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Factors Affecting Sustainability of Project Management Processes

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ABSTRACT

There are major efforts carried out by governmental institutions to improve the sustainability of construction projects. One of the most important problems and challenges facing project's sustainability is deterioration of urban and short life time of building. The aim of this study is to identify the main factors affecting the sustainable projects in order to develop a program to evaluate the sustainability and increase the efficiency of construction by re-evaluating the most affecting factors in the sustainability of the projects and identify the obstacles facing implementation of sustainable buildings.

To achieve the research objectives, a questionnaire was designed to gather information from engineers of different specializations in construction sectors. The questionnaire includes eighty nine factors which are the most important factors affecting the sustainability of construction projects through the five stages of the project. Two hundred questionnaire were distributed and only one hundred and nine responded .The data were analysed by using one of a statistical programs SPSS. The analysed results shows that the selecting sustainability material, developing appropriate rates for all project resources carefully, planning maintenance for construction work and following work that was carried out according to the requirements and specifications of contract. These are the most critical factors which help in sustaining construction, whether before or during construction, and making routine and corrective maintenance of the most prominent factors that help to maintain the service life of building and sustaining it after its establishment.

A Program was developed to evaluate the sustainability of construction either before or after construction, in order to increase the efficiency of a sustainable project and maintaining its life span. The output of the program was represented as a degree of sustainability by evaluation during a certain stage or all the stages of a project and re-evaluating the most important elements affecting on sustainability of project, reaching its highest level of sustainability. It is concluded from the program of evaluating sustainability that the degrees of sustainability may varies from one building to another according to the importance, the volume of construction, the period in which the evaluation is done and the faced challenges. The construction sector in Egypt needs to disseminate the concepts and Principles of sustainability more broadly as it is not applied enough in Egypt.

Keyword: Time - Cost - Quality - Questionnaire - Evaluation -Sustainability-Project Management-Construction

1. INTRODUCTION

Recently, the construction industry has achieved a large and noticeable development due to its relation with all sectors whether educational, residential or touristic...etc. Because the construction industry is one of the most consuming fields of resources and energy through the construction process, it was necessary to evaluate the sustainability of construction projects in order to prolong the life-span of the building. This is by forecasting, planning, regulating and controlling the resources of the project in order to keep resources and energy of future generations and also to achieve its objectives through the various stages of the process.

1.1 Background

Studies show that the construction sector consumes (40-50%) of the world's energy. Also, more than half of the primary natural resources (about three billion tons per year) are used in the construction field [1].Therefore, the invitation continues to deal with the environment in a more balanced shape to search for planning and designing alternatives of modern cities and new residential complexes through the use of natural energy sources, including new and renewable ones. [2]

Previous research focused on environmental issues, concerning economic and social issues, and their role in creating a sustainable building and prolonging the life-span of the building with ideal costs and reaching the highest quality during construction and operation. [1]

1.2 Research Problem

a) The life-span of construction projects in Egypt was short, resulting wholly or partially collapses.
b) The continuous depletion of resources and energy used in construction industry is so large quantities which affects the future needs of the coming generations.
c) It may cause imbalance among available resources, population growth and noticeable development in construction industry.
d) The meaning of "sustainability" isn't widespread in construction industry and team work.

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1.3 Research Aim

a) Identifying the most influenced factors affecting the sustainability of construction projects.
b) Applying a model to evaluate the sustainability of projects in construction field through different construction stages.
c) Increasing the efficiency of the construction during or after construction.
d) Integrating the concepts and principles of sustainable development in the process of decision-making during the different project stages.

1.4 Scope of the Study

The research will focus on evaluating the sustainability of construction projects – residential and service projects - due to the increase of these projects in Egypt in the recent years. It also focus on:

a) Identifying the most important factors affecting the sustainability of projects during the construction process.
b) Identifying the obstacles facing the construction industry for a sustainable long-term building before, during and after construction.
c) State support to improve public awareness towards sustainability and to apply it within the priorities of the construction industry.

2 LITERATURE REVIEW

2.1 Definition of Sustainability

There are many definitions for sustainability which are as the following:

2.1.1 General definition

"Satisfying needs of present generations without affecting the ability of future generations to get their needs."

2.1.2 Definition of Sustainable construction

Sustainable construction can be defined as a construction process which is carried out by incorporating the basic objectives of sustainable development. It is also a process that provide appropriate solutions to the environmental problems of building to become intelligent building environmentally using renewable energy and responding to local conditions.

From the above definitions: it is clear that the definition of sustainability of Construction is to prolong the lifespan of the building using renewable energy and resources in the construction process and reducing the environmental impact throughout the lifespan of the building with low costs and high qualities, not to damage the future needs[6].

2.2 Management of Sustainable Projects

Management is defined as: planning, organizing, directing and controlling the resources of all types in a certain period of time to achieve a certain goal [6].

