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ALTERNATIVE CONSTRUCTION MATERIALS FOR THE SUSTAINABILITY OF THE RESIDENTIAL ENVIRONMENT (AN ANALYTICAL STUDY)

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Abstract

The research included identifying alternatives for construction materials that have aspects of sustainability (environmental, urban and economic integration) in order to obtain costs that achieve the goal, which is the economic aspect. The research also includes identifying the properties of these materials and comparing them with the usual materials that are used in the current era, as the world is now heading to search for what fulfills requirements of man in his life, especially with regard to place of comfort in residential environment in which he spends two-thirds of his time. The research dealt with all its parts, which included introduction and previous studies. And a methodology that dealt with what: sustainable building material and sustainable housing environment. As for practical side, it focused on an analytical study of characteristics of some materials alternatives that achieve required in comparison with the results given by ordinary building materials, which appear through the practical application of statistical programs at work. Through use of two types of aggregates, concrete was obtained, with a resistance of more than (30) MPa, with a mixing ratio of (1: 1.5: 3) and an duration of (7) days. And since focus of research is on alternative materials, we used results of laboratory tests for industrial aggregates, and according to temperatures (700, 950, 1180) degrees Celsius, they are (24.3, 32.5, 37.7) MPa. At duration of (21) days, it was (25.6, 35, 38.7) MPa, respectively, while at age of (28) days, it was (29.2, 37.9, 41.7) MPa, and same mixing ratio and temperatures. Research is of great importance in environmental aspects by building its capabilities to resist causes of environmental problems. - Social by employing constructional alternatives according to customs and

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traditions of occupying population. Economic by achieving principle of efficiency and need with least possible costs..

Keywords: *Alternative Construction Materials*, Urban And Economic Integration.

Introduction

The residential environment depends on several components - aiming to improve them to ensure the creation of areas of comfort for the human being, as he spends most of his time in it.

The environment in general and housing in particular are exposed to problems that affect its ability to provide the necessities of life for the population. These problems continue and increase as products of balance between them and technical progress and industrial development and the use of influential materials that increase the volume of pollution to the environment, in addition to the steady population growth. All of this motivated the person to search for alternatives to build his home that suit the situation in which he lives, including the axis of the construction materials he uses in construction.

Research problem:

The research problem lies in two aspects:

The first: What is related to the environment itself and its problems resulting from differences in it due to the industrial and technical development of polluting industries.

The second: is the aspect related to the housing environment, how to secure it from pollution, especially through building materials that directly affect the environment.

Research Hypothesis:

To achieve the goal and indicate the importance, the research assumes the following hypotheses:

1- There are environmental problems that need solutions.

2- The presence of alternative materials that achieve the goal that can be used to improve the environment.

3- The existence of a technical development that can be adapted to contribute to strengthening the environmental elements.

Research Importance:

Research is of great importance in the following aspects:

-Environmental through building its capabilities to resist the causes of environmental problems.

-Social by employing structural alternatives according to the customs and traditions of the occupants.

-Economic by achieving the principle of efficiency and need at the least possible cost.

Research Aims:

The research aims to:

a- Improving the environmental elements of housing requirements.

b- Finding alternatives to building materials in line with the requirements of the residential environment.

c- Reaching the degree of sustainability through building materials.

d- Ensuring sustainable housing for human comfort and health.

Research Structure:

The structure was prepared according to the research idea that needs a sequence of steps upon which the required results are based, and accordingly the following structure was adopted:

1-Theoretical aspects to be used as a preliminary guide to achieve the goal of the research. This will be included in the second chapter of the research.

2- As for the practical aspect, analysis and the obtained results, the third chapter of the research will deal with the use of statistical programs for analytical purposes after finding material values that give guarantor results to reach the goal by providing some materials from components that are already present in the environment.

2-Methodology:

The world has begun to recognize the importance of nature and the need to preserve it, and this principle has been adopted in many areas, the most important of which may be the field of designing and constructing buildings. Here comes the role of the next generation in working with this principle, not as an option that can be added to the building, but rather as a necessity in any work we work on.

Environmentally friendly buildings, also known as sustainable buildings, is the practice of creating structures and using processes that are environmentally responsible and resource efficient in terms of construction across the building life cycle: from site identification, design, construction, operation, maintenance, renovation, and deconstruction. Utility, durability and comfort.

The housing in our residential environment is characterized by architectural pluralism, which resulted from the diversity of ideas, different tastes, and the presence of the required expenditure, forgetting an important aspect of the residential environment, which is sustainability, which was influenced by modern theories in achieving integration (environmental, social and economical agglomeration). In meeting human requirements, taking into account the compatibility between the material and spiritual sides, at a time when most contemporary cities, especially residential areas, suffer from shortcomings in achieving this trend, as the inevitable development led to the emergence of problems in the residential environment, which led to the alienation of man from his environment. It is

necessary to take care of improving the residential environment and giving human considerations to the objectives of urban development within the sustainability plan.

This chapter includes two main axes: the first is the concept of sustainability, its dimensions, principles and levels, especially the housing level, to define the theoretical framework that achieves sustainability in the residential environment, while the second includes sustainable housing: its nature, systems and characteristics to reach modern planning and design mechanisms, achieving the concept of sustainability in the residential environment Modernity in its environmental, social and economic dimensions. Before clarifying building materials, it is necessary to refer to the concept of sustainability.

2-1-Sustainable Building Materials (Properties, Use and Impact)

2-1-1:Sustainability

Sustainability is defined as a concept that stems from a humanistic theory that tends to care for man and his future, and then preserve the environment that gives continuity to humanity with the aim of achieving sustainability (environmental, social and economic) and thus activating the spirit of life in a way that allows the population to meet their needs in the present and the survival of what ensures the sustainability of the future. (Najeel, 2008, p. 3).

It is also known as dealing with natural, ecological, technological and economic systems, with the specificity of the place in designing a building adapted to the surrounding environment (Kharoufa, 2006, p. 6). The basic idea of sustainability is based on maintaining balance and restoring balance. It is an approach aimed at balancing the current and future economic and environmental influences.

Sustainability requires achieving a balance between environmental factors and social and economic considerations, and this is achieved in many applications, one of which is architecture. (Al-Zubaidi, 2006, p. 2).

This concludes that the idea of sustainability is built on pillars that achieve permanence in communication between generations. This means for all aspects of the human environment represented by the space it occupies and the external environment.

Accordingly, sustainability is based on: it is the fulfillment of human desires, his home and his environment, while ensuring the share of future generations for the continuity of life.

The foregoing concludes that sustainable development is the research and implementation of radical plans that enable society to succeed in its equilibrium interaction - indefinitely - with the natural system (vital or abiotic) by maintaining a certain level that allows for their recovery.

