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The Influence of Construction Waste Recycling on the Project Feasibility study

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ABSTRACT: *There is no requirement in the foundations of project management for those in charge of managing construction projects to reuse site wastes, so because it is considered a pollutant to the environment. Therefore, it is imperative to study how to link construction project management with international environmental assessment standards to reuse and recycle materials at construction sites., and how to benefit from them in This leads to saving energies and the use of environmentally friendly building materials, as well as the consequent savings in the necessary financing for the projects. This study aims at to classifying y the waste generated from construction sites and identify the most important waste that can be used after recycling in to achieve the economic feasibility of the projects. and determine the economic size of the waste collected according to the type of sites, and projects being built, and the cost of recycling, and making the necessary tests for the recycled materials in the projects to study the difference between them and the materials being supplied. The study concluded that reducing the amount of waste in building materials leads to a reduction in the cost of construction, and also a reduction in the project implementation times, the mechanism for making the necessary tests, and following up on the recycling of materials to reach the required quality of materials.*

Keywords*: Waste – Recycling – Environment – Feasibility – Economic - Material.*

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I. INTRODUCTION

Since the 1960s, environmental warnings have emphasized the importance of protecting and preserving the environment. Buildings have become seen as micro-ecosystems that interact with the larger ecosystem, leading to the emergence of ecological architecture and sustainability. This trend has become popular in architecture and urbanism, as science seeks ways to rationalize energy, optimize resource use, and reduce consumption to address environmental threats such as resource depletion, pollution, and climate change.

The world recognizes the close link between economic and environmental development due to the high costs of building materials and energy. As the number of people increases while resources decrease, the concept of sustainable development has emerged, emphasizing the importance of participation from governments and people in various development sectors, including urban ones.

The application of sustainability concepts in architecture is not just a scientific luxury but a new scientific method of professional practice based on systematic collective work, integrating roles and efforts at all levels. The construction sectors are responsible for the environmental and economic responsibility, as they consume resources through materials and energy consumption, resulting in polluting waste that causes severe environmental damage [1-5]. Construction activities face a significant challenge in fulfilling their requirements and achieving comprehensive sustainable development. Management plays a crucial role in preserving the environment during projects, making it a competitive challenge in these sectors. The success of an engineering project depends on identifying and estimating financial needs realistically, ensuring a surplus of money is uninvested. If the estimate is less than the reality, the project may face financial difficulties and deficits, disrupting the schedule and causing implementation issues. Costs are a significant factor in financial evaluation, and a system to study economic feasibility before starting a project is necessary. This system compiles, classifies, and analyzes project expected costs, presenting them to decision-makers to follow up on deviations and correct them early. The approved budget allows for the selection of the best project from among proposed options, ensuring the project's financial feasibility and sustainability [6-7].

1. Method and Data Collection

1.1. Methodology

The research follows the descriptive analytical approach with regard to the theoretical side of the study and its applied side. The experimental approach was relied upon.

1.2. Data Collection

1.2.1. Building Materials Used

- Basic building materials : basic building materials are defined as the materials used in the construction of the basic load-bearing and portable building elements, which are usually the general structure and walls of the building, which can suffice the building as an architectural space, and therefore reinforced concrete, building bricks, metal structures and various coverings are considered among the basic building materials It is noted that most of the basic building materials currently used are largely imported from abroad, which wastes transportation energy, and increases the load on continuous storage operations during transportation [8-9].
- Auxiliary building materials: and auxiliary building materials They are defined as materials added to complete implementation processes with basic materials or to complete the external shape of the building, including materials that are used to assist in the construction process such as formwork, scaffolding and other elements that are installed and dismantled, or bonding materials added to the building such as mortar and adhesives Or any element used to complete or finish a building process, such as whitewash, wood, glass, lime, and others [9-10]. The most important types of auxiliary building materials can be identified as follows:

- Formwork, which is Temporary Construction for the purpose of pouring fresh concrete into it. Wooden formwork, metal formwork, and the severity of hollow ceilings, and it is noted the possibility of dispensing with formwork or saving them by using different methods of implementation [11].
- Building mortar: and the amount of mortar needed for buildings is identified through tables specially prepared for this purpose, and thus the amount of mortar can be determined. What kind of brick consumes the energy needed to manufacture the mortar for it [12].

1.2.2. Building System

Self-Building System: This system relies on residents' own efforts and their social and psychological needs to design their homes. It has developed in Egypt through various projects and research. Labor-based Construction System: This system relies on human energy, including mental and muscular, for employment. Methods vary across countries and depend on local natural building materials, simple manual building and construction equipment, and primitive transportation methods. This system is common in developing countries and is considered a grave mistake without finding an alternative solution [14].

