference in the amount of filling cement or block sizes is clear. This prevents the option of keeping the bricks exposed aesthetically, without the need for plastering. The same applies to cement bricks, but on a lower level of difference due to the inaccuracy of the molding forms. In both cases, this requires an extra amount of cement plastering to overcome the deformation of the blocks and level the wall correctly.

On the other hand, this issue is not that obvious in sand bricks but they are rarely used for walls due to their high density. For light white blocks, this issue is almost absent, which allows keeping the bricks exposed or in case of plastering, a thin cement layer only would be sufficient, giving decorative options and saving extra plastering cost. Also due to the insufficient firing of

clay (red) bricks, there is always a percentage of bricks wasted during transportation and building. This percentage is almost absent for white blocks because of packaging for transportation, the automated process and quality control.

Property owners

The property (building) owner is the actor with the highest power of purchase for controlling the finances of the projects. If the owner is building without guidance from an architect, the preferred type of brick is the 12 cm red brick, because it is the traditional known local type of brick besides being the cheapest. The thermal insulation is of the owner's interest for his private residence but he does not know other thermally insulating blocks. The option of using 25 cm red bricks is usually refused, not for financial reasons but for the extra area it occupies. As a property owner explains, the priority is to the rooms' space, then to thermal insulation then to the cost. Accordingly, when trying to find other insulating solutions (up to his knowledge) he is either faced by the space waste or the high cost of thermally insulating chemicals. For owners building their residence in luxurious neighborhoods, they are willing to use a more expensive brick, if it does not waste space (especially if the unit is small in size) even if the insulating brick is more expensive than the traditional one.

Building Materials Producers

Field visits to several types of bricks factories were conducted aiming to understand the whole manufacturing process and the supply chain of the bricks industry. The red bricks industry has been traditionally going on the same process of firing and depending on the intensive workforce without a

Figure 20: Piles of sand and gravel to be mixed manually to form concrete. (Source: The author)

Figure 21: Concrete mixing station in a cement bricks factory. (Source: The author)

change except for the type of burning fuel either diesel or natural gas. The high labor demand is usually considered an advantage for decreasing the unemployment rate, but the issue is with the lack of a safe working environment and the health issues caused in the long run. Moving on to the cement blocks manufacturing, where the usage of the manual workforce is moving on to be limited to machinery operating and minimum manual work. The concrete mixture is changing from manual mixing to mixing stations and forklifts are being used instead of manual handling. Light white bricks manufacturing is a completely automated supply chain with minimal human interfering.

All the bricks producers claimed that their products do not need any special labor or equipment or finishing materials. When asked about the usual clients; it was obvious that red and solid bricks are used on all scales of projects, however, hollow cement and light white blocks are mostly used on large scale projects owned by business developers or organizations. Solid sand bricks are used for fences usually without the need for plastering but now rarely for walls, for its high density.

Green Buildings' codes in Egypt

Considering the laws and regulations as the main activity by the ministry of housing, the Egyptian building laws and regulations related to the environment were reviewed.

In the year 2008 the law number 119 known as the 'Unified Building Law' was released, to regulate and systemize the building process in the whole republic. This law is up till now the main reference and the regulator of the building process. Unfortunately, neither the law nor its executive appendix has taken green architecture concepts into consideration. Hence, the law needs modification on a large scale to catch up with the universal green standards generally, not to mention building materials and insulation (Karim M Ayyad, 2012) (Ministry of Housing, 2009)

The Green Pyramid Rating System (GPRS) was drafted in 2010 by the Egyptian Green Building Council (EGBC) and the Building Research Centre (HBRC). *'The Green Pyramid Rating System is a national environmental rating system for buildings. It provides definitive criteria by which the environmental credentials of buildings can be evaluated, and the buildings themselves can be rated'* (Council, 2011). In other words, GPRS is only a rating system that is not obligatory to be followed contrary to the 'Unified Building Law'.