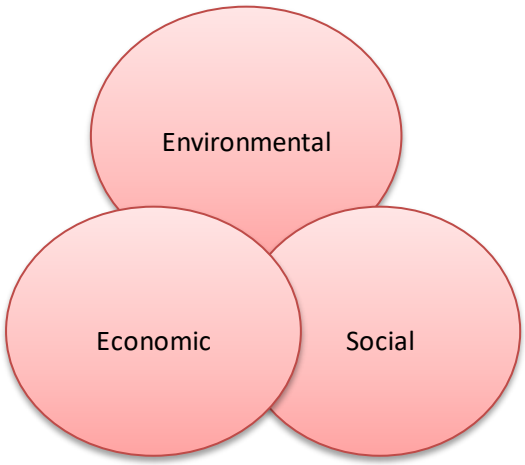
It is a multifaceted process that guarantees the natural environment, the economic system and the nature of social life, a secure, sustainable system and the welfare of peoples. For its success, all efforts must be combined in all disciplines to reach sustainability and preserve our world, (.Abu Dayyah, Ayoub, Jordan, 2009).

Sustainability has basic dimensions represented by the environmental dimension, the social dimension, and the economic dimension, and each of them complements the other. It is an integrated system that can not disrupt any of them and affect the rest. A summary of (Al-Zubaidi, 2006, p. 31-30) as illustrated in Figure (2-1).

To define these dimensions within the integrative concept of sustainability, the so-called (triple bottom line) - through this term, it is possible to crystallize the point of view that affirms: "We cannot achieve environmental, social or economic sustainability separately, rather the three dimensions must be taken at the same time", to improve environmental quality and economic growth while achieving social justice.

Figure (2)

The overlap between the dimensions of sustainability



Source: Researchers based on multiple sources.

Principles of Sustainability:

The principles of sustainability represent the core foundations upon which sustainable architecture is based, which fall under its main names, all the details, areas and definitions that deal with sustainable architecture. The theoretical framework of the principles of sustainability aims to help designers to search for more solutions, providing them with a set of ready-made solutions, because each problem requires its own design solutions stemming from the diversity of environmental and cultural conditions that affect each building according to the different location, climate, society and available building materials, taking into account The basic principles of sustainability are: (Al-Zubaidi, 2006, pg. 79):

Figure (3)

Demonstrates the sustainability of using solar energy to provide clean electric energy

Resourse:

http://www.hndasa.com/showthread.php?s=ba3ffd73e997852a9654af1cb65cd377&t=114

The principles of sustainability lie in helping designers to search for more solutions, because the problems are diverse and multiple. They are: (Al-Zubaidi, 2006, pg. 79):

First: the principle of resource rationalization, which means reducing resource consumption, reusing and recycling natural resources.

Second: The principle of design according to the life cycle of the building, which provides a methodology for analyzing the construction process and its impact on the environment.

Third: The principle of humane design, which focuses on achieving a comfortable and healthy environment for humans.

Fourth: The principle of safe design in accordance with the standards of self-protection and theft prevention.

Fifth: The principle of environmental performance susceptibility in noise and heat treatments and increasing the distance from the effects of the external environment.

Sixth: The principle of functional consistency through the relationship of the housing components with each other without moving to exposure to external influences.

Seventh: The principle of optimum utilization of clean energy by relying on natural lighting and ventilation.

2-2: Sustainable Housing:

When the term "smart buildings" appeared, they are buildings in which environmental systems are integrated, such as energy use, temperature control, lighting, sound, workplace, and communications.

Accordingly, the concept of sustainable housing means:"The housing equipped in a technical way, by which he acquired the ability to think in order to change his behavior according to the needs of the inhabitant, and to adapt to the external conditions. That is, it means the ability to program the housing in an electronic way with a set of possible possibilities that enable its various components to adapt and act according to the corresponding predetermined conditions and variables.

2-2-1:Diversity of building materials in the house .

The impact of the development in the use of building materials on the type of material used in construction, as industrial materials, with their innovative and changing qualities and characteristics, replaced natural materials, and this may sometimes lead to a loss of connection between modern and old architectural works, so it was necessary to work on finding building materials that bear the common denominator Between the ancient and the modern, the requirements of environmental architecture are provided.

With regard to the properties of these materials, the development in the production of modern materials affected their general properties, whether they were formal, thermal, mechanical and chemical properties, as there was a huge change in the properties of the material. Thermal properties are among the most important properties that must be studied, due to their role in creating appropriate living conditions inside and outside the building, in addition to reducing the use of the material.

I have used local building materials that are suitable for the environment with low heat capacity and good thermal insulation, such as stone and clay, meaning that this type of building material delays the heat transfer through it into the building until late in the day. Renewable materials, so they are sustainable materials in today's language such as::stone, Clay , Bricks and red bricks , local timber and aggregates, ---ets.

Environmentally friendly building materials include depleted building materials and renewable materials.

Sustainable materials mean materials that can be reused in the future, or materials that have been recycled, and they must meet two basic conditions

1- It is one of the materials with high energy consumption, whether in the manufacturing, installation or even maintenance stage.

2- It contributes to increasing the internal pollution in the building, i.e. it is from a group of building materials (and finishes) that are called correct building materials and they are often natural building materials

1- Thermal properties:

It is the ability of the material to thermal insulation, and it is measured by the thermal conductivity coefficient. The lower the conduction coefficient, the greater the material's resistance to heat transfer. The thermal resistance is inversely proportional to the coefficient of thermal conductivity through the material.

As for the reflective materials, they are due to their high ability to respond to radiation and heat waves. They are considered effective materials in thermal insulation,

provided that they meet an air space. The ability of these materials to insulate increases by increasing their luster and polish.

2-Mechanical properties:

Some insulating materials are characterized by durability and bearing capacity.

Therefore, it can sometimes be used to contribute to the support and loading of the building, in addition to its main objective, which is thermal insulation. For this, the strength of bearing pressure, tensile and shear, etc. is considered.

3- Absorption:

The presence of water in the material reduces the thermal insulation value of the material or reduces the thermal resistance, as it may contribute to the rapid destruction of the material.

It depends on the properties of the material in terms of its ability to absorb and permeate, as well as the surrounding climate. As for the characteristics by which the material is affected by moisture, they are absorption and permeability.

4- Safety and health:

Materials have certain insulating properties, including those that may expose humans to danger, whether at the time of storage, during transportation or installation, or during the period of use. It may cause impairments in the human body, which necessitates the importance of knowing its chemical composition. As well as its other physical characteristics in terms of its susceptibility to combustion and sublimation.

5-The sound:

Some materials are used to achieve some acoustic requirements such as sound absorption, dispersal and vibration absorption.

In addition to the above characteristics, there are characteristics that may be necessary when choosing the appropriate material, such as knowledge of density, ability to resist shrinkage, possibility of use, uniformity of dimensions, resistance to chemical reactions, available sizes and thicknesses..etc. In addition to all of the above, the economic factor finally plays an important role in making the decision, in the price of the insulating material has a great impact when choosing.

2:2:2: The use of alternative building materials

The absence of practical alternatives to building materials and the reliance on certain materials in construction made the high prices of building materials an obstacle to the construction of complexes and residential houses, and this is evident through the high costs of these materials, which requires the use of a number of alternatives that can be widely used to relieve pressure on traditional materials Present such as light concrete and hollow concrete building blocks.

1- lightweight concrete:

Lightweight concrete with wide use in the world is known as concrete containing lightweight aggregates with a density between (90 and 115) ft^3 / pound according to the American Standard (ASTM C567) for the year 2008.