Partial Mechanization Construction System: This system relies on partial replacement of machines instead of labor in some implementation stages, with less than 80% of the work on the site automated. This involves automation of various equipment works, such as excavation, transportation, mixing materials, and preparing concrete. Despite the global trend towards mechanized building systems after World War II, the dispensation of a large amount of employment in this sector is considered a grave mistake without finding an alternative solution 15-16].

2. Waste Recycling in Building Projects

2.1. Building Life Cycle

The traditional building life cycle model, which includes four main processes: design, construction, operation, maintenance, demolition, and removal, is narrow and lacks consideration for environmental issues and waste management. To address this, a three-stage model can be proposed, starting with nature as the source of materials and returning the outputs of the building after demolition. The model includes the pre-construction phase, which includes site selection, design preparation, production of necessary materials, selection of construction systems and equipment, and preparation for construction operations [17-20].

The construction phase includes all construction, finishing, and preparation operations, and the building is operated, used, and maintained. The operation and maintenance phase includes housing and use of the building, as well as periodic maintenance. The reuse phase involves reusing the building after its original purpose and reusing its spaces [21-23].

The post-construction phase includes demolition and removal of the building and dealing with waste. The recycling stage involves reusing building materials after demolition due to the lack of feasibility to restore or repair it. The manufacturing stage sorts recycled materials for reuse in the construction stage, and the waste management stage separates waste that can be recycled and used in construction operations. This model can be further refined to address sustainability concerns and promote a more sustainable building life cycle [24-28].

2.2. Consumed Construction Energy

The construction industry is one of the main activities in Egypt, as it represents more than 40% of the development plan in Egypt. When constructing buildings, the need for non-renewable energy sources must be reduced in order to design an energy-efficient building. Focus should not only be on the energy used after the construction of the building and during its use, but also the energy involved in the production of building components [29-30].

3. Factors Influencing Building's Energy Consumption during Construction

There are a number of factors affecting energy consumption in the construction stage of the building, and it is noted that these factors control how and the amount of energy consumption at this stage, as their characteristics affect the method of energy consumption through their impact on the various consumption elements represented in equipment, labor and the waste of building materials Mismanagement of project implementation, which will be mentioned in this section, and it is noted that these elements are collectively governed by a group of factors, namely the building materials used, the building systems used, the implementation methods used, the design process, and time control., and it is noted that the characteristics of each of these factors have a direct impact on Energy consumed at this stage of building construction [31]. See figure (2).

3.1. Type of Used Material for Construction

Building materials are considered the most influential factors on the construction stage of the building because of their many characteristics and a clear impact on other factors, and the impact of their type on energy consumption in the building construction stage is shown through. The greater the weight of the material, the greater its transport capacity - the load of any transport vehicle is fixed, and therefore the increase in the weight may lead to more transport times and therefore a greater consumption of energy. The hardness of the material (hardness) determines its susceptibility to breakage, and the smoother the outer surface the less cohesion with the finishing materials. It also affects the transportation capacity, whether from the location of the availability of raw materials to factories or from factories to the construction site. Local materials are preferred as they are known to local labor, which is also preferred to be used to reduce their transportation and training energy [34:38].

3.3. Used Execution Method

The execution method is considered the main controller of the execution capacity, and therefore it controls the capacity of labor and implementation equipment, which requires ensuring good control over them and preventing waste in them, especially when most of the executed works are on the construction site. It is one of the common phenomena that affected urban production in Egypt, which reflects poor implementation and inefficiency of control or management, which represents a material waste that reduces the life span of facilities [44], The implementation methods used determine everything related to the implementation of labor, equipment, waste and management style in the construction, storage, and finishing operations, and so on. The construction phase of the building through:

- Prefabricated elements or processing in the factory leads to a process of transferring from the sites of raw materials to the factory. Traditional methods, on the other hand, lead to the process of transporting the raw materials directly to the site. The energy of transport is highly dependent on the execution method used in such cases. [45].
- The energy of equipment and labor: where the method of implementation is chosen with the least effort and therefore an effort of energy for each of the labor and equipment in a way that does not conflict with the quality of the product, and in proportion to the required implementation time [46].
- The materials used in the implementation: where some implementation methods specify the necessity of using auxiliary materials to do them, such as the use of wrenches, and the method of implementation may determine the quality of these materials, for example, the method of implementation determines the necessity of using wooden or metal wrenches or others, and thus controls the manufacturing capacity of some materials used in implementation [43]. (See Table 1)
- Wasted building materials: for example, choosing the execution method leads to determining the place of implementation, and the implementation of the elements in a closed place, for example, leads to more quality than their implementation on the site as a result of the possibility of control and monitoring, and thus affects the amount of waste of these materials, in addition to that some of the characteristics of the methods of building materials The different implementations used may lead to mortal building materials at any stage helping it [35].
- Finishing energy: where the implementation method used determines the shape of the final surface of the building as well as the characteristics of the building material used, and thus affects the amount of finishing needed by the building and determines the manufacturing capacity of finishing materials as well as the energy of finishing labor [45].