The GPRS consists of seven categories for the assessment of the building's environmental performance and each of these categories contributes with a certain weight towards the certification of the building. One of these categories is 'Materials and Resources', which contributes with 12% of the whole weight in GPRS. The 'Materials and Resources' category consists of five main criteria which are summarized with their credit points and weights below in table 2. It is worth mentioning that the GPRS provides 4 levels of certification and projects must gain credit points more than 40 to be certified by the GPRS (Ahmed Osama Daoud, 2018)

Main Criteria	Maximum Credit Points	Weight in Percentage	Requirements and Options
Renewable Materials and Materials Manufactured Using Renewable Energy	4	2	- Option 1: using at least one construction material which is obtained from renewable resources such as natural stones, earth, etc. - Option 2: using at least one construction material which is manufactured using renewable energy sources such as solar energy, wind energy to reduce CO2 emission
Regionally Procured Materials and Products	6	3	Credit points are gained when construction materials and products value have been extracted or manufactured within a distance of 500 km of the project site with no less than 50% of the total materials value based on cost
Reduction of Overall Material Use	6	3	- Option 1: using standard assemblies and reducing customized spaces - Option 2: using materials that does not need finishing

			- Option 3: using materials that possess high durability and require low maintenance
Alternative Building Prefabricated Elements	4	2	Credit points are gained for utilizing totally or partially prefabricated elements. The quantity of prefabricated elements should not be less than 10% of the total element quantity. These prefabricated elements are used to reduce the need for construction skills and reduce materials waste
Environment – Friendly, Sound and Thermal Insulation Materials.	4	2	Credit points are obtained for using materials which satisfy specific requirements as follows: 1) free from chlorofluorocarbons, 2) does not release toxic fumes when burned, 3) the percentage of volatile organic compound is less than 0.1, 4) thermal insulation materials should have an ozone depleting materials of zero and a low global warming potential which does not exceed 5

Table 6: Criteria of the 'Materials and Resources' category listed in the GPRS. (Source: (Ahmed Osama Daoud, 2018))

The table shows that the GPRS did not mention any specifications or recommendations for the green materials from what is available in the Egyptian market. Besides that, the thermal insulation of the materials was almost neglected, as it was only given a maximum percentage of about 0.25% of the whole GPRS grading.

The previous discussions revealed a lot concerning the market's behavior and purchasing power. Starting with the property owner, who is considered the main actor for controlling the finances of purchasing the building's envelope masonry materials. Then follows the architect, who has a high interest in the issue and can manage the remaining actors to achieve his goal. Unfortunately, the research institutes have a limited power to affect any of the other actors, although having a high knowledge and interest.

Putting the most power and the final decision in the hands of a non-expert (the owner) who is always looking forward to cutting expenses, besides not being restricted by laws is very risky. However, there is a potential for a wise decision if the owner is guided by experts, particularly in the case of convincing him of a direct benefit.

The suggested Value chain, Constraints, and Challenges

After conducting the interviews and analyzing the actors, the following value chain, constraints, and opportunities tables can be identified.

According to the value chain, activities should be divided into two categories:

- Basic activities, which are the brick material, manufacturing process, usage in construction, promotions and offers.
- Supporting activities, which in this case are codes and regulations, training the human resources, materials research and development, and investments.

The term 'actor' refers to any stakeholder in the value chain.