Lightweight concrete is produced by different means, methods, materials and equipment, according to the companies producing the equipment and chemicals that generate them.

Light concrete is called by different names, depending on the methods of its production, it is called aerated concrete, (cellular light weight concrete), lime light weight concrete, and foamed light weight concrete [ASTM - Structural Tests].

Lightweight concrete, as indicated by its name, is characterized by its low weight and density, good thermal insulation, and its resistance to fire and frost.

2-Benefits of lightweight concrete :

A - Low cost in most cases.

B- Light concrete has good workability, which allows different surface treatments to be carried out.

C - Weight can be reduced with a wide range of densities and resistances.

D- Additional savings can be achieved due to the low dead weight of the building.

E - Reducing the weight leads to ease of transportation and reduces its cost.

F- Economy in transportation in addition to reducing the labor force.

G - Benefits for energy conservation due to good thermal insulation properties and thus reducing air conditioning costs.

H - Acoustic properties, as this type of concrete causes sound absorption and thus reduces noise.

I- Light concrete with high fire resistance.

3-The application of lightweight concrete

Light concrete is used in the following areas:

1-They are located on-site for low-cost units of apartments, residential houses and one-story buildings.

2-In the manufacture of building blocks for tall buildings.

3- In making panels and partitions for walls with different dimensions. Either ready or pour my site.

4-In all types of insulating works, including hollow walls.

5-On roofs and ceiling panels.

6-In sound insulation.

7-In the construction of prefabricated factories and indoor and outdoor home building panels.

8-For foundations, roads and footpaths.

9-In paving playing fields and tennis courts

10-In filling the partitions between the ground bridges.

11-In the aircraft parking floors.

12-In the explosion-proof installations.

13-In the sound-blocking roads.

14-In protecting slopes.

15- In armed and unarmed establishments.

2:3: Sustainable Residential Environment:

2-3-1: The concept of sustainable housing:

The concept of housing has evolved over time, and it is no longer just a concept that expresses shelter, but rather has become a lifestyle that provides all the basic components of the city and the residential neighborhood, starting with public areas, green spaces, places of entertainment, axes of movement and shopping places.

The contemporary urban environment suffers from the phenomenon of urban disintegration, which resulted from the accumulation of a number of random designs and random building materials included in its composition, which led to confusion of design with social compatibility and the residential environment became, not representing the identity of the region from the climatic aspect. Contemporary housing suffers from negative overlap between uses, which has resulted in negative events on the residential environment, the most important of which is pollution.

1- Site and its (Nature & Characteristics

2- Climate Conditions

3- Building System and its Orientation

4- Building Materials, appropriateness with its various characteristics, its treatment with the climate, its quantity on site, and its ability to be recycled

5- The ability of the site to activate the use of clean energy

2:3:1:1:The Concept of Urban Environment

The environment is defined as a series of relationships between material elements and humans, and these relationships are on three levels between some of the same material elements in the city on the one hand, and between material elements and humans on the other. On the other hand, and between humans and humans on the third. Therefore, the environment is a structure and not a random assemblage of things, in which the relationships and interactions between the human element (people) present in that structure, and the material element that is represented by everything that surrounds these people are fused, and through the characteristics of the relationship between the two elements and their nature, the nature of the environment and its identity are determined, Spatial form integrated in aspects:

A- Spatial organization, which is represented by the associative relationships between environmental spaces, such as the spatial organization of housing, which affects the concept of public and private and the sense of safety.

B - Meaning organization, which comes with spatial organization, and is represented by the meanings carried by urban blocks and expressed by signs, colors and scale.

C - Communication Organization, which is represented by the relationships between individuals in the urban environment, that is, social communication among them.

D. Organizing the physical structure, which is represented by the materials used in the environment and the characteristics of the place (its nature, orientation, external spaces ..... etc.(

Those spatial characteristics of the built environment (Belt Environment), which reflect the reciprocal relationship between the space organization and the social organization within the residential environment.

2:3:1:2: Housing Environment Elements

Lawton describes the environment as an ecology system that has four components: (Al-Jaberi, Muhammad Abed, 1998, p. 49)

1-The human being.

2-The physical environment, which includes natural, geographical, and man-made characteristics.

3- The Personal Environment, which includes individuals who constitute important sources of behavioral control, such as family and friends.

4- The social environment, represented by institutions, norms, and social traditions.

Two types of environments can be distinguished:

A - The first: a natural environment created by the Creator (glory be to Him).

B - The second: a built (industrial) environment made by man himself, relying on the natural environment, taking advantage of its capabilities and resources, including the urban environment, which includes everything that is included in the built environment in an urban assembly. See Figure (4).

Figure (4)

A modern model of detached housing units showing the residential environment

Resource: Ghosheh, Abdullah Assem, "Residential Projects and Sustainable Development", published research. Amman, Jordan, 2007, p. 25.

2-3-1-3:: Residential environment and building materials:

Natural materials are used in only a small part of construction projects in general, and among the small houses that house one or two families in Germany, natural materials make up (17) percent of building materials and about 5 percent of insulation materials, explains Edmund Langer of a German organization near from Munich is engaged in the development and marketing of raw materials for construction.

The organization notes that the range of building materials products made from natural resources has expanded beyond the list of wood fibers and insulation materials using cork boards.

From the foregoing, the following was extracted:

1-Sustainable building materials are many and varied, and they can be used to meet the requirements of achieving the principle of comfort.

2-The requirements of the residential environment are integrated upon compatibility between the building materials used.

3-Considerations to achieve the orientation towards sustainability in the dwelling. This must be determined through the components of the dwelling, primarily building materials.

4-The foregoing gives the idea and defines the paths of verification of finding practical alternatives to the current building materials to achieve an environment in which the elements of comfort are available

This is what will be reached after entering into the practical aspects that, after being integrated, will give a model for a clear identification of the qualities and characteristics of these alternatives.

3-Experimental work and analysis of results

-General:

The work in this part of the research depends on analyzing the characteristics of a number of construction alternatives that have an important impact in transferring the residential environment from its traditional state to a pattern that achieves aspects that ensure obtaining a comfortable environment in which aspects of thermal and sound insulation and other characteristics of sustainability.

There are many building materials, and each has its own role and characteristics that ensure its use in the environment. On this, reference will be made to some basic materials that are effectively used in construction operations, especially the housing environment in which a person spends most of his time.

3-1:Determinants of the environmental design of the dwelling:

3-1-1: Housing Design Considerations:

Which includes the social considerations represented by the family lifestyle, the number of occupants, and the relationships with the environment.

3-1-2:Design requirements for the dwelling:

1- The climatic zone, which greatly affects the determination of building materials or their alternatives.

2-Location, meaning the location of the housing unit in relation to the place.

3-Direction and direction, meaning that the residential area is accurate in direction in a way that ensures control of the residential requirements in this aspect.

4- The shape of the building, which includes the design axes of the dwelling and the neighboring dwellings.

5- The height of the building.

6-The shape of the walls.

7- Type of roofing, concrete or its alternatives.

8-Used building materials.

9-Internal and external finishes.

10-The requirements for raising the thermal performance of the building (openings.

11-Natural lighting and illumination.