Table (1): Implementation rate and percentages of different materials according to different methods of implementation

Method	Traditional	Formwork	Laminate Tiles	Raised Riles
		Items		
Reinforcement Rates	100 kg/m^3	60 kg/m^3	110 kg/m^3	110 kg/m^3
Concrete	46 m^3 per floor	78 m^3 per floor	78 m^3 per floor	56 m^3 per floor
m^3/m^2 Steel	18	30	30	22
Building	2.94 m^3/m^2	0.82 m^3/m^2	0.82 m^3/m^2	0.94 m^3/m^2
Interior Paint	1.4 m^3/m^2	0.95 m^3/m^2	1.40 m^3/m^2	1.40 m^3/m^2
Exterior Paint	2.45 m^3/m^2	1.40 m^3/m^2	1.40 m^3/m^2	1.40 m^3/m^2
Paint	m^3/m^{2}2.90	2.98 m^3/m^2	2.98 m^3/m^2	2.90 m^3/m^2
		Building Rate		
Structure	100 days	35 days	75 days	10 days
Floor	20 days	7 days	15 days	2 days
Building Unit	10 days	3.5 day	7.5 days	1.5 days

3.4. Labor

If it was possible to direct workers to do their work correctly, this value could be reduced by 30% at least. Average productivity of worker decreased to two-thirds of the productivity of the worker in 1959-2020. In many companies, this effect extends to confusing production and causing apathy to serious workers. Loss of labor is estimated at about 35% of labor costs in Egypt. Then the matter developed to calculate the work according to the time taken to carry out the work, after determining standard times in which the worker does the work required of him to complete the work, and these times were determined according to standard conditions and factors to complete this work, bearing in mind that [47],

The total time = work completion time + rest periods Eq (1)

4. Construction Material Energy Loss

The percentage of waste in Egypt reaches 40% Of the value of building materials, that is, they represent 16% of buildings (labor and building materials) in Egypt. The various processes in it before it is lost through various implementation processes such as construction, burning, finishing, etc., and the wasted energy resulting from them is collected and added to total energy consumed. The rate of waste varies from one substance to another and depends on several factors, which are summarized in [47]. The tendency to manufacture by pressing and then natural drying, as happens for cement bricks, is better than manufacturing by extrusion, then drying and burning. Choosing the appropriate design module for building units reduces the presence of dead people during the implementation phase.

4.1. Demolition Waste

There are many definitions issued by specialized bodies and organizations for the concept of waste, but one of the clearest definitions was contained in the British Environmental Protection legislation in 1990, which defined waste in two points as follows:

- Any material that constitutes waste, scrap or any other unwanted material arising from the implementation of operations.
- Any material or commodity that needs to be disposed of due to its exposure to breakage, damage, pollution or corruption.

If this is the common term for waste, construction and demolition waste can be defined as the remnants, residues, debris, increases and piles of building and demolition materials that result from construction, restoration, repair, demolition and removal activities of facilities. A great deal of the responsibility of construction activities for wasting resources is due to the various construction works resulting from building, renovating or demolishing and removing huge amounts of waste. The most important traditional disposal methods include several operations, such as burning in open dumps outside cities, throwing into water bodies such as seas and oceans, and burial in landfills. The excess of rubble disposal, the consequent overcrowding of burial sites, and the resulting environmental threats and health risks.

4.2. Construction Waste Rates

The volume of construction and demolition waste in the United States of America has been estimated at about 24% of the total waste that is disposed of in municipal dumps. Demolition consists of large cohesive parts and mixed blocks that may be difficult to separate, as they are attached to each other with bents or nails or adhered to cement, welding or other methods of assembly.

4.3. Construction Waste Components

The components of construction and demolition waste includes a wide list of elements and components of buildings that are demolished and materials that are consumed in the new construction processes, as all materials brought to the project site with their various basic and support functions are all liable to become part of them for one reason or another within the scope of the waste that is Usually disposed of at the end of the project.

Buildings result in waste such as bricks, concrete, and wood that are not used or damaged for many reasons during the construction process. Regulatory research indicates that these materials may reach 10-15% of the materials used in construction, and the current components of building waste such as plasterboards (Gibson board) is dangerous when landfilling, as it produces hydrogen sulfide, which is a poisonous gas, and many elements of construction waste can be recycled, and press containers are often used to transport them.