Support Activities	**Regulation and Administration infrastructure** Codes and building regulations					Margin
	Human resources Training and teaching					
	Development and Technology Production upgrading					
	Resources (procurement) Future investment					
Primary Activities	Inbound logistics **Material** - Upgrading and Experimenting - Climatic mapping - Testing and adaptation	Operations **Manufacturing** - Specifications - Market's need - Centralized/ decentralized	Outbound logistics **Construction Use** - Architects and consultants - Contractors/ Builders	Marketing **Promoting** - Future benefits - Publications - Stakeholders education	Services **Offers** - Financial solutions - Technical solutions - Specifications improvement	Margin

Table 7: The suggested value chain for the buildings envelope materials. Developed according to Porter's model. *(E.Porter, 1990)*

Activity	Constraints and Challenges
Raw material	- Some materials are the same since decades and there is no desire for a change. - Raw materials are not technically tested in all cases.
Manufacturing process	- High amount of harmful air emissions. - Traditional factories are not always abiding by the product specifications and standards.
Building construction	- Not all architects are aware of the environmental impacts of the different types. - Masonry builders are not highly skilled. - Low market demand for environmental construction materials.
Products promoting	- Product price is the main incentive. - Users prefer the usual materials. - Weak marketing campaigns. - No role model by developers or the government.
Purchase offers	- High competition with traditional types.
Codes and building regulations	- Absence of an obligatory code for energy efficiency. - Building laws are not strictly followed. - Experts are not consulted for law writing.
Training and teaching	- A few literature concerning the topic. - No connection between the researches committee and on the ground market.
Production upgrading	- Producers are not looking forward to development. - Absence of connection between practitioners and research institutes.

Table 8: Constraints and challenges facing environmentally friendly bricks in Egypt.

Activity	Opportunities
Raw material	All the bricks raw materials are extracted or produced locally and widely available.
Manufacturing process	- Offers high job opportunities. - Provide the market's needs.
Building construction	- Easy know-how.
Products promoting	- The current trend towards environmental aspects. - The increasing price of energy. - The presence of advanced technologies.
Purchase offers	- Construction loans are available. - Environmentally friendly is considered a high-end residence added value.
Codes and building regulations	- Recent governmental moves towards building laws enforcing.
Training and teaching	- Several researches are being done concerning energy consumption and environmental housing.
Production upgrading	- The government is encouraging energy saving. - Initiatives are launched to upgrade the bricks production.
Future investment	- Growing investments in the construction section, housing especially.

Table 9: Opportunities for environmentally friendly bricks in Egypt.

Conclusion of chapter three:

This chapter started with introducing the value chain analysis concept, to identify the primary and supporting activities related to the brick industry. Collecting data through interviews took place after identifying the stakeholders and rating their power to interest in choosing the type of brick. Each interviewed actor is an expert in his field with previous experience with the

different types of bricks. It was also essential, to review the Egyptian green building codes, considering them a factor affecting the buying decision.

Chapter Four: Discussion and Recommendations

Chapter Four:
Discussion and Recommendations

In this chapter, the findings and results of the research will be discussed, suggesting a group of recommendations that would improve the competitiveness of environmentally friendly bricks in the building industry.

Study overview

The construction sector is one of the nation's main pillars of development. Currently, the real estate market is supported by the government through the private formal and public sectors in the form of establishing new cities. Unfortunately, traditional construction behavior is causing now several drawbacks concerning its environmental impacts and the excessive use of energy. Not mentioning the global development in the masonry works that are still being lacked for in Egypt. This research investigated the potentials of the bricks industry in Egypt and the reasons for lacking bricks diversity in the construction sector. Although bricks are currently an irreplaceable component in any building, especially as a building envelope due to the construction techniques, the market users with its three housing sectors are not varying enough in the usage of different types of bricks according to the climatic conditions. Rather mainly dependent on one or two types only, disregarding the possible direct and indirect consequences of this. On the other hand, the assessment of the bricks types available in the market showed a variation in the thermal insulating properties as well as the environmental impacts of their manufacturing process. The traditional red brick is still favored by the people,

due to many socioeconomic reasons in the Egyptian community. Although several attempts for reintroducing ancient materials or more environmentally friendly materials were undertaken in recent times, none were successful in fulfilling the market's needs.

The research aimed to study the environmental impacts of the different types of bricks available in the Egyptian market and its relation to the stakeholders' construction needs and preferences. In an attempt to stand on what is needed to improve the competitiveness of the underutilized brick materials. The research used the methodology of making field studies to the bricks factories and interviewing a group of actors in the field.