12-:Building materials and their alternatives:

These determinants are design evaluators, especially with regard to building materials. Many researches have been conducted on it to determine its characteristics and suitability to achieve comfortable housing.

This requires finding alternatives that are compatible with technical progress (beneficial - harmful) to the environment. Our research dealt with this aspect of alternatives to building materials.

3-2: Building materials and their alternatives:

With regard to the building materials in the study area, they have characteristics that interfere in the formulation of the construction policy that puts solutions to a number of chronic environmental problems. It will be addressed through its structural material and construction method for its elements according to the following concepts:

First: Functional flexibility: The available building materials, represented by clay, bricks, stone, wood and plaster, are materials with simple bearing, which made the building consist of small voids separated by thick bearing walls, as shown in Figure (5) which It shows the wall thickness of (63.5) cm, which is built of stone and plaster and its ends with plaster, as it is fixed in its place and not movable, which means weak functional flexibility.

After entering the manufactured building materials (such as cement and iron), the construction method changed, by adopting the structural structure that expanded the space and gave freedom of functional change (when required). Figure (6) shows the degree of functional flexibility in the modern house built with reinforced concrete.

Second: Efficiency: which means the possibility of housing through the building materials used in it to meet the requirements of sustainability.

But here appears the problem of cost and the large energy that the dwelling needs to secure the comfort necessities, as it uses mechanical air conditioning and thermal and sound insulation materials that require large costs, then:

1-High functional flexibility - with a structural structure as a pattern and a manufactured building material.

2- High environmental efficiency - the method of employing natural building materials or raw materials for the manufacture of building materials in harmony with the environment.

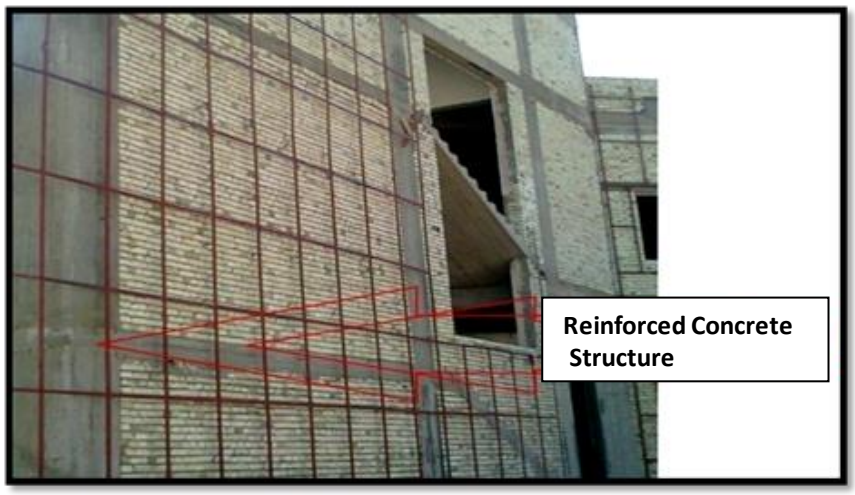
Figure (5)

Weak functional flexibility in the walls of traditional buildings despite the increase in the degree of thermal and sound insulation

Resource: Researchers; A picture of one of the walls of the study area houses

Figure (6)

The concrete structure increases the functional flexibility, the capacity of the interior spaces and the multi-story



Resource: Researchers, a picture taken from one of the buildings in progress.

It is clear that this method results in the possibility of modification through the introduction of building materials such as (bricks, cement, aggregates and iron) that gave diversity in the shape of the building, but reduced the properties of sustainability. From this it is inferred that the construction behavior is achieved by compatibility between building materials and construction method in light of natural and climatic conditions, social and economic considerations, the availability of resources and raw materials and the presence of technology, to give a homogeneous urban product.

3-3: Alternatives of Building Materials

3-3-1:Alternatives to Aggregate (Lightweight Aggregate):

Aggregate is represented by rocky particles that range in size from small grains such as sand to medium ones such as gravel and then represent gravel stones that are crushed and then in construction work. (Muhammad Abdel-Baqi Ibrahim,and others,2003). See Figure(7)

. **Figure (7)**

Both types of aggregates appear in many shapes and sizes

A - Coarse Aggregate B – Fine Aggregate

Resource: Researchers

There are fixed characteristics that must be available in the aggregate for the purpose of using it in construction works, which are: (Noor Abda, a research published on the Benacity website; http://www.benacity.com/forum/t6163.html)

1- The granular gradient, which is the distribution of sizes different aggregate granules.

2-Durability, the limits of gradation and the maximum size of the coarse aggregate are important because they affect the amount of aggregate, water and cement in the mixture, and thus the strength and durability of concrete.

3-The shape of the granules and the texture of the surface, as they greatly affect the fresh concrete.

4- Abrasion and compressive strength, are considered important properties depending on the use of concrete.

5- Absorption and moisture of the aggregate surface.

In practice, the researcher conducted tests on two types of aggregates used, and the results recorded in Table (1) were obtained.

Table (1)

Characteristics of ordinary sand and estimated cost

No. of Model	(SO3)%		Clay%	
	Test	Specification 45/1984	Test	Specification as a maximum (45/1984)
1	0.12	0.5	1.65	2
2	0.36	0.5	0.73	2

Resource: Researchers

Table (2) shows the characteristics of the gravel used in the study area.

Table (2)

Estimated cost and characteristics of ordinary shares

No. of Model	(SO3)%		Gradation	
	Test	Specification 45/1984	Test	Specification as a maximum (45/1984)
1	0.2	0.1	gradual	gradual
2	0.07	0.1	Deflection in sieves (14, 10) mm	gradual

Resource: Researchers

This is with regard to the common aggregate used a lot. If we wanted to look at the alternative, we would find that there is the following:

1- The presence of a natural aggregate that is light in weight.

2- The possibility of manufacturing lightweight aggregates.

1- Natural Light Weight Aggregate (LWA):

For the purpose of showing the properties, two (2) models were adopted that gave the results as in Table (3) Table (4):

Table (3)

Estimated cost and properties of lightweight sand

No. of Model	(SO3)%		Clay%	
	Test	Specification 45/1984	Test	Specification as a maximum (45/1984)
1	0.093	0.5	0.4	2
2	0.14	0.5	0.11	2

Resource: Researchers

Table (4) shows the characteristics of the natural lightweight gravel used.

Table (4)

Estimated cost and characteristics of lightweight gravel

No. of Model	(SO3)%		Gradation	
	Test	Specification 45/1984	Test	Specification as a maximum (45/1984)
1	0.04	0.1	gradual	gradual
2	0.077	0.1	gradual	gradual

Resource: Researchers

2- Industrial LWA Aggregate:

A lot of research has carried out applied studies for the manufacture of many types of lightweight aggregates, and it has reached positive results, depending on:

The quantities of clays, their locations, their quality in terms of the balance of the proportions of the elements in their composition.

The ratio of (MgO - magnesium oxide) in the clays is the limiting factor, because magnesium oxides (MgO) increase the looseness and disintegration of the clay the higher its percentage in it. Figure (8) shows a red clay model as a basic material for the manufacture of a type of lightweight aggregate.