In general, the composition of construction and demolition waste varies significantly depending on the type of project from which it is generated. For example, rubble resulting from old buildings often contains gypsum and lead pipes, while the rubble of modern buildings may contain a noticeable amount of plastic and glass. The US Environment, as well as the Australian Environmental Protection and Climate Change Agency, are approximate averages of the percentages of materials present in conventional construction and demolition waste at the following rates as shown in Table 2;

Table (2): Components of construction and demolition waste
Source: Report into the Construction and Demolition Waste Stream Audit 2007

Material	Percentage in Construction Waste %
Concrete Waste	**22,9**
Fines < 4.75mm	**21,6**
Timber	**20**
Clay products	**8,8**
Ferrous & non-ferrous metals	**5,7**
Natural aggregates	**5,6**
Plasterboard	**3,7**
Paper and cardboard	**3,2**
Plastic	**2,9**
Other materials	**5,6**

5. Construction Waste Management

The concept of construction waste management means the active and continuous process to reduce the access of waste materials used to the air, land, or water. From this continuity approach, waste can be reduced and the demand for primary natural resources is reduced [48]**.** The option to treat waste for recovery are several methods available for the management of construction waste, (See figure 3):

- Reduction.
- Reuse.
- Recycling.

5.1. Reduction

Reducing the production of waste comes at the top of the priorities when studying ways to manage it. Finding polluted waste and then treating it before disposing of it is a way to avoid the symptoms of the problem rather than confronting its source. It is possible to reduce the amount of construction and demolition debris by paying attention to estimating quantities of materials needed for construction.

5.2 Reuse

Construction waste includes materials such as: broken concrete, bricks, stones and rocks, asphalt, dirt, sand, wood, glass and others. It is possible to reduce this waste through reuse practices such as [51, 52]: Reuse of demolition waste from equipment such as wooden floors - doors, windows, pipes, etc., in new projects.

5.3 Recycling

Recycling construction and demolition waste reduces the costs and amount of materials that need to be disposed of in burial sites. Recovery rates can be achieved up to 80% and more by treating waste in a range of physical and mechanical processes. There are three possible directions for those managing construction projects in terms of waste recycling, including the following. Waste is at each stage of construction, so the practice of temporal coordination of waste removal from the site by transporters takes advantage of this. The trend is that building contractors do not participate in waste recovery operations at the site. This trend also reduces the burden or responsibility on building contractors in terms of waste recovery and treatment, and does not require an empty site for collection.

6. Modeling

6.1. Mixture

The researcher experimented with more than one mixture at the beginning of cement, sand, water and crushed concrete as aggregate without any additives to find out the appropriate mixture, the most cohesive and the best in terms of compressive resistance, using a lot of research on concrete mixtures until the researcher reached the unification of the cement mixture on all samples in volumetric ratios following:

Components Mix Ratio	Water	Cement+ Fly ash	Sand	Concrete Waste	Proposed Additive
Volume Ratio	**1**	**1.5**	**3**	**3**	**1.5**
Mass (kg)	**0.165**	**0.40**	**0.950**	**0.165**	**0.20 – 0.60**

Water about 10%, cement + fly ash about 15 %, sand about 30%, and concrete fraction about 30%.

6.2. Mixtures

6.2.1. First Mixture

“Water about 10%, cement + fly ash about 15 % + sand about 30% +concrete fraction about 30% + 15% marble ash”

- Dimensions and weight test: The weights, dimensions and apparent density of the samples (the density of the brick without deducting the air spaces in it) were as follows in Table (3):

Table (3): Mass, Volume and Density of test samples for the first proposal.

Sample	Mass (Kg)	Outer Dimensions (cm)			Total Volume cm^3	Density (gm/cm^3)
		Length	Wide	Height		
S1	3500	25.1	12.1	6	1822.26	1.8
S2	3240	25	12	6	1800	1.9
S3	3690	25.1	12.1	6.1	1852.63	1.99

6.2.2. Second Mixture

“Water about 10%, cement + fly ash about 15 % + sand about 30% +concrete fraction about 30% + 15% glass ash”

Table (4): Mass, volume, and density of test samples for the second proposal

Sample	Mass (Kg)	Outer Dimensions (cm)			Total Volume cm^3	Density (gm/cm^3)
		Length	Wide	Height		
S1	3500	25	12	6	1800	1.94
S2	3240	25	12	6	1800	1.96
S3	3690	25.1	12.1	6.1	1852.63	2.00

6.2.3. Third Mixture

“Water about 10%, cement + fly ash about 15 % + sand about 30% +concrete fraction about 30% + 15% steel furnace slag”

Table (5) Mass, volume and density of test samples for the third proposal

Sample	Mass (Kg)	Outer Dimensions (cm)			Total Volume cm^3	Density (gm/cm^3)
		Length	Wide	Height		
S1	3660	25	12	6	1800	2.00
S2	3670	25	12	6	1800	2.00
S3	3700	25.1	12	6	1807.2	2.00