To implement a sustainable building, it was necessary to identify the most important points that should be followed to reach a sustainable building through the construction stages of the project [7] as the following

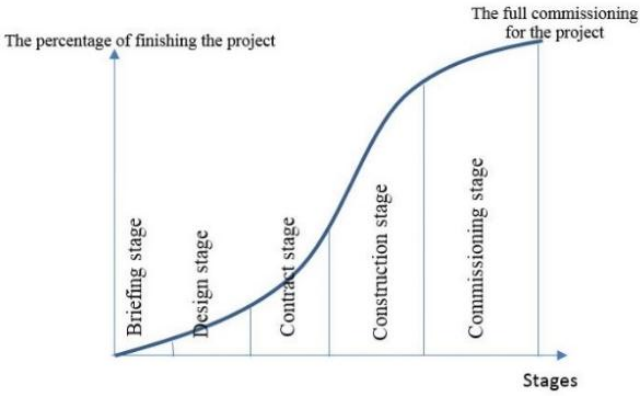

Figure (1) Stages of the project [8]

2.2.1 Briefing stage

It is the stage of birthing the project as a concept reflecting the need for users. The team can write a briefing report to the owner to illustrate the briefing of implementing the project or not with putting different alternatives in the case of its existence. So that the owner can take the right decision. Then managing the necessary resources and starting the procedures for obtaining the necessary legal approval and working designs [9]. Establishing a sustainable building requires the following:

a) Estimating the time periods for the terms of the project, allowing implementation according to sustainability criteria.
b) Choosing sustainable raw materials and resources.
c) Choosing a suitable location which achieve the highest sustainability. [2]
d) Taking into account the impact of the project on the surrounding environment.[7]

2.2.2 Design stage:

Once the owner approved the briefing study and the implementation of the project, the design stage starts. In this stage the selected alternative is translated to an applicable models and then preparing a full range of architectural, construction, executive and detailed designs .It also includes identifying general and special specification in addition to establishing tables of quantities of the project. Studying the risks and identifying the best method to deal with are also considered in this stage. [9] Establishing a sustainable building requires the following:

a) Flexible design, which allows future modifications.
b) The design of the building helps in self-sufficiency of energy and resources inside the building.
c) The design should take into account using modern and advanced technology in the implementation of works.
d) Taking into account the welfare of design, the convenience of users and improving the standard of living.
e) Using raw materials which can be recycled and reused.
f) Taking into account the use sustainable materials.
g) Designing of the building shall adapt to the surrounding climatic conditions.
h) Confirming the standards of sustainable design and putting sustainable solutions.
i) Choosing the optimal systems in design and construction fields.

2.2.3 Contract stage

This stage begins after or during last part of the design stage. The contract is depending on the availability of construction documents, the importance of the desired implemented project, and the timetable for implementation, the selection of a contractor, signing a contract and determining the obligations of all parties to the project and how the risk is managed. Establishing a sustainable building requires the following:

a) Items formulated in contract using a style which is unlikely including more than one interpretation or contradiction in the terms of work.
b) On writing contract must take into account the principles and the concepts of sustainability and with the participation of expert's opinion.
c) General and special requirements for the project take into account the principles and concepts of sustainability.

2.2.4 Construction stage

It is considered one of the most exciting executive stages, as it consumes most of the time and about 85% of the total cost. It means the transformation of what has been designed into reality under the specifications and requirements that have been agreed in the contract, making regular evaluation, implementing a high-quality work and making the necessary tests for the work done.[7] Establishing a sustainable building requires the following:

a) Putting a realistic performance rates for labor, equipment and raw materials.
b) Control over the rates of performance for all project resources as workers, raw materials and equipment.
c) Quality control, monitoring and recording the results of quality activities and evaluating the performance.
d) Procedure tests and examinations on the materials used.
e) Reviewing alternative solutions for the problems facing the sustainable building.
f) Ensuring the adherence of the material suppliers in dates according to the schedule for implementation.
g) Permanent communication between the designer and executive engineer that helps in solving many of the different points of view.
h) Reviewing the timetable for implementation of the program and action plan.
i) Site planning, removing any waste from the site and temporary primary attachments.

2.2.5 Commissioning stage

This stage is considered the last stages of implementing the project and its importance varies according to the nature of the project and it is divided into three parts: (the primary handover - the final handover - the operation).

Establishing a sustainable building requires the following:

- Routine and corrective maintenance for the building.
- Reviewing the performed work to make sure that the implementation in accordance with the requirements and specifications of contract [9].

Kibert - specialist in the construction - also developed a "conceptual model for construction projects," that achieve the principles of sustainability management and called it "sustainable constructions", the model shown in Figure (2) consists of three axes:

- The horizontal axis is for the major resource projects, which are consumed during the construction, operation and maintenance.
- The upper oblique axis is for the stages of the buildings, constructions and facilities.
- The vertical axis is for the principles of sustainability that must be followed and pursued in all the resources described in the horizontal axis during all stages of the project described in the oblique axis.

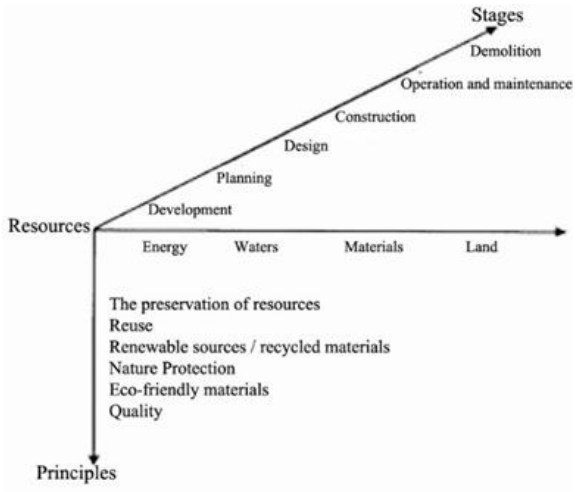

Figure (2) Sustainable Construction for Kibert[10]