Figure (8)

Aamj and Hussainiyat red colored clay model used in the production of lightweight aggregates

Resource: Researchers

This means that this light aggregate can produce lightweight concrete (**the aggregate being the filling part of the mixture, which controls its weight, and the shape of the aggregate has an effect on the density of aggregate and concrete**).

But what indicates the aggregate is the lack of density due to the presence of two types of voids:

-Voids resulting from combustion of organic matter and swelling of clay.

-Pores generated by the combustion and loss of some chemical elements from the clay composition.

As for calculating the manufacturing costs (approximately) to produce aggregates for the purpose of showing its economic efficiency and the feasibility of its production, compared to ordinary aggregates, it depends on:

1- The volume of production required.

2- The type and size of the technology used (machine and techniques).

3- A culture of sustainability in all its aspects to preserve and improve the environment.

3-3-2: Lightweight Concrete (LWA Concrete):

Many experiments and research were conducted to produce a variety of lightweight concrete, depending on the type of lightweight aggregate used in it. This gave an additional property to concrete, which is the abundance of materials due to the reduction of dead loads and the energy saved from thermal insulation. (FIP Manual, 1983, p.233-245), look at Figure (9) .

Concrete is a heterogeneous mixture of a group of materials mixed in certain proportions (cement, water, sand, gravel) with some additives sometimes. (Abu Odeh, 2008, p. 73).

Figure (9)

Light Structural Concrete

Resource: : Laterlite technical Assistance, ""General Catalogue 2007"", Edition (2006), Italy, p.6, by website : www.laterlite.eu .

3-3-3: Insulation LWA. Concrete:

It represents the type of light concrete that is used for thermal insulation purposes. Its density ranges between (600-1000) kg/m3, and its durability ranges between (25-100) kg/cm2. (Laterlite, 2006, p.7).

3-3-4: Light Medium Strength Concrete (Moderate LWA. Concrete):

It is the concrete that comes between the two previous cases. Its density ranges between (900-1400) kg/m3, and its durability ranges between (100-150) kg/cm2. (Laterlite, 2006, p.7).

Concrete properties (endurance, density, thermal and acoustic insulation) depend on the materials that go into its formation, and thermal insulation (the thermal conductivity coefficient K- which ranges between (0.13-0.24) W/m. Kcal and pressure bearing between (0, 48- 5,17) Newton / mm (Laterlite, 2006, p.7).

3:4: Experimental Work:

For the concrete of the study area and to determine its properties and details, the examination was carried out on concrete mixtures of the types of cement and available ordinary aggregates. The results were as in Table (3-5) for the age of the cubes (7) days. (3) models of (6) cubes of dimensions (15 x 15 x 15) cm for each model.

Concerning the measurement of the degrees of thermal and sound insulation, it was carried out on the field on some facilities constructed of concrete from the materials mentioned in Tables (5) and using mercury thermometers and sound insulation measuring devices. And calculate the thermal conductivity through the equation: (ACI Manual of Concrete, 213R-16,1989).

$$K = 0.072 * e^{(0.00125f)} \quad \text{.....(1)}$$

when:

K = coefficient of thermal conductivity ((Watts / m. Kilocalories)

f = Dry density of the sample (kg/m^3)

e = exponential function.

Table (5)

Concrete using ordinary aggregates at the age of (7) days

Sample No.	Cubic No.	Weight (gm	Density (kg/m3)	Strength (N/mm2)		Mix. Ratio	W/C	Iraqi Standard (N/mm2)
				Cubic	Rate			
1	1	8216	2464	20.6		1:1.5:3	0.5	17.5
	2	8312	2483	30.9				
	3	8369	2423	24.8				
	4	8251	2463	22.3				
	5	8456	2477	22.75				
	6	8206	2458	0.7	3			
2	1	8037	2450	34.44		1:1.5:3	0.5	21
	2	8234	2378	35.13				
	3	8055	2316	28.99				
	4	8235	2447	38.21				
	5	8015	2307	31.34				
	6	8224	2418	29.54				
3	1	8332	2240	47.4		1:1.5:3	o.5	26
	2	8050	2290	34.36				
	3	8370	2270	33.21				
	4	8245	2510	36.14				
	5	8640	2500	37.12				
	6	8530	2510	38.11				

Resource: Researchers

Table (6)

General characteristics of ordinary concrete

No. of Model	Strength MPa	Density Kg/m³	Thermal Insulation	Sound Insulation	Thermal Conductivity (K*)
1	26.8	2140.7	6	22.6	1.52
2	31.7	2188.3	5	21.1	1.46
3	33.23	2456.2	6	21.5	1.49

***(K)= watts/meter. kilo calories.**

Resource: Researchers, based on practical tests and their results in Table (3-5), field observations and previous experiences.

By using the statistical program **(Genstat)** they show the density, as in model No. (2) in Table (6) - it achieved the best (significant) density of (2288,3) kg/m3, followed by model (1), as the value of (LSD(p=0.05)=24.12). As for the resistance, the analysis resulted in a

significant difference between the three models. It appeared that the two models (2 and 3) produced (31.7 and 33,23) Mpa respectively with an insignificant difference between them, while the two models achieved a significant difference from Model (1) whose average resistance was (26.8) Mpa. When it appeared (LSD(p=0.05)=5.65).

This type of concrete is still limited in use despite the environmental efficiency, and its advantages are:

1-Reducing construction costs to reduce the dimensions of structures.

2-Increasing the height of the building (residential buildings) and increasing the internal spaces.

3-Reducing the costs of construction materials (the cost of transporting and mixing concrete, the cost of molds, ...etc.).

4-indirect economic costs such as fire resistance, thermal insulation, sound insulation.‹

5- Extending the life span of ordinary aggregates with depleted quantities over time.

To complete the analysis of the results of concrete, using crushed natural lightweight aggregate, and to calculate the thermal insulation of the models according to the density values obtained from it and with different ages of the cubes, using equation below:

$$K=0.072*e^{(0.00125f)} \quad \text{(1)*}$$

That equation by which the values of the thermal conductivity coefficient are determined. It was found that the model (5) showed the best result in terms of thermal insulation, as its value reached (K = 0.594, 0.599, 0.606) respectively and according to the age of the model.

Table (7)

The results of the examination of lightweight concrete blocks at the age of (7) days.

No. of Model	Density Kg/m³			Strength MPa			Thermal Conductivity (K) * at 1180 C°
	700C°	950 C°	1180 C°	700C°	950 C°	1180 C°	
5	1792	1736	1688	20.3	23.8	24.1	0.594
6	1792	1744	1704	15.0	22.55	28.8	0.606
7	1865	1844	1824	24.3	32.5	37.7	0.704
8	1768	1728	1712	19.1	23.8	31.2	0.612

Resource: Researchers

Table (8)

The results of the examination of lightweight concrete blocks at the age of (21) days.