6.2.4. Fourth Mixture

“Water about 10%, cement + fly ash about 15 % + sand about 30% +concrete fraction about 30% + 15% minced rubber”

Table (6): Mass, volume, and density of test samples for the Fourth proposal

Sample	Mass (Kg)	Outer Dimensions (cm)			Total Volume cm^3	Density (gm/cm^3)
		Length	Wide	Height		
S1	3300	25	12	6	1800	1.83
S2	3290	25	12.1	6	1815	1.81
S3	3300	25	12	6.1	1830	1.80

6.3 Testing

6.3.1. First Mixture Tests

6.3.1.1. Stress Test

These samples, when placed on the pressure testing machine, 28 days after the samples were manufactured, recorded the following fracture loads shown in the following table (7);

Table (7) (stress resistance in newton/mm^2 for test samples for the first proposal

Samples	Ash Stress (N)	The average total area of the two brick faces exposed to loading (mm^2)	Stress Resistance (N/mm^2)	Brick Classification
S1	**300×10^3**	**30.00**	**10.00**	**Medium Bearing Hollow Building Units**
S2	**340×10^3**	**30.00**	**11.33**	
S3	**350×10^3**	**30.00**	**11.66**	

Comparing these results with what was stated in the Egyptian Code for Building Works, which are shown in regarding the requirements for the validity of building units manufactured from concrete, we find that the manufactured samples exceed the requirements and specifications found in the Egyptian Code for Bricks Cement hollow for medium-carrying hollow units is about two times, where the bearing strength of the latter in the Egyptian code is 5 Newton / mm^2, while in the units manufactured by the researcher, the pressure bearing strength exceeds 11 Newton / mm^2, according to the Egyptian , it is not The pressure bearing strength of the medium-carrying clay bricks is less than 7 N / mm^2 for one brick and 8 N / mm^2 for an average of five bricks, and then we find that the bricks that were manufactured exceed that by about one and a half times in terms of the ability to withstand pressure.

6.3.1.2. Absorption Test

After 28 days of finishing of the brick mixture, the dry brick samples were weighed on the scale, then immersed in water for 24 hours and immediately after that the samples were weighed and the results were as follows in a table (8);

Table (8): Absorption test results for tested samples of the first proposal.

Sample	Dry Mass (kg)	Mass after immersing in water (kg)	Absorption ratio	Absorption %
S1	**3500**	**3800**	**3500-3500-3800**	**8.5**
S2	**3240**	**3500**	**3240-3240-3500**	**8**
S3	**3690**	**4000**	**3690-3690-4000**	**8.4**
Absorption Average				**8.3**

6.3.2 Second Mixture Tests

6.3.2.1 Stress Test

These samples, when placed on the pressure testing machine, 28 days after the samples were manufactured, recorded the following fracture loads shown in the following table (9);

Table (9) Stress resistance in newton/mm^2 for test samples for the second proposal

Samples	Ash Stress (N)	The average total area of the two brick faces exposed to loading (mm^2)	Stress Resistance (N/mm^2)	Brick Classification
S1	**240×10^3**	**30.00**	**8.00**	**Medium Bearing Hollow Building Units**
S2	**230×10^3**	**30.00**	**7.60**	
S3	**280×10^3**	**30.00**	**9.30**	

By comparing these results with what was stated in the Egyptian Code for Building Works, we find that the manufactured samples exceed the requirements and specifications found in the Egyptian Code for hollow concrete bricks for heavy-bearing units The hollow is about one and a half times where the bearing force of the latter in the Egyptian code is 5 Newton/mm^2, while in the units manufactured by the researcher, the pressure bearing force exceeds 8.5 Newton/mm^2, and according to the Egyptian code and as shown in Table (8) the pressure bearing force is not less For medium clay bricks bearing about 7 Newton/mm^2 for one brick and 8 Newton / mm 2 for an average of five bricks, and then we find that the bricks that were manufactured exceed that, as their average ability to withstand pressure is about 8.5 Newton /mm^2.