2.3 Evaluating the Sustainability

The methods of measuring sustainability vary from one area to another depending on the specified specialization or the desired purpose. The criteria to measure sustainability varies according to the different aspects of sustainability [The economic aspect - the social aspect - the environmental aspect] according to the three bottom Line which are defined as the balance among the three complemented aspects of sustainability. Note that there is an equity between the three aspects as in figure (3) [11]:

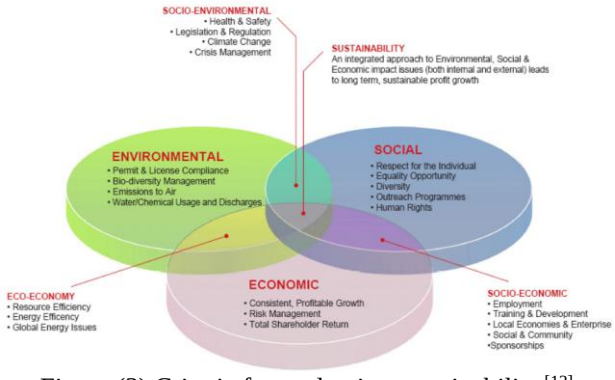

Figure (3) Criteria for evaluating sustainability [12]

2.3.1 Economic criteria

It is defined as processing of cash flow related to the actual economy of the life cycle of the building, it is one of the main criteria in the measurement and evaluation of sustainability.

Therefore the role of economy is prominent in evaluating the level of sustainability and it is divided into two levels [13].

- The general level (Re-using and savings in the materials consumption, Recycling and reusing)
- The private level (Observing the designs and fine detail from exploiting for each space and area)

The indicators that are affiliated to economic standard are as the following:

Using of the building - Maintenance and repair - Waste treatment - Economic value of the building - Benefits arising from the building.

2.3.2 Social criteria

These criteria should be used to describe the social problems and issues surrounding the building to create equal opportunities in obtaining the basic services. The indicators that are affiliated to social standard are as the following:

The quality of the building that is practically a place to live - Health and Safety problems -Obtaining services - User satisfaction.

2.3.3 Environmental criteria

The laws to protect the environment significantly is contravened with the evolution and the development. States shall enact laws to protect the environment, forgetting the great exploitation of natural resources which harm the environment itself. The protection of urban environment should be of interest to all considerations. This standard is based on compatibility and adaptation with the environment. The indicators that are affiliated to environmental standards are as the following:

Building performance- Durability and life span- Construction site- Depending on renewable energy and non-depletion of non-renewable resources [13].

2.3.4 Other special parameters

There are also other special parameters as the measurement of creativity and innovation in design. Depending on the technology, the development processes and attention to scientific aspect are the only way to get the sustainable project, where the role of creativity and innovation is appeared in design and its impact on sustainability

2.4 Raising the Efficiency of Construction

The factors which are used to raise the efficiency of construction are as the following:

2.4.1 Selection of sustainable building materials

Building materials play an essential role in enhancing sustainable projects and contributing to economic prosperity. Using of building materials has a substantial impact of the environment, mainly because of the large quantity of non-renewable resources with the potential for depriving future generations of their use [12].

To implement the objectives of sustainability, one should select a sustainable building materials to be used in the construction of the project which is urgently needed. The careful selection of sustainable materials for construction is the easiest way for designers to start integrating the principles of sustainability in the construction project [14].

2.4.2 Performance rates of project resources

One of the main outlines in project management is to optimize the use of available human and physical resources to achieve the best investment for these resources and to provide the highest quality, in time with ideal cost. Performance rates were measured by the researcher through the Council of the future leaders of Arab Contractors Company taking into account the performance levels to reach a sustainable building[15].

2.4.3 Check list for the implemented work

In the past, the administrative regulations focused on achieving the expected objectives using simple statistics and random samples. With the beginnings of the twentieth century, the focus shifted to the effective performance of the team work; by doing definition of the partial detailed problems between processes through a strategy of continuous improvement cycle. The twenty first century focused on (QMS) quality Management Systems to combine Sustainability and transparency as ground work to achieve meaningful link between quality and satisfying the investor and the consumer. [2] [16]

2.4.4 Maintenance of the building

Maintenance of a building means a group of scientific techniques and its management, which includes the full supervision of the building after the implementation for life-time to preserve the architectural, structural and mechanical components or rehabilitation again so that it is fit for use and perform its functions well. [17]

a) Planning maintenance work (before construction):

Putting an integrated plan for maintenance of each building is very important to preserve the life of building and thus the national wealth of the country. Generally, the preservation of the maintenance process at regular intervals "preventive maintenance" is important because it prolongs the life of building and maintains the estate's wealth. It is also possible to integrate concepts and principles of maintenance for some construction stages, which facilitates maintenance operations [18]:

1- Maintenance during the design process.
2- Maintenance during the construction process.
3- Maintenance during operation and usage.

b) implementation of the necessary maintenance work (after construction):

Whatever the building was sustainable in its design it must take into account that it is operated responsibly. Guarantee and maintenance [O&M] operation and maintenance personnel and maintaining is considered to be a part of the planning for the project and helps to maintain the sustainability criteria that is designed at the beginning of the project and integrates every aspect of sustainable construction in the operation and maintenance stage of the life of the building. When buildings reach to the end of their useful life, it usually has to be demolished. Disassembly is a way to harvest what is usually considered "waste", and re-used as useful materials for building. This requires calculating the period of time for repairing, inspection and maintenance work to achieve lower cost and keep the longer lifespan of the building[19] as shown in figure(4).