Based on the literature review, the aspects hindering the market from development towards facing the environmental challenges through the buildings' envelopes were identified and reviewed according to each housing sector. Also, the method of the value chain analysis –derived from the concept of business development- was used to identify the opportunities and constraints for improving the masonry construction in Egypt.

The impact of switching places

If a brick material replaced another in the building process, what will be the impact on the different aspects?
As mentioned before, red (clay) bricks are the most prevailing as a masonry material between the housing sectors. On the other hand, light white bricks have proven to have the least harmful environmental impacts and the lowest u-value, which rates it as the best of what is currently available in the market. Assuming a switch in the quantity of usage of each type, the impact will be obvious in different aspects. Starting with the manufacturing, at least 80% of the harmful air emissions related to brick production and produced from firing red bricks will be cut off (red bricks occupy 80% of the masonry market). The market will have a wider variance of block thicknesses, all providing a better level of thermal insulation. Technically, a lighter block means less dead load to

be carried on the building's structure, decreasing the quantity of structural elements needed (concrete and steel). The energy needed for active systems (cooling or heating) will be reduced, reducing the building's operating cost and the cost of the cooling systems. Assuming the increase in the production of white blocks as much as the red bricks will possibly decrease the block price. This would also open the door for more research and development in other elements of the building, as a reaction to the market's environmental urge.

Key Ideas for Discussion

Improving social perception

The society underestimates the importance of a building envelope, bricks in particular as it is a hidden part of the building that does not have any aesthetic benefit. High-income groups are not willing to invest in a building envelope. While preferring to pay more for active cooling systems and decorative aspects rather than using a more expensive brick or a building a thicker wall. Investors are targeting the maximum financial profit by cutting off the building expenses as possible. Restricting the designers and consultants to a certain budget. However, when it comes to elements that have an immediate turnover they (ex: aesthetics) they are willing to invest in what suits their client. Low-income groups are already limited with their budget, looking for the cheapest units that fulfill their primary needs. Unaware of the future financial burden that such units will cause them within a short period. Mentioning awareness, the governmental campaigns targeting the rationalization of energy use were always limited to home appliances use, totally ignoring the construction sector. Although campaigns in this sector could be easily followed if they offer financial incentives for the builders who follow an energy efficiency criteria.

Developing codes and specifications

The least thermal comfort levels should be secured while saving energy. The Egyptian building code indications must require a minimum for the resistance and insulation of the building envelope based on the climatic zone of the building. Yearly consumption and financial expenses per energy source should be forecasted through official documents that must be calculated by specialists and presented with the administrative work documents. This may require also, the presence of a control system for the design and implantation, guaranteeing the compliance of the type of the chosen brick with all the building's heat transfer element; finishing materials, openings, etc.

Asking to achieve this in the meantime given the capabilities of the housing governmental authorities may be impractical. Nevertheless, if a series practical plan was put regarding improving the building authorities and developing their capabilities, then a bright future would be waiting for the real estate market in Egypt.

The code creating is a progressing cycle and is typically a reaction to a need which is more a reflection of practice. So it should not be an end result that is enacted once and applied for all, however, should rather be considered as a trial document that will be tried practically and modified according to the learned through implementation. Subsequently, it is suggested that, during the code development process, open meetings with specialists should take place to talk about and debate the code articles. In parallel, working closely with the current experiments and construction practices, with all the stakeholders including masonry builders, contractors, and property owners. The construction business, building materials industry, and the market are all factors that create pressure on the code and impact it (El-Kabbany, 2013). The GPRS needs to be updated to include the building envelope properties on a wider scale, adding to promoting more for the certification.