6.3.2.2 Absorption Test

After 28 days of complete doubt of the brick mixture, the dry brick samples were weighed on the scale, then immersed in water for 24 hours, and immediately after that the samples were weighed. The results were as follows in Table (10);

Table (10): Absorption test results for tested samples of the second proposal

Sample	Dry Mass (kg)	Mass after immersing in water (kg)	Absorption ratio	Absorption %
S1	**3500**	**3750**	**3500-3500-3750**	**7.1**
S2	**3530**	**3800**	**3530-3530-3800**	**7.6**
S3	**3710**	**3980**	**3710-3710-3980**	**7.2**
Absorption Average				**7.3**

6.3.3. Third Mixture Tests

6.3.3.1 Stress Test

These samples, when placed on the compression testing machine, 28 days after the samples were manufactured, recorded the following fracture loads shown in the following table (11);

Table (11) Stress resistance in newton/mm^2 for test samples for the third proposal

Samples	Ash Stress (N)	The average total area of the two brick faces exposed to loading (mm^2)	Stress Resistance (N/mm^2)	Brick Classification
S1	**240×10^3**	**30.00**	**8.00**	**Medium Bearing Hollow Building Units**
S2	**290×10^3**	**30.00**	**9.60**	
S3	**300×10^3**	**30.00**	**10.00**	

By comparing these results with what was stated in the Egyptian Code for Building Works related to the requirements for the viability of building units manufactured from concrete, we find that the manufactured samples exceed the requirements and specifications in the Egyptian Code for hollow cement bricks for heavy hollow bearing units by about twice, where the bearing strength of the latter in the Egyptian Code is 5 Newton/mm^2 , while in the units manufactured by the researcher, the pressure bearing force exceeds 9 Newton/ mm^2, and according to the Egyptian code, the pressure bearing force of heavy clay bricks bearing is not less than 7 Newton/mm^2 for one brick and 8 Newton/ mm^2 for an average of five bricks, and then we find that the bricks The manufactured one exceeds this as its pressure tolerance ranges from 8-10 N/mm^2.

6.3.3.2 Absorption Test

After 28 days of complete doubt of the brick mixture, the dry brick samples were weighed on the scale, then immersed in water for 24 hours, and immediately after that the samples were weighed. The results were as follows in Table (12);

Table (12): Absorption test results for tested samples of the third proposal

Sample	Dry Mass (kg)	Mass after immersing in water (kg)	Absorption ratio	Absorption %
S1	**3660**	**3850**	**3660-3850-3660**	**5.19**
S2	**3670**	**3900**	**3670-3900-3670**	**6.26**
S3	**3700**	**3980**	**3700-3980-3700**	**7.5**
Absorption Average				**6.31**

6.3.4. Fourth Mixture Tests

6.3.4.1 Stress Tests

When these samples were placed on the compression testing machine, 28 days after the samples were manufactured, the following fracture loads were recorded as shown in the following table (13);

Table (13) Stress resistance in newton/mm^2 for test samples for the fourth proposal

Samples	Ash Stress (N)	The average total area of the two brick faces exposed to loading (mm^2)	Stress Resistance (N/mm^2)	Brick Classification
S1	**70×10^3**	**30.00**	**2.3**	**Medium Bearing Hollow Building Units**
S2	**80×10^3**	**30.00**	**2.66**	
S3	**90×10^3**	**30.00**	**3.00**	

By comparing these results with what was stated in the Egyptian Code of Building Works for the requirements for the viability of building units manufactured from concrete, we find that the manufactured samples exceed the requirements and specifications in the Egyptian Code for hollow cement bricks for intermediate non-bearing hollow units, where the bearing strength of the latter in the Egyptian Code is 2 Newton / mm2. While in the units manufactured by the researcher, the average pressure-carrying strength of the three bricks exceeds 2.56Newton /mm^2, and according to the Egyptian code, the pressure-carrying strength of the non-load-bearing medium clay bricks is not less than 2.5 Newton/mm^2 for one brick and 3 Newton/mm^2 for an average of five bricks. Then we find that the bricks that were manufactured correspond to that, as their ability to withstand pressure ranged from 3.2-00.3 N/mm^2, and the researcher noticed that mixing chopped rubber with cement - even after treating rubber with sodium hydroxide (caustic soda) - weakens the cement mixture and reduces its ability To withstand pressure, but it significantly reduces the weight of the brick and increases its thermal insulation properties, so this type of brick can be used in non-load-bearing structures in general, such as fences and structures located above the roofs because it Non-carrier facilities that need good thermal insulation properties due to their continuous exposure to atmospheric factors.

6.3.4.2 Absorption Test

After 28 days of complete doubt of the brick mixture, the dry brick samples were weighed on the scale and then immersed in water for 24 hours and immediately after that the samples were weighed and the results were as follows in Table (14);

Table (14): Absorption test results for tested samples of the fourth proposal

Sample	Dry Mass (kg)	Mass after immersing in water (kg)	Absorption ratio	Absorption %
S1	**3200**	**3500**	**3200-3200-3500**	**9.3**
S2	**3290**	**3600**	**3290-3290-3600**	**9.4**
S3	**3300**	**3600**	**3300-3300-3600**	**9.1**
		Absorption Average		**9.26**