The process of determining the time of maintenance depends on the estimated cost for maintenance compared to the probability of collapsing the building.

Total cost [Tc] = Kfa [1 - probability of collapse] [F1] + Kn [probability of collapse] [F2]

$F1 = [[m + 1]^{n} -1] \setminus [[m+1]^{tp} -1] [m + 1]^{n}$

$F2 = [[m + 1]^{n} -1] \setminus [[m + 1]^{-tp} -1] n [m + 1]^{n}$

[Tc] means total cost through period of time required periodicity for maintenance process, which is achieving less expensive

tp = is the period of time for the proposed maintenance

N = is the whole lifespan of the building

Kfa = is the cost of the examination and repair

Kn = is the cost resulting from the collapse

M = Initial repairing cost

F1 = First examination F2 = Second test

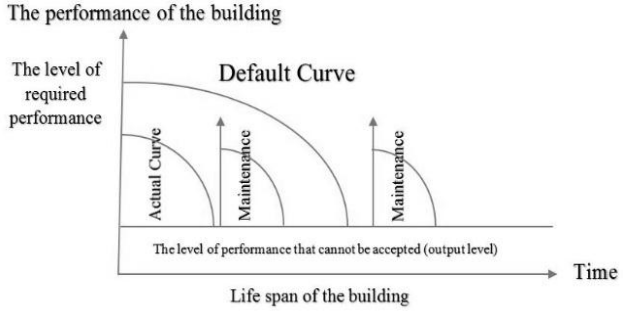

Figure (4) Relationship between lifespan and performance level [7]

3. DATA COLLECTION

This study will use questionnaire to accomplish the aim of this research. The questionnaire should be designed to help the researcher to analyze data quickly and accurately to express the opinion of the person who fills out the questionnaire by using likert scale and represent important degree ratios as shown in table(1) according to the three aspects of the project (quality, cost and time).

Important	1
Moderate important	2
Weak	3

Table (1) Likert scale - Degrees of evaluation

3.1 Questionnaire Design

The questionnaire is designed due to interviews with many engineers to reach to the most effective factors in the sustainability of the projects. The questionnaire includes the most important 89 factors that affect the sustainability of the building, before and after construction and it consists of two parts:

Part (A) includes information about the person who fills out the questionnaire to find out the opinions and the orientations of all specialization. The information includes the number of years of experience, existing business, the sector in which he/she is employed, the field of work and specialization. Also the extent of his/her knowledge of the principles and concepts of Project Management Professionals and description of each engineer. Also concerned with the company's classification, its class and company's plans to apply the concepts and principles of sustainability for the implementation of the sustainable projects.

Part (B) includes:

i. Identifying the extent of the impact of each of the following factors on the sustainability of construction projects during the five stages : (Briefing stage - Design stage - Contract stage - Construction stage (implementation) - Commissioning stage) by putting (√) for each factor according to Time , Quality and Cost

Quality: means the optimal consumption of energy and renewable resources for not harming the environment and compliance with specifications.

Time: means the sustainable long-term building from the beginning until the end of the life span.

Cost: A total of what is spent on the building from the beginning of its construction until the end of life span**.**

ii. The obstacles that face the construction industry to implement a sustainable long-term building before, during and after construction.

iii. The procedures that can be taken by the State to improve public awareness towards sustainability and its application within the priorities of construction industry.

3.1 Pilot Test

The purpose of experimental test is to make sure that the respondent understands the questionnaire and to find out the shortcomings and ambiguities. The questionnaire was translated into Arabic to help the respondent to understand it. A number of questionnaires is distributed to engineers carrying certificates of project management or scholars in the field and also to people with experiences. So that the questionnaire will have a large rate of confidence so that there will not be any proportion of hesitation in answering the questionnaire.

3.2 Research Sample

The questionnaire is based on personal interviews with awarded engineers in this field with the help of the opinions of experienced engineers in addition to the management of construction projects' book and PM book 4th.The sample of the research was chosen to represent the companies that work in construction field (residential - services). It was chosen to be very carefully in the selection of the sample and was chosen to take into account all specializations, years of experience, the nature and scope of the work of the engineer according to the Egyptian Federation for Construction and Building Contractors, as shown in table(2).

Classification	1st	2nd	3rd	4th
Number of companies	168	137	195	488

Table (2) Number of Egyptian construction companies in each class in infrastructure field

The following equation was used by Said Saker[20] and many other researches

$$SS = Z^2 * P * (1-P) / C^2 \quad (1)$$

$$New\ SS = SS / (1 + ((SS-1)/POP)) \quad (2)$$

Where:

SS = Sample size Z= Z value.

p = percentage of picking a choice, expressed as decimal (0.5) used for sample size needed).

C = confidence interval, expressed as decimal.

New SS = Correction for finite population

To ensure good representation of each stratum, the following number of each category of certain class as given in table (3) has been selected:

Company's classification	Number of companies (population)	Number of companies of sample
First	168	30
Second	137	25
Third	195	35
Fourth	488	88
Total	988	178

Table (3) Sample Size

3.3 Data Analysis

After collecting data, the answers of the questionnaire were coded to enable them to be computer processed. The questionnaire is analyzed using Statistical Package for Social Sciences (SPSS). This program provides important data such as mean, median, mode and other statistical terms which are suitable in achieving the objectives of the study.