Being a Role Model

Taking advantage of the mega residential projects taking place by the government in different regions of the country is a great opportunity. Such projects are a chance for not only offering units with reliable thermal insulation but also for giving an example to the individuals and developers of the importance of thermal insulation. Considering it as part of their social responsibility towards the society. The government would be giving a wrong example by building all the projects without varying relevantly in the building's envelope. The public sector should have a strong connection with the research institutes and become a role model for the private sector.

Production methods

Brick manufacturing process offers a variation of technology from low to medium scale process, and can likewise reach large scale manufacturing as well. The traditional red brick industry has essentially three points of interest, which make it an effective and inescapable material. The accessibility to an active source for raw materials, the need for high labor extending employment opportunities for the local individuals, in addition to the high productivity rate, which thus prompts cost decrease. Learning from this and targeting these three issues will help in accomplishing the best production framework that is proper for the local context.

Depending on a large scale of production of a single material, like cement or clay bricks to be the main supplier throughout the republic is of no relevance to any climatic conditions. The thermal mass got to be the main aspect in the criteria of the masonry works, as important as the availability and the financial cost.

Knowledge exchange in the Academic Field

The issue of brick usage became neglected lately and most of the researches' concentration now is on other processes of construction although such a fundamental is not yet resolved. The lack of literature and the few experiments are not helping in further development of the topic.

Colleges added environmental and sustainable design courses to Architecture and construction educational plans, and academics know about the significance of staying aware of the international development. Youthful Egyptian researchers in the building field comprehend the significance of changing consumerist patterns. That is why they are exploring international strategies to decrease power utilization and GHG emission inside the Egyptian context. Over the last twenty years, there has been a noteworthy increase in scholarly publications and research for energy performance in Egyptian housing. In any case, numerous studies are racked in college libraries, and there is a gap between the scholar community and administrative forces. In this manner, more grounded cooperation policies ought to be encouraged to realize applicable procedures and implement them on field ground. (Edeisy Mohamed, 2018)

Developers' role

Out of social responsibility, real estate developers ought to be supporters of different local materials, investing in spreading and developing environmentally materials. Also, when such developers adopt a strategy, it becomes an incentive for the smaller investors and the self-builders to follow. Contractors are an actor that should not be ignored either on small or large scales. But to be practical, contractors will always prefer the easy, quick, and cheap option. That requires an increase in the productivity rates of some products to meet the continuous market needs. The increase in the number of produces of the same products would increase the competitiveness, increasing the development of the product, and decreasing the price, which is all in the markets' favor.

The Financial decision

The initial cost is an undeniable factor in any purchase process. Nevertheless, the value for the cost is the determinate of the success of the deal. If the value is unknown, then the initial cost would become the only buying factor. This is the main issue related to the market's criteria for choosing bricks, the initial cost is controlling the building envelope (block) material, thickness, quality, or thermal mass in short. As mentioned previously, in fact, this criterion backfires on different aspects starting with the financial one. The awareness of this fact could be missing the property owners, but it should not be missing the professionals overtaking the building process (architects, consultants, contractors, etc.). The materials producers are also responsible to address the users according to their level of knowledge. Several studies compared the initial cost to the operating cost of cheap materials with low thermal mass to more expansive materials with high thermal mass and proved that the latter was more beneficial. However, the financial calculations were not included in this study for the belief that the initial cost is a variable factor that could change at any time depending on the supply and demand, a cheaper technology, etc. But what should be the constant factor of purchase if the futuristic impact which would be irreversible.

Recommendations:

Industry Improvement

1. Assist manufacturers of environmentally friendly materials (for example tax decrease for large producers; support youthful potentials and encourage new companies in this field).
2. Provide loans and aids for factories changing towards reducing their environmental harm and energy usage.