7. Results

- By using a concrete fracture in addition to a marble slither with cement and water, it was possible to manufacture building units of heavy bearing bricks that have a very high-pressure strength, achieving an average of 11 N/mm^2, and an average absorption rate of 8.3%, which is almost half of the permissible percentage in the code Egyptian, where it does not exceed 16% for load-bearing bricks and does not exceed 20% for non-load bearing bricks.
- By using concrete breakage in addition to breaking glass with cement and water, it was possible to manufacture building units of heavy bearing bricks that have high pressure bearing strength, achieving an average of 8.3 N/mm^2, and an average absorption rate of 7.3%, which is slightly less than half of the permissible percentage. It is in the Egyptian code.
- By using concrete fracture in addition to iron kiln slag with cement and water, it was possible to manufacture building units of heavy load-bearing bricks that have high pressure-carrying strength, achieving an average of 9.2N/mm^2, and an average absorption rate of 6.31%, which is slightly greater than a quarter of the percentage allowed in the Egyptian code.
- By using concrete fracture in addition to chopped rubber with cement and water, it was possible to manufacture building units of non-heavy bricks that have low pressure bearing strength, achieving an average of 2.N/mm^2, which is an average that is in line with the minimum limits of the Egyptian Code, and achieved an average absorption rate of 9 ,26%, which is slightly more than half the percentage allowed in the Egyptian code.

II. Conclusion

- The annual rate of construction and demolition waste production in Egypt occupies a large part of the total solid waste production in Egypt.
- The shortcomings in solid waste management in general and construction and demolition waste, especially in the noticeable absence of intermediate stations, industrial recycling complexes and sanitary landfills.
- Egyptian laws include texts for the disposal of construction and demolition waste, and do not include any clauses indicating the limitation of their generation.
- The institutional arrangements for the management of construction and demolition waste in Egypt are incomplete and require a lot of development and modification.
- To remedy the shortcomings in the institutional arrangements for the management of construction and demolition waste, attention must be paid to the establishment of intermediate stations and industrial recycling complexes and to choose their locations accurately so that they are as close as possible to the main sources of waste. The researcher suggested establishing 10 intermediate stations in governorates: Cairo, South Sinai, Giza, Luxor, Alexandria, Red Sea, Damietta, Aswan, Suez, Kafr El Sheikh, Gharbia, because these governorates have many available places to recycle process.
- Construction and demolition waste is a wasted and untapped national wealth that can be exploited in the manufacture of units of building bricks, provided that the system responsible for managing solid waste in general in Egypt is developed.

- A brick made of construction waste with rubber achieved the highest amount of thermal insulation and the least amount of pressure bearing at a relatively high cost of about 674 pounds per thousand bricks.
- A brick made of construction waste and broken glass achieved a thermal insulation capacity of about one and two-thirds of the capacity of clay bricks and about twice that of cement bricks for thermal insulation at a cost of about EGP 542 per thousand bricks.
- A brick made from construction waste and a marble slab achieved a thermal insulation capacity of about one and a half times that of clay bricks and about one and three quarters of the thermal insulation ability of cement bricks at a cost of about EGP 510 per thousand bricks.
- A brick made of construction waste and iron kiln slag achieved a thermal insulation capacity of about one and a third of the capacity of clay bricks and about one and a half times that of cement bricks for thermal insulation at a cost of about 502 pounds per thousand bricks.
- Through the use of building units manufactured from construction and demolition waste, the electrical energy consumed for cooling and air conditioning can be significantly reduced.
- Building units manufactured from construction and demolition waste have a relative economic and environmental advantage over clay and cement bricks that are commonly used in residential buildings in Egypt.

Recommendations & Further Works

- Parliament should recommend adding some principles and practical directions to the executive regulations of the Solid Waste Management Law to manage the quantities and types of construction and demolition waste in Egypt.
- The researcher recommends that those who try to knock on the door of this research point try to reduce the proportion of cement or search for an alternative to cement as a bonding material in the manufacture of recycled bricks due to its high price, in order to achieve the highest possible environmental and economic benefit.
- The researcher recommends trying to search for other alternatives in the waste of demolition and construction and trying to apply the experimental method in using it to reach practical and logical results based on laboratory experiments.
- The researcher recommends trying to make a total replacement for one of the components of the mixture used in the manufacture of building brick units instead of partial substitution and trying to conduct experiments on it because this may reduce the material cost of the proposed bricks.
- Contractors must adhere to the policy of separation from the source as much as possible - especially in construction waste more than demolition - so that it is easy to deal with the resulting waste properly.
- Contractors must abide by the laws of construction and demolition waste management, in terms of transportation and burial, and not to conduct these random operations that harm the environment and make it difficult to benefit from these wastes.
- Contractors must commit to submitting monthly or at least annual reports to the authorities concerned with the localities and governorates on the volume and quantity of waste transported to intermediate stations or legitimate landfills in order to form an information base based on accurate data.
- The government, under the supervision of the Ministries of Environment and Local Development, should work on studying the establishment of intermediate stations in the governorates, which are expected to be hotbeds for gathering the largest amount of construction and demolition waste.
- The Egyptian government must establish a sector in the localities that is affiliated with the Ministry of Environment to collect construction and demolition waste from each governorate because it is considered a wasted national wealth.
- The government should encourage the private sectors to invest their money in recycling construction and demolition waste to create new job opportunities and benefit from this waste as a raw material for many industries and avoid its harmful effects on the environment resulting from its accumulation.