4. QUESTIONNAIRE ANALYSIS

This includes analysis of the information obtained from the questionnaire after being processed by Statistical Package for Social Sciences "SPSS". Two hundred questionnaires were distributed (One hundred and sixty paper copies through personal interviews in addition to forty distributed to other engineers through Electronic Network (http://goo.gl/I6qTRD).

The number who responded to the questionnaire is 83 hardcopy and 26 electronic questionnaire i.e. a total 109 with percent 55%. Data was analyzed to establish a program for evaluating the sustainability of construction projects and working to raise the efficiency of the construction by re-evaluating the most important elements affecting sustainability of projects.

4.1 Data Analysis

4.1.1 Field of work

By analyzing results concerning the field of work of engineers, it's clear that the largest ratio is for the construction engineers and technical office engineers, which gives a great confidence to the results of the questionnaire due to great experience of construction and technical engineers who are more frequently to face obstacles and problems of building industry.

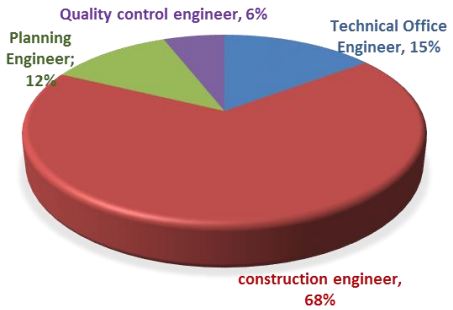

Figure (5) Respondent classification by Field of work

4.1.2 Years of experience

By analyzing the results concerning the years of experience it's clear that the largest percentage is given to 10-15 years experienced engineers which isn't few.It's also clear that the construction sector in Egypt leads to the immigration of skilled Egyptian workers, including engineers after prosperity of construction sector in arab nations and this leads to lack of experiences (5-10), (15 and more) especially in the public sector.

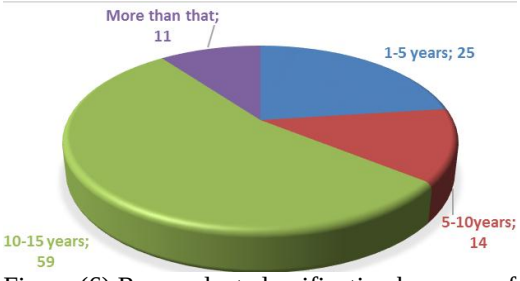

Figure (6) Respondent classification by years of experience

4.1.3 The labor sector of the engineer

By analyzing results concerning the sector which the engineer belongs to, it's clear that the ratio between public and private sector are close to each other .This benefits in applying the results to all sectors.

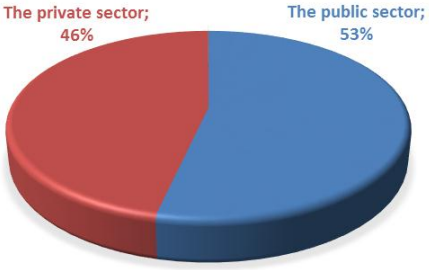

Figure (7) Respondent classification by the labor sector of the engineer

4.1.4 The nature of the project

By analyzing results concerning the nature of the project, it's clear that the most percentage is limited between the residential and service projects due to their large size of business in Egypt.

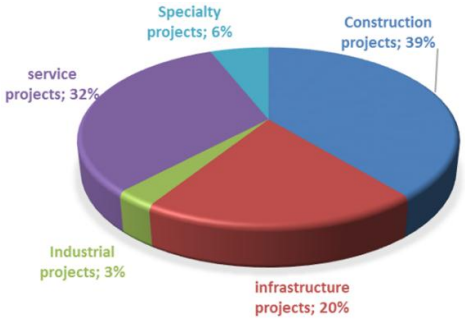

Figure (8) Respondent classification by nature of project

4.1.5 Specialization of Engineer

By analyzing results concerning specialization of engineer it's clear that most percentage is for civil and architectural engineers as it's the most interesting in the field of sustainability in the construction sector for their large experiences and are more exposed to problems which occur during the implementation.

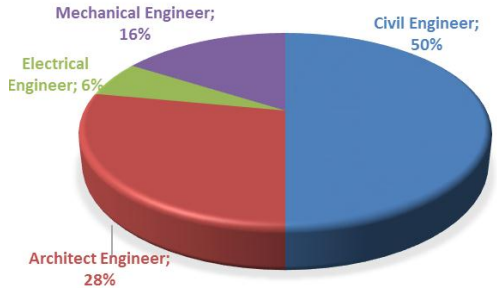

Figure (9) Respondent classification by specialization of Engineer

4.1.6 Application of concepts and principles

By analyzing results, it's clear that the concerns of the engineers about the importance of applying the concepts and principles of management in the implementation of projects is average. It is clear that there should be more efforts to enhance the management concepts and principles in the academic side and the implementation. It also gives us indication about the level of knowledge of respondents to managing projects.

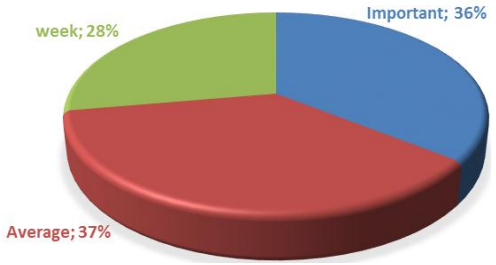

Figure (10) Respondent classification by application of concepts and principles

4.1.7 Engineer's area of expertise

By analyzing results, it's clear that the largest percentage is for engineers who work in contracting companies because of its big return when applied on construction companies to remove any obstacles or problems facing the implementation of any construction that is sustainable.