No. of Model	Density Kg/m³			Strength MPa			Thermal Conductivity (K) * at 1180 C°
	700C°	950 C°	1180 C°	700C°	950 C°	1180 C°	
5	1834	1792	1696	25.4	35.0	38.7	0.599
6	1812	1760	1752	19.2	24.0	32.5	0.643
7	1828	1812	1786	25.1	27.3	35.4	0.704
8	1760	1732	1718	20.8	27.3	35.4	0.616

Resource: Researchers

Table (9)

The results of the examination of lightweight concrete blocks at the age of (28) days

No. of Model	Density Kg/m³			Strength MPa			Thermal Conductivity (K) * at 1180 C°
	700C°	950 C°	1180 C°	700C°	950 C°	1180 C°	
5	1798	1760	1704	29.2	37.9	41.7	0.606
6	1754	1736	1724	21.65	25.35	35.0	0.626
7	1816	1784	1744	28.7	36.9	44	0.637
8	1760	1736	1712	23.0	31.6	40.3	0.612

Resource: Researchers

Figure (10)

Experiment cube model

Resource: Researchers

3-3-5: L.W. Lightweight Concrete Blocks:

Since the process of obtaining lightweight concrete, it is possible to obtain light concrete blocks, since the basic material of the block is aggregate and its density depends on the density of the aggregate used.

3-4: Lightweight stone as a structural alternative:

Stones and rocks are among the oldest materials on earth that were used by man to build his dwelling. The pharaohs also used it in building the pyramids and cities, and it was used in Iraq, for its presence in various and large quantities and sediments, one of its most important characteristics is that it was produced by the effects of the climatic and geological conditions of the region.

The main types of stone are:

1- Volcanic Stones: Igneous rocks are among the types of granite (flint), the strongest of the stone types and difficult to form before the emergence of the machine.

2- Sedimentary Stones: Limestone is the most important of its types, which in turn are of types used for construction purposes such as (conch, dolomite, sandy, limestone). Figure (11) illustrates this.

Figure (11)

sedimentary limestone type

Resource: Qadhi, Talal bin Mustafa, "Minerals and Industrial Rocks", College of Earth Sciences, King Saud University, p. 2.

It is considered one of the important industrial rocks when it is pure, and it is used in the cement industry, glass, iron production, thermal insulation wool industry, and the ceramic industry, in addition to being a basic building material.

3- Metamorphic rocks: sometimes called metamorphic, such as black slate, and most of its use is in road floors and pavements. Its durability is (30-150) kg/cm2.

The stone is considered one of the sustainable materials in the environmental and economic aspects due to the positive aspects it achieves in the aspects of thermal and sound insulation and the lowest cost.

3-4-1:Stone properties:

First: Durability: It is the resistance of stones to weather factors, and it depends on its composition and texture.

Second: Absorption: It is the percentage of water absorbed by the dry stone in (24) hours.

Third: Expansion and Contraction: This property depends on the temperature and varies from one stone to another. It is concluded that the stone material has good mechanical, physical and chemical properties.

It is possible to enter into an analytical aspect of some types of stone used in the residential buildings of the study area, in order to know their characteristics and validity in achieving sustainability.

Table (10)

The results of the laboratory test to determine the characteristics of the stone used for construction in comparison with the Iraqi Standard (1387/1989).

processing area	Test Type	Model Dimensions(cm)	Test Result	Iraqi standard 1387	stone class	number of cubes
kilo(60) South of Ramadi	Compressive Strength (Mpa)	10*10*10	12.4	>12	A	6
	Absorption%	10*10*10	10.2	<12		6
	Bulk Density	10*10*10	1715	1750-2150		6
	Broken Resistance (Mpa)	35*35*3.1	4.6	>3.5		6
South of Heat City (Kubayssa)	Compressive Strength(Mpa)	10*10*10	22.7	>12	A	4
	Absorption%	10*10*10	6.8	<7.5		4
	Bulk Density	10*10*10	1980	1750-2150		4
	Broken Resistance (Mpa)	35*35*3.0	4.81	>3.5		4
South of Haditha City	Compressive Strength(Mpa)	10*10*10	24.8	>12	A	4
	Absorption%	10*10*10	7.92	<12		4
	Bulk Density	10*10*10	2068	1750-2150		4
	Broken Resistance (Mpa)	35*35*3.2	4.58	>3.5		4

Resource: Researchers based on the results of laboratory examination of the obtained data.

1-The stone of the study area and its surroundings differ from one site to another. This difference is due to the concentration of the elements and compounds that make up it and the geological period. The Iraqi specification specified a classification of the stone based on its values, and the stone of the front area (Kilo 60) west of Ramadi is of Class A. As for the heat stone, it shows the characteristics of a stone with other specifications in terms of density, weight and great durability.

2- The types of stone available in the locations from which the models were taken, table (10) are evaluated on the basis of:

(A): Light weight (low density).

(B): Cohesion and hardness.

From the foregoing, it was concluded that the stone (light in weight and low in density), can be used in building walls and partitions, as it is high in density and low in water absorption, which means ((that stone as a local building material is a sustainable material and gives positive [economic-environmental] characteristics) and the result is social as being It can be configured according to the requirements of the architectural formation defined by the foundations of the traditions of society. Table (11) illustrates this.

Table (11)

The comparison between the types of stone in the study area

Location of Stones	Cost ($)	Compressive Strength(Mpa)	Density Kg/m3	Absorption%	Thermal insulation C°	sound insulation ds
kilo(60) South of Ramadi	35.6	12.4	1715	10.2	6	28
kilo(70) South of Ramadi	36.7	30.8	2340	4.31	14	52.7
South of Heat City (Kubayssa)	39.3	22.7	1980	6.8	18.4	61
South of Haditha City	44.9	34.1	2355	5.6	9.7	37.2
south of Al-Qaim city	79.2	21.5	1979	5.8	10	42.5
south of Al-Rutba city	92.8	35.3	2068	3.1	5.6	26.9

Resource: Researchers based on practical examinations and daily observations

In addition to the above, there are other alternative materials such as lightweight bricks and others.

3-5:Lightweight Bricks:

= Types of LW Bricks:

- Light sandy bricks, similar to ordinary sandy bricks, but in addition to the mixture, extrusive materials such as aluminum foundation powder made from grains of river sand, sometimes sand, and fly-ash of kilns are used. Among its features:

(1) It is light in weight. (2) Density (600-650) kg / m3. (3) High durability.

(4) Heat resistant. (5) Good thermal insulation and good sound insulation.

(6) Resistant to earthquakes. (7) Easy to form and in multiple sizes.

For comparison purposes and to show the characteristics of the bricks used in the study area, some types of bricks were tested. The results were as shown in Table (12), as the tolerance strengths and absorption rates varied. In order to demonstrate the possibility of ordinary bricks in achieving the principles of sustainability for the building, its properties (economically, environmentally, and technically) were analyzed, and the results were as shown in Table (13). Thermal insulation was measured for walls built of bricks and plaster finishes from the inside and ficus from the outside.

The statistical program (Genstat) was used to find out the effect of the model on the properties of compressive strength and absorption (meaning that there are significant differences for the three models) in Table (12).

Compressive strength: it was found from the analysis of variance table that there are very significant differences in the level of compression of the three models, and the value of the least significant difference was (Least Significant Differences of-Means (LSD), p=0.05), it was (1.44), and it was Compression averages for the three models, respectively, are (12.8), (14.97), and (16.3). By using the value of (LSD), it is clear that the third model is more acceptable.