3. Have an updated specifications code for the industry of brick manufacturing including all types of bricks locally manufactured or any future products.
4. Air emissions must be controlled by having local environmental regulations, in addition to increasing the initiatives of changing the fuel of the currently operating factories to more environmental alternatives.
5. A waste management concept should be followed; including adequate disposal, recycling, and minimizing waste as possible.
6. Create initiatives for controlling the energy use through using low carbon fuels, upgrading heating techniques and materials, and implementing energy-saving systems.
7. Implement strict regular inspections on the usage of hazardous materials to avoid contamination to the land, especially factories operating on the Nile shore.
8. Labor and working conditions got to be officially regulated and complying with the International Labor Organization (ILO) requirements on working hours, etc.
9. Provide medical insurance to the workers and have a regular check up on those involved in manual handling or with any Hazardous materials.
10. Extra training is essential for workers working in confined spaces or exposed to high temperatures while providing them with protective clothing and equipment.

Market Development

Supply energy-efficient building materials at reasonable prices.
To reach this goal, the following steps need to be executed:

1. Reward suppliers with incentives to concentrate on environmental materials and energy efficiency.
2. Pull in interest in investment in energy-efficient blocks by offering governmental support and urge construction corporates to use new environmental construction products from the Egyptian local market.

3. Establishing an organization of a network of manufacturers, small producers, and merchants attached to the chamber of commerce and industry.
4. Grow cooperation with banks and privately owned businesses for market development and financing support.
5. Constant market assessment.

Technical Development

1) Encourage specialists, planners, and designers to adopt environmental techniques.
2) Create a foundation for keeping the designers, planners, and technicians updated with the developed construction techniques.
3) Integrate the scholarly network of technical institutes and universities to propose reasonable innovations and possible solutions.
4) Create an information base (can be a virtual one) of experimental projects, accessible materials, economic analysis, and investments.

User (Household) support:

1) Replace electricity and fuel subsides with an alternative system for environmental subsides.
2) Provide technical support and consultation at convenient costs.
3) Provide bank loans as a motivation program.
4) Have reference points that are governmentally/privately monitored, to provide bricks with the minimum level of environmental specifications at competitive prices.

Chances for future researches

- Lack of research in the field of masonry in Egypt was obvious during the data gathering phase of this research. Although, there are several researches available concerning environmental construction and renewable energy in buildings. Bricks can be reconsidered as part of the environmental and energy aspects for future literature.
- This research was limited only to housing, other types of buildings can be considered too, that may be open more towards the environmentally friendly concept.
- This research was only focusing on bricks already available in the Egyptian urban market, future researches can consider the reintroduced or the newly experimented types of bricks and the possibility of integrating them in the market.

A complete business model of the methodology of the improvement of the environmental bricks market can be considered for engineering and non-engineering researches.

Limitations of this study

Being done during the time of the covid-19 pandemic limited the increase of number of interviews and field studies. As well as the absence of recent information and/or studies concerning the local manufacturing of bricks in Egypt.

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Annexes

Annexes

Annex I: List of Interviewees and Field Surveys

Name	Profession	Entity	Date
Alaa Abd El-Bary	Consultant Civil Engineer	AAA consulting and design	27-7-2020
Magdi Mahmoud	Consultant Architect	Home Design	13-8-2020
Amr El-Hamawy	Consultant Architect	Concept Group	20-8-2020
Dr.Rafaat Hassan	Property owner		15-10-2020
Dr. Nemaat Nazmy	Senior researcher	HBRC	14-10-2020
Mohamad Garee	Master Builder	Self employed	17-10-2020
Wael Alsayed	Brick factory manager	TechnoBlock brick factory	3-9-2020

Field Surveys and site visits
Enabba Mall, fifth settlement
El-Islah Traditional red bricks factory, Giza
TechnoBlock Cement bricks factory, the 10th of Ramadan industrial area
El-Dorra cement bricks factory, Giza