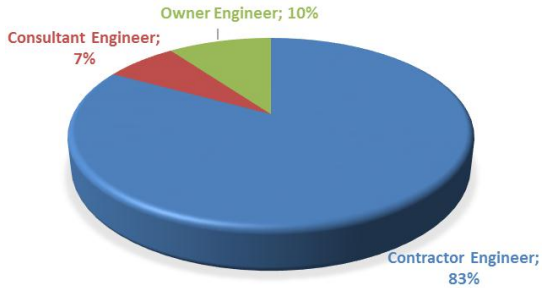

Figure (11) Respondent classification by area of expertise

4.1.8 Classification of Company

By analyzing results, it's clear that the fifth, sixth and seventh categories of the construction contractors do not care about introducing and applying the principles and concepts of sustainability in the construction projects. Their concerns are Limited on the physical return. And the first five categories of construction contractors have the most attention, and interested in the introduction and the application of the principles and the concepts of sustainability in construction projects.

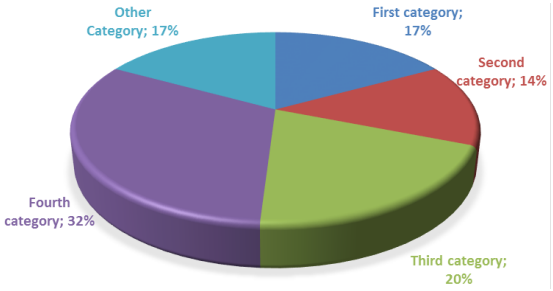

Figure (12) Respondent classification by classification of Company

4.2 Factors Affecting the Sustainability

Table(4) shows the average grade of importance of the factors mentioned in the questionnaire on the sustainability of the project through the different construction stages (Briefing stage -Design stage -Contracting stage -Construction stage -Commissioning stage). This helps in the evaluation of sustainable construction projects in order to raise the efficiency of the construction by re-evaluation of the most important factors according to the results of the questionnaire reaching the best level for sustainable project. The evaluation is divided into before and after construction.

Code	%	Factors
B7	7.01	Choosing sustainable raw materials and good project resources
E8	6.77	Putting a realistic performance rates for labor ,equipment and raw materials
F8	5.33	Reviewing the performed the work which carried out to make sure that the implementation is according to the requirements and specifications of contract.
F3	4.84	Routine and corrective maintenance for the building
F6	4.09	Making necessary tests on the implemented work
D2	3.56	Items formulated in contract by a style which is unlikely more than one interpretation or contradiction in the terms of work
C10	3.50	Choosing appropriate systems in the design and methods of construction
D10	3.39	Determining the best method for presenting the project as well as the methods of contracting
D4	3.22	Using new methods and techniques in implementation
F5	2.97	Increasing awareness among users to have the optimal use of the building
F1	2.13	Finishing all activities of the project partially or totally without shortage
C4	2.08	The design should take into account using modern and advanced technology in the implementation of works
D7	1.94	Taking into account the contract laws and regulations of each country
C2	1.93	Flexible design, which allows future modifications
D1	1.91	Writing contract must take into account the principles and the concepts of sustainability and with the participation of expert's opinion
D3	1.78	Requiring that companies are specialized in advanced implementation of those kinds of works
D9	1.67	Contract contains financing system , advance payments and how to do a physical deal
D5	1.65	General and private requirements for the project takes into account the principles and concepts of sustainability
D8	1.64	Clarifying the responsibilities and required tasks of each parties of work
F2	1.51	The owner is using the sustainable building by the same designed purpose
E11	1.50	Calculating the needs of raw materials , workers and equipment items for each project accurately
Code	**%**	**Factors**