With regard to absorption, it was found from the analysis of variance table that the three models did not differ significantly from each other, and the general average was (20.26) when the value of (LSD (P-0.05) = 4.72) and the averages were (20.26) and (18) respectively. ,03) and (22,5).

Table (12)

Regular brick tests used in housing construction

Model no	Compression N/mm2	Absorption %	Florsance	Class of bricks	Iraqi Standard (25/1988)		
					Compression	Absorption %	Absorption%
1	13.6	21	Light	C	13	22	Light- Medium
1	12.4	20.8	Light	C	13	22	Light- Medium
1	13.5	21.2	Light	C	13	22	Light- Medium
1	12.1	19	Light	C	13	22	Light- Medium
1	12.2	19.5	Light	C	13	22	Light- Medium
1	12	20	Light	C	13	22	Light- Medium
2	13.4	20	Light	B	13	22	Light- Medium
2	13.7	18.8	Light	B	13	22	Light- Medium
2	15.5	21	Light	B	13	22	Light- Medium
2	15.04	19.5	Light	B	13	22	Light- Medium
2	16.6	21	Light	B	13	22	Light- Medium
2	15.6	22.17	Light	B	13	22	Light- Medium
3	14.4	21.9	Light	B	13	22	Light- Medium
3	17.21	23.3	Light	B	13	22	Light- Medium
3	16.8	23.1	Light	B	13	22	Light- Medium
3	17.3	22.9	Light	B	13	22	Light- Medium
3	16.68	22.65	Light	B	13	22	Light- Medium
3	15.42	21.2	Light	B	13	22	Light- Medium

Resource: Researchers based on the geological survey data

Table (13)

The physical properties of bricks that show the comparison between them in construction

Bricks Type & Number	Cost USD	Endurance resistance MPA	Absorption %	Thermal Insulation[5]	Sound Insulation[4]
Abu Jass (1)	**128.5**	**12.8**	**20.25**	**9**	**33.3**
Engineer (2)	**128.5**	**14.97**	**18.03**	**10**	**32.6**
Dhari (3)	**122**	**16.3**	**22.5**	**12**	**40.3**

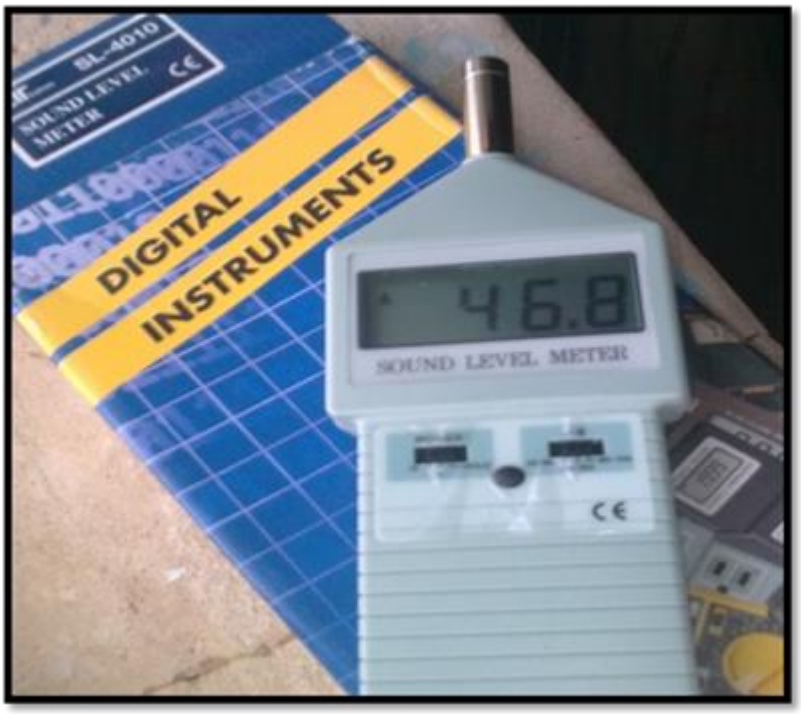
Resource: Researchers based on practical and field examinations in Table (12).

Figure (12)

A device for measuring the sound insulation of buildings used by the researcher.

([4]): The sound insulation was measured locally by the researcher using a sound intensity measuring device (DIGITAL- Instruments- SLJ4010, Lutron) shown in Figure (5-14) in units of decibels and using mercury thermometers.

([5])Thermal and sound insulation was measured locally by the researcher for walls with a thickness of (24) cm each, each with (+2) cm of (+3) cm of whiteness. Thermal represents the difference between the outside and the inside.



Resource: Researchers

4-1: Conclusions:

1- The effect of any change on one of the components of the residential environment moves involuntarily to bring about a change in the other part of the components, causing an impact on human behavior negatively or positively.

2- The contemporary residential environment suffers from the phenomenon of inconsistency resulting from the accumulation of a number of random designs and random building materials included in its composition.

3- For the purpose of reaching sustainable development at the level of the housing environment, it comes by matching between (place, climate, and building material) through a flow that combines the three elements above:

4- The difference in the residential environment between one climatic location and another resulted in a difference in the type and gender of the appropriate building materials, as they were used according to their characteristics that achieve environmental sustainability at the lowest technical and material costs and with the longest time path for the building within that environment. The desert region used stone (Stones) as a basic material in housing construction, which has the characteristics of resistance to harsh conditions by using it in construction processes or external or internal finishes (thermal insulator).

5- Sustainability in the residential environment derives from the region's ability to achieve the principle of self-sufficiency in building materials or raw materials for the manufacture of lightweight building materials, and to achieve the principle of preserving the land as a site of agricultural activity in relation to the study area.

6- It is concluded that studying the climatic elements and analyzing their work due to its great influence in determining the quality of the residential environment and the building material that enters into the process of building it. The greater the effect, the greater the preference for building materials that have properties (resistance, hardness, composition, ... etc.) in building residential structures, assuming that the economic aspect and thermal insulation are secured.

7- It is clear from the analysis that the thickness of the structural element is determined by knowing the thermal properties of the materials used in that element, taking into account the level of shading, the orientation of the building, the area of the openings in it, and the degree of thermal insulation of the structural element, but depends on the density of the structural material and is inversely proportional to it, on the condition that no Neglecting other physical properties of materials.

8- The choice of the building material depends on the foundations and constants related to:

A- The type of building required, its style, and its physical, mechanical and chemical properties.

B- Costs, including (extraction, transportation, transformation and use).

C - The extent of fluctuations in climate elements.

D- Its proximity to industrial waste sites such as acid fumes.

E - The extent of its exposure to fire.

9- The validity of using desert clays in the manufacture of lightweight aggregates (L.W.A.), from clays available in them with very large reserves, achieving sustainability in economic and environmental aspects.

10- The use of light aggregate has achieved the production of lightweight concrete (LWA Concrete) with a density ranging from (1690-1715) kg / m3, which is (26-30)% less than the density of ordinary concrete. It has the potential to replace ordinary concrete in housing and buildings.

4-2: Recommendations:

1- Achieving the principle of self-sufficiency in building materials or raw materials for the local building materials industry, and achieving the principle of preserving the land as a site for other activities.