Annex II: Interview Guide Sheet

Broad Topic	Examples of Specific questions
	What type of building envelope would you prefer for a villa (the housing model) in the 5th settlement?
Building materials (bricks) ecological impact	Have you ever studied the environmental effects of using specific types of bricks? Do you search for alternatives in case discovered negative environmental effects?
The masonry work	Are there a special kind of equipment and labor skills needed for using some bricks? Simply describe the process of masonry construction. Do you face any trouble in finding skilled labor for the type of masonry you want to use? What are the usual problems?
Construction via specifications and consulting	Do you have specific recommendations for alternative brick materials in your designs? (for consultant architects) Do you try to convince your clients to use different types of bricks instead of half red bricks? How likely do you succeed and what are the obstacles? What do you think does it take to change the market's behavior? Do you consult a structural engineer in case you suggest unusual masonry for the building envelope? (for architects) Have you implemented a building with unusual types of bricks? Do you need to make special construction details tailored for unusual brick types?
Codes and regulations	Do you follow any energy code (Egyptian or other) when choosing the building materials? Are there any codes or specifications for the building envelope?
Opportunities of changing the market behavior	What do you think are the existing opportunities that help in building with environmental materials? In your opinion, who is the most important actor/stakeholder, in choosing environmentally friendly construction materials?

ملخص البحث

أصبحت الاستدامة وصديقة للبيئة وتوفير الطاقة وغيرها من المصطلحات معروفة على نطاق واسع في مجال البناء مؤخراً. ومع ذلك، أصبح استخدام هذه المصطلحات نوعًا من انواع الأناقة أكثر من امتلاك الإرادة للبناء بهدف تحقيقها. يحاول الباحثون تسهيل حصول البناة على أهدافهم المالية مع الحفاظ على البيئة. للأسف، فإن معظم توصيات وإرشادات الباحثين عندما يتعلق الأمر باختيار طوب البناء، إما تعتمد على مواد بناء غير متوفرة او مقارنات مالية لا تشمل عملية البناء بأكملها.

يهدف هذا البحث إلى إيجاد أرضية مشتركة بين أصحاب المصلحة في قطاع الإسكان والحلول المقترحة لحل قضايا الطاقة والبيئة المتعلقة بالبناء في مصر. لا يُقصد من هذا البحث أن يكون دليلاً إرشاديًا للبناة ولكنه توضيح للتطبيق العملي لتغيير سلوك البناء ومعايير اختيار مواد البناء. سيكون التركيز بشكل أساسي على الطوب باعتباره غلافًا خارجيًا للهياكل الخرسانية.

يتحقق الهدف من الدراسة من خلال تقييم أنواع طوب البناء في السوق المصري والتحقق من سلوك السوق عندما يتعلق الأمر باختيار مواد البناء. سيكون هذا التقييم من خلال تصنيف الطوب وفقًا لتأثير صناعته بيئياً. يجب أن يتم التحقيق في سلوك السوق من خلال مقابلات مع أصحاب المصلحة في مشاريع الإسكان. بدءً بالمهندسين المعماريين لأنهم هم الذين يوصون ويحددون المواد المستخدمة في عملية البناء.

ينتهي البحث بقائمة من التوصيات التي تشمل جميع أصحاب المصلحة في قطاع البناء. يجب أن تستند هذه التوصيات إلى دراسة سلوك أصحاب المصلحة وتفضيلاتهم.

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام .إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة 2020.

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث: مالك عمرو الحموي

التاريخ: 11/08/2020

تقييم استخدام الطوب الصديق للبيئة للإسكان في مصر

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

إعداد :مالك عمرو الحموي

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لجنة الحكم

أ.د .....الممتحن الخارجي التوقيع

أستاذ.....

جامعة.....

أ.د .....
أستاذ.....
جامعة.....

أ.د .....
أستاذ.....
جامعة..... تاريخ المناقشة: .....

الدراسات العليا

ختم الإجازة أجيزت الرسالة بتاريخ:.....
موافقة مجلس الكلية .../.../... موافقة مجلس الجامعة .../.../...

11/08/2020

جامعة عين شـــــمس

جامعة شتوتجارت

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2020