B3	1.47	Estimating the time periods for the terms of the project, allowing implementation according to sustainability criteria
C7	1.46	Taking into account the welfare of design , the convenience of users and improving the standard of living
B4	1.42	The proper estimation for all project resources of raw materials, equipment and labor for construction
C15	1.41	Design takes into account the use of raw and renewed sustainable materials
B6	1.40	Identifying individuals and agencies related to the project
C11	1.40	Using raw materials in the project that can be recycled and reused
C5	1.37	Continuous communication between the design and implementation engineers during stages of the project
C12	1.33	Team of work of designers at a good level and have a precipitant experiences in the implementation of works
C13	1.32	Reviewing all the documents ,conformity with the public and private specifications and client's requirements
B11	1.22	The appropriate choice of the project site
E14	1.21	Quality control, monitoring and recording the results of quality activities and evaluating the performance
E16	1.17	Control over the rates of performance for all project resources as workers , raw materials and equipment
E39	1.12	Following-up , receiving works and compliance with project specifications and industry assets
E22	1.10	Providing a suitable environment for workers
E2	1.04	Reviewing all drawings , documents for the project and the absence of ambiguity in documents
B9	1.01	A detailed explanation for the business and determine the scope of the project accurately
B10	0.99	Corresponding requirements of the local entities with the concepts and principles of sustainability
B12	0.95	Identifying the initial cost to implement the project accurately
B14	0.94	Making an expected risk analysis and then a plan for the project
B1	0.90	Preparing the Briefing takes into account the concepts and principles of sustainability with the participation of expert opinion
C1	0.88	Designing a Building to resist internal factors or factors produced from users' behaviour
B5	0.85	Identifying individuals and agencies related to the project
F4	0.47	Preparing recommendations and lessons learned from the project
E13	0.46	Developing and following team work to improve their performance and raise their efficiency
E38	0.46	Drafting performance reports and measuring progress
E6	0.46	Identifying and sequencing activities and their relationship with each other
E20	0.45	Efficient project manager and his skills and experience and speed of its decision-making
E3	0.45	Determining the relationships between the various parties to the project and determining the validity of each of them
F7	0.43	The formation of committees to deliver partly and suspended works and repairing defects and end notes
E40	0.43	Taking a treatment and preventive measures to change works to rectify any negative deviation
D6	0.32	Integrated content of the contract from tables, the quantities, specifications , drawings and list of items
C8	0.29	Designing of the building shall adapt to the surrounding climatic conditions
C6	0.28	Knowledge of the design engineer by implementation methods to allow easy implementation without the complexity
C9	0.28	Taking into account the design to achieve a better exploitation of the spaces , voids and client requirements
Code	**%**	**Factors**
C14	0.28	Good planning and design of using land and Water Resources
B15	0.27	The appropriate choice of the size of the project and its suitability to the capabilities and expertise of executing company
B2	0.23	Identifying the client's requirements or the owner accurately
B16	0.23	Contacting with the relevant to collect necessary data to make designs
C3	0.22	The design of the building helps in self-sufficiency of energy and resources inside the building
B13	0.22	Determining the status of the adjacent buildings of the project and taking precautionary measures to minimize the impact
B8	0.21	Taking into account the impact the surrounding environment on sustainable building and vice versa
E27	0.15	Evaluation for implementation contractors and measure their progress
E28	0.14	Difficult weather conditions, by which the works of the project are implemented
E7	0.14	Developing appropriate time program possible for company and implementing work with high quality
E25	0.14	Preparing a detailed plan for the implementation, monitoring and closing operations according to customer's requirements
E4	0.14	The used tools and methods in implementation helping to reach to a sustainable build
E24	0.13	Periodic follow-up work and alternative plans for change requests that may occur on the project
E33	0.13	Making necessary requests which help in the construction of a sustainability building
E36	0.13	Appling requirements of health , safety occupational and environmental requirements
E5	0.13	Working on breakdown structure and the division of the work for the project as small as possible for ease control
E29	0.13	Contractor possibilities of skilled labor , modern equipment and expertise in the implementation of works
E19	0.13	Political motivation for workers to reach Sustainability building
E34	0.13	Not to order human resources workers with heavy work or more of the energy by increasing hours of working
E37	0.13	Meetings, seminars and conferences to exchange information and data among a team work
E1	0.12	Verifying the scope of the project to achieve the desired objectives of the project
E21	0.12	Technical and managing crew team work having a good level (Contractor - Consultant)
E18	0.11	No tangle in the functions of workers, leading to low efficiency of implementation
E35	0.11	Identifying roles , responsibilities and skills needed to implement the project activities
E12	0.11	Examining and testing used materials
E26	0.11	Making sure that the project plan is complete and workable
E31	0.10	Monitoring , controlling the risks ,facing and identifying a new risks
E10	0.10	Preparation of a management plan to provide the resources , time , required quality and cost
E15	0.10	Quality assurance to review the requirements of quality and making sure to use quality standards
E30	0.10	Developing plans to face the risks and work to eliminate the threat , convert it or reduce it
E17	0.10	Homogeneity between members of the team and concerning the humanity ties team work
E23	0.08	Maintenance of equipment and tools periodically to ensure the implementation of works with high quality
E9	0.07	Preparation of a plan for managing the communication between the different project amusing
E32	0.07	Ideal use of resources , raw materials , storage methods and style of handling

Table (4) Percentage of importance of different sustainability factors for the five stages of construction

It is clear from the above table that the most important factors affecting sustainability of the construction stages are as follows:

a) Before construction
- Evaluation of selecting sustainable materials.
- Evaluation of performance rates for the resources of project.
- Evaluation of planning maintenance work for the buildings.
- Evaluation of the work which carried out to make sure that the implementation is according to the requirements and specifications of contract.

b) After construction
- Evaluation of routine and corrective maintenance for the building.

4.3 Company's Plans to increase Sustainability

1. Using of sustainable materials in implementation of works.
2. Putting a realistic performance rates for labor, equipment and raw materials.
3. Oversight in the implementation of work application of the concepts and terms of quality and the concepts of safe and health in work.
4. A predictive maintenance for the old buildings in order to reform and renew the constructions to prolong their lifespan.
5. Designs should take into account the principles and the concepts of sustainability in construction projects by considering durability aspects in design and appropriate detailing.

5. PROPOSED MODEL

One of the objectives of the study is to find a way to predict the degree of sustainability of the building by knowing the most influential factors on the sustainability of construction. This will help the researcher in the re-evaluation of these factors in order to reach the best rate of the sustainability of the building. It will also present the extent of the compatibility of the building with the concepts and principles of sustainability. Because of the large number of construction fields, this study will focus on the residential and service projects. Furthermore, the program is developed to predict the degree of sustainability in construction projects and re-evaluation of the most influential factors on sustainability before or after construction .It can also help to provide minimum number of recommendations to the program's users.

The weights for each of the factors affecting the sustainability are estimated by this equation:

$$\text{Percentage of factor of sustainability no.(1)} = \frac{\text{factor's wight no.(1)}}{\sum_{1}^{89} \text{factors' wight}}$$

5.1 Evaluation

Calculating the average values of the factors that help to predict the degree of sustainability. The researcher took into account the weights purposes in case of evaluation of one or more stages separately or evaluation of all stages. Figure (13) is a chart to show how to use the program CCES.