2- Taking into account the environmental and social depth and site conditions when preparing housing development programs in particular and comprehensive sustainable development in general.

3- Developing a strategy to determine the available and latent capabilities of the region, through the preparation of adequate studies on human and natural resources in it, in order to create a state of balance between environmental requirements and the required construction behavior, to ensure the full sustainability of the residential and urban environment.

4- Guidance to build a database based on the results of the geological survey and geological maps of the types and reserves of natural building materials and raw materials available in the study area, updated annually using modern technologies, to be a reference on which all utilization and manufacturing operations are based and programmed according to the need of the construction market.

5- Directing the adoption of studies, research and experiments through which the researchers achieved an achievement by reaching a positive result in the manufacture of lightweight aggregates from the available clays in the province. Similar to previous experiences in the world, to serve as a basis for moving towards setting a practical model for the sustainable development of the residential environment.

6- Recommending the development of a database concerned with the industrial development of the construction sector, adopting the development of proposed plans for the expansion and diversification of construction industries locally, and preparing economic feasibility reports (calculating inputs and outputs) to indicate the relative importance of building materials.

7- Recommend the adoption of new construction and industrial methods that improve the quality of the residential environment in the city, study the availability of materials and resources, their places of use, how to preserve and recycle them through modern methods, and work on their sustainability to improve that environment.

8- Recommend the adoption of the method of using natural building materials such as stone, as it achieves the characteristics that meet the environmental needs of the study area.

9- Because the problem is multifaceted (environmental, costs and production, local climate, social compatibility, technical development and machine development), all of them require the development of systems that coordinate and program the process of searching for the best through:

A- Developing scientific foundations and derived methods to achieve comprehensive goals in securing a residential structure that is suitable for the situation of man in his environment, and to achieve a scientific addition as it is being studied for the first time with the details contained in the research.

B- The building yard is supported by new work mechanisms, which achieve building industrial development on the axis of building materials from raw materials in the study area, to help the technical authorities in setting up a mechanism that enhances the effectiveness of the residential environment in cities, as it constitutes a systemic framework that adopts the preparation of building materials on the basis of:

First, the production of alternatives to the usual building materials from raw materials that are not depleted.

Second, the cost of production and use.

References:

1- The Holy Quran.

2- Abd al-Razzaq, Najil Kamal al-Dabbagh, Shamael Muhammad Wajih, "The Sustainability of Traditional Cities between Yesterday and Modernity Today (a comparative study), Engineering and Technology Journal, Vol. (26), No. (11), 2008,

3- Kharoofa. Omar Hazem Ahmed, "Energy in Sustainable Local Architecture", unpublished doctoral thesis, University of Baghdad, College of Engineering, Baghdad, 2006.

4- Al-Zubaidi, Maha Sabah, "Environmental Sustainability in the Formation of Housing Clusters in Iraq," a Ph.D. thesis submitted to the Department of Architectural Engineering, College of Engineering, University of Baghdad, 2006.

5-Abu Dayyah, Ayoub, "The Concept of Global Warming; Its factors, causes and ways to confront it "", The Society for Energy Conservation and Environmental Sustainability, Jordan, 2009.

6- American Standard (ASTM) - Structural Tests.

7- Al-Jabri, Muhammad Abed, "Globalization and Cultural Identity, Ten Propositions," The Arab Future Magazine, Issue 228, the twentieth year, Center for Arab Unity Studies, Beirut, February, 1998.

8- Al-Jabri, Muhammad Abed, "Globalization and Cultural Identity, Ten Propositions," The Arab Future Magazine, Issue 228, the twentieth year, Center for Arab Unity Studies, Beirut, February, 1998.

9- Ghosheh, Abdullah Assem, "Residential Projects and Sustainable Development", published research. Amman, Jordan, 2007.

10-34- Muhammad Abdel-Baqi Ibrahim and Shaimaa Muhammad Kamel Mahmoud, "The Advantages of Using Light Porous Concrete Blocks Versus the Use of Cement Bricks in Design and Construction," 2003.

11- http://www.benacity.com/forum/t6163.html)

12- FIP, Manual, "" Concrete Society"" , FIP. Manual of Lightweight Aggregate Concrete, London, 1983.

13- Abu Odeh, Ahmed Hussein, "Concrete Technology", Arab Community Library, 1st edition, Amman, Jordan, 2008.

14- Laterlite technical Assistance, ""General Catalogue 2007"", Edition (2006), Italy, p.6, by website :www.laterlite.eu.

15- ACI Manual of Concrete, 213R-16,1989

16- . Qadhi, Talal bin Mustafa, "Minerals and Industrial Rocks", College of Earth Sciences, King Saud University.2006.

17- The National Center for Structural Laboratories, "Material Specifications", Baghdad, 2001.

18- The National Center for Structural Laboratories, "Specifications for Structural Works, Baghdad, first edition.

19- Iraqi Standard 45/1984 - Aggregate Tests.

20- Iraqi Standard 1077/1987 - Tests of concrete blocks.

21- Iraqi Standard 25/1988 - Tests of bricks made of clay.

22- Iraqi Standard 1387/1989 - Natural stone specifications for building uses..

23- Akef, Adnan and Kelly, Imad Yaqoub, "Geological investigations of the areas surrounding the city of Ramadi," General Directorate of Geological Survey and Mineral Investigation, (no date).

24- Consulate, George, "The Role of Social and Functional Factors in Contemporary Solutions for Bathhouse Housing," published research, Tishreen University Journal for Scientific Studies and Research, Engineering Sciences Series, Volume (28), Issue (2), 2006.

25- Najeel Kamal Abdel-Razzaq, Sari Fawzi Abbas, "The Formation of the Facades of Residential Complexes and its Impact on the Urban Landscape of the City of Baghdad," Engineering and Technology Journal, Vol. (26), No. (5), 2008.

26- Ministry of Planning and Development Cooperation, Central Statistical Organization, Annual Statistical Collection, Baghdad, 2007.

27- ACI. Manual of Concrete practice 1985, Part1, Materials and General Properties of Concrete.

28-Council on Tall Building and Urban Habitat, Fourth World Congress (Tall Building; 2000 and Beyond), Hong Kong, 1990.

29- Encyclopedia of "The Regional Geology of Iraq " Vol.1, Baghdad ,1980.

30-http://uotechnology.edu.iq/tec_magaz/volume262008/No5/Researches/1A

31-http://www.uotiq.org/tec_magaz/volume262008/No11/Researches/3A.pdf

32-http://www.alhandasa.net/forum/showthread.php?t=110260

33-http://www.archcairo.com/forum/showthread.php?p=73536

34-http://www.archcairo.com/forum/showthread.php?p=73536 35- http://arch-sustainable.blogspot.com

36- http://www.3mda.com/vb/t24386.html

37- http://www.akafi.net/archive/index.php/t93411.html

38-http://www.almuhands.org/forum/showthread.php?t=77722

39-http://amazing-building.blogspot.com

40- Data collected from the relevant institutions in ministries of Iraq:.

A- Statistical data: - Central Statistical Organization / Directorate of Statistics of Anbar Governorate.

B- Location and geological data: - The General Authority for Geological Survey and Mineral Investigation / Ministry of Industry and Minerals.