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Figures

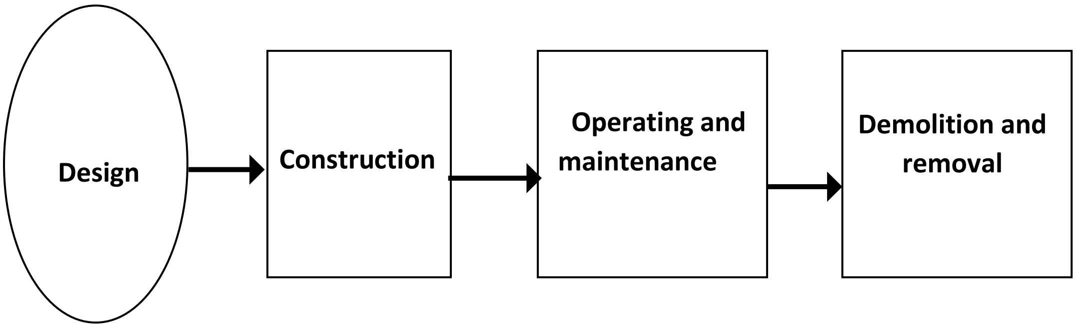

Figure (1): Traditional lifecycle of building.

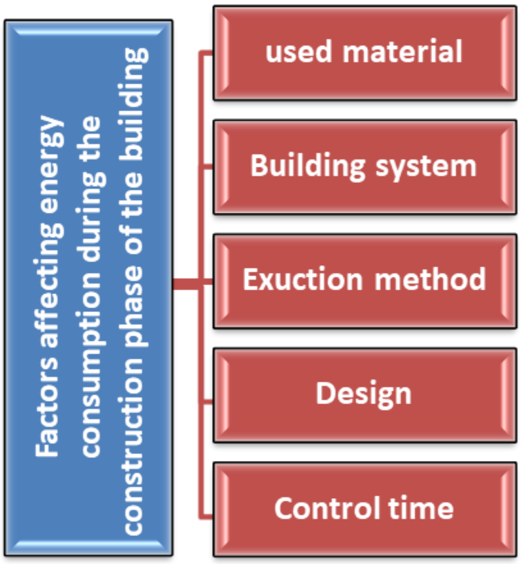

Figure (2): Factors affecting energy consumption during the construction phase of the building.

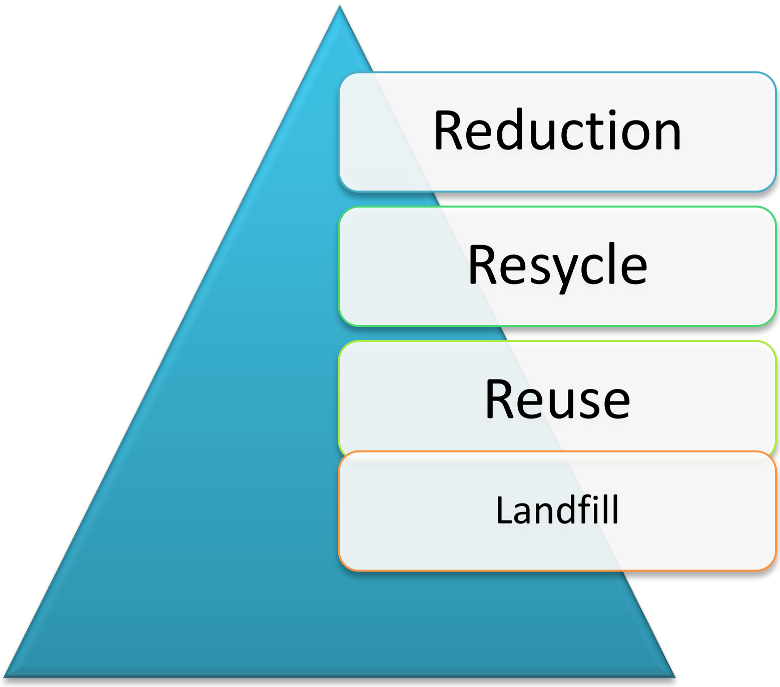

Figure (3) options for dealing with construction waste.