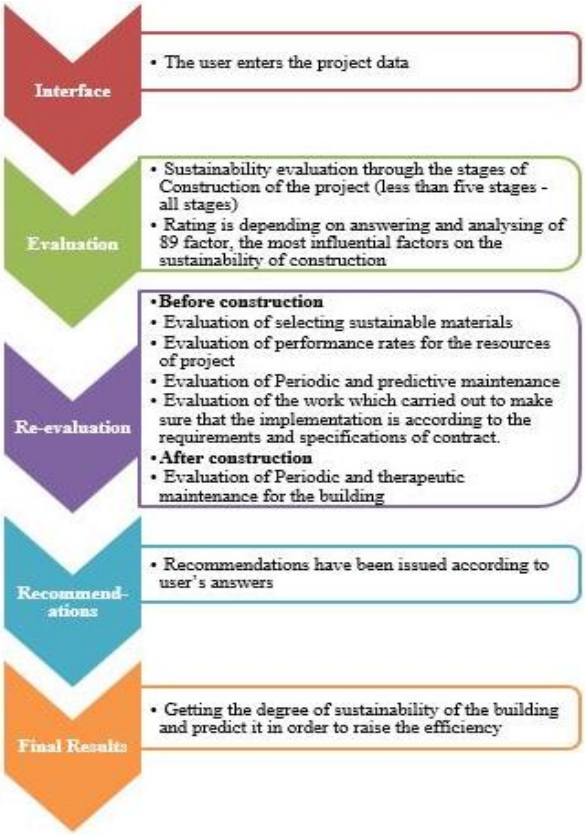

Figure (13) Flow Chart developed program CCES

5.2 Case Studies:

The goal of applying many cases is to ensure the validity of the program in determining the degree of sustainability of the building in order to predict the sustainability in any stage of the project or for the stages of Construction of the implemented building.

Building Name	Domestic Building		Completion of social housing for 20 Building (480 units)		Sheikh zayed buildings	
Evaluation	before	after	before	after	before	after
Briefing stage	8.50%	7.50%	6.80%	6.59%	16.96%	16.71%
Design stage	12.12%	11.12%	12.88%	11.32%	10.23%	9.44%
Contracting stage	12.61%	13.50%	13.04%	14.12%	19.02%	18.52%
Construction stage	14.52%	15.42%	14.33%	13.15%	9.82%	9.88%
Commissioning stage	15.44%	14.68%	15.59%	14.90%	6.15%	6.65%
Initial Result	63.19%	62.22%	62.64%	60.08%	62.18%	61.20%
Final Result	68.90%	64.45%	65.97%	61.58%	65.27%	63.98%

Table (5) Summary for residential projects cases studies

Building Name	Office Building		Mosque		Water Treatment Electrical Building	
Evaluation	before	after	before	after	before	after
Briefing stage	12.30%	9.00%	10.41%	9.08%	12.05%	10.76%
Design stage	14.50%	12.35%	14.00%	11.14%	15.84%	13.78%
Contracting stage	16.98%	16.04%	15.92%	14.50%	17.89%	14.98%
Construction stage	19.76%	15.99%	18.96%	17.64%	21.04%	19.33%
Commissioning stage	13.02%	11.59%	10.86%	10.10%	12.41%	10.14%
Initial Result	76.56%	64.97%	70.16%	62.46%	79.23%	68.99%
Final Result	91.03%	73.06%	83.50%	68.56%	91.86%	78.16%

Table (6) Summary for service projects cases studies

Table (5 and 6) shows the evaluation of sustainability of number of case studies. Results illustrate the low level of sustainability of construction and that the construction sector is in need of publishing concepts and principles of sustainability.

6. CONCLUSIONS

This part summarizes the results of the study to achieve its goals .It has been found that it should take into consideration the concept of sustainability in construction projects. This has a positive impact on the preservation of lifespan of the building, reducing the environmental impact and the constant depletion of non-renewable resources. This also coupled with ideal costs and highest quality for the building until the end of its lifespan.

6.1 The Effective Factors on Sustainability

(Before Construction)

a) Evaluation of selecting sustainable materials:

This factor gets the highest rank in this thesis by percent 7.01% and the result is compatible with many earlier studies and researches. The use of building materials play an essential role in increasing sustainable projects and contributing to economic prosperity which have a positive and large effect on the environment.

b) Evaluation of performance rates for the resources of project:

The main outlines in the project management is to optimize the use of available human and physical resources to achieve the best investment for these resources to provide the highest quality, in time with ideal cost. This factor gets the high rank in this thesis by percent 6.77% and the result is compatible with many studies and researches.

c) Evaluation of planning maintenance work for the buildings.

d) Evaluation of the work which carried out to make sure that the implementation is according to the requirements and specifications of contract.

6.2 The effective factors on sustainability

(After construction)

- Evaluation of Periodic and predictive maintenance.

Note: The level of sustainability varies from one building to another according to their services life, the faced challenges and their importance. So the concepts and the principles should be published more broadly as it is not applied enough in Egypt

6.3 Recommendations for Future Studies

Future studies should be implemented for other types of projects. It is recommended to redo this kind of research every five years to find other factors that may appear during the notable development of the construction process and propose a relationship by which the construction project's age can be estimated in years.

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