MATERIALS SELECTION IN THE CONSTRUCTION PROJECTS: CHALLENGES, CRITERIA AND PATTERNS

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Abstract - The choice of materials for engineering purposes in the construction industry is a time consuming and costly process**.** Almost always, more than one material is suitable for engineering applications in the building industry, and the choice of final materials is a compromise option that can have some benefits and some disadvantages. A large number of materials, along with the complex relationships between the various selection parameters, often make the selection of materials in the construction industry a complex and difficult issue, which is associated with uncertainties in the decision making process. In other words, selecting materials in a construction project is a multidisciplinary effort and often requires a variety of research fields such as materials science and engineering, mechanical engineering, industrial engineering, and other utilities and utilities. From the other hand, in recent decades, according to the proof of the need to observe the principles of sustainability across all industries and societies around the world, sustainable materials also attracted important role in the stability of many construction play. The selection of sustainable materials in construction projects, despite a wide variety, is characterized by a variety of specifications that determining these indicators can have positive outcomes in advancing the construction industry's goals; Determining these indicators is an interactive process that requires the coordination of various information from different sources of the project and overlooks the various factors involved in the projects at all stages of the project implementation and the decision-making process in the design process. According to the above, in this research, the research will attempt to evaluate the main criteria for selecting materials from the first stage, considering the life cycle of materials and sustainable development in construction projects, in the form of a key model. The results show that sustainability criteria can be selected in the main five technical, economic, social, managerial and environmental categories, and in each section, could be determined the sub-criteria and based on them and before the starting of the project, the selection of materials be Managed with the objectives of sustainability.

Keywords - Sustainability Criteria, Material Management, Material Selection, Challenges and Pattern.

I. INTRODUCTION

Nowadays, new materials and technologies, which are the guarantors of sustainable development in the construction industry, have come to the market, which play a very important role in ensuring the sustainability of the building. These materials directly or indirectly absorb the environment around the building energy, and this ensures a reduction in the use of fossil fuels and, as a result, the sustainability of the building and optimal energy consumption [1]. The choice of sustainable materials in a building system is the first step in the process of designing structures in construction projects, which results in the overall coordination of structures including structural form, geometry and structural components, primarily, reducing the cost and implementation time of the project, managing energy consumption and etc. ... is in the next degree. In addition, today, civil engineering projects have become more mechanized and, with the growth of the construction industry, the role of choosing sustainable materials in achieving profits and optimal production in the construction industry is vital. Selection of a proper and principled building system in construction projects is stated with different specifications. This is an interactive process that requires the coordination of various information from different sources and overlooks the factors involved in project at all stages of design and decision-making process. Of course, the matter of choosing and deciding to pick this material is still accompanied by the builder unawareness, especially in the construction industry, and it is a challenging issue. Managing these challenges, considering the most important criteria, can be a logical solution to achieving the principles of sustainable construction through the choice of sustainable materials. This process needs to be done by experts in the light of important criteria before the project starts. Considering these factors, what are the most important criteria for selecting sustainable materials in construction projects? In this research, after reviewing some of the challenges of selecting materials in construction projects, the management of material selection based on sustainability in the life cycle was considered. Finally, some effective measures in the selection of sustainable materials with this view are presented as a model for the selection of materials in construction projects.

II. LITERATURE

In recent years, there has been an increased research interest in the materials management theories and

methods. Trusty [2-5] & Woolley [6] further disclosed that existing databases on such materials and their formats are not designed to efficiently and directly provide such information to decision makers. They note that the available data on such materials are normally in the read-only format, and are stored in various operational databases that are not easily accessible to decision makers in usable forms and formats. As a result, decision-making failures during the planning and design stage (s) of low-cost green housing projects hinder their use in terms of their industrial capacity utilization in the housing industry. While several studies [2-6] have emphasized the relative importance of information access in aiding well-considered and justifiable material choices during the early stages of the design process, Wastiels et al. [7] argue that the existing material selection method focuses mainly on limited aspects of such materials, in terms of their properties and factors that influence the decision making process. Quinones [8] asserted that some low-cost green building materials, for example, contain high embodied energy that leads to ecological toxicity and fossil fuel depletion impacts during their manufacturing phase. She argued that ignoring the relevant factors or properties of any of such materials during the crucial material selection phase could reduce the effective life of that product to less than half of its normal effective life span. Moreover, Seyfang [9] and Trusty [2-6] argue that choosing the right materials for a particular project can be a very complex decision-making task, given that the selection process is influenced and determined by numerous preconditions, decisions and considerations. They suggested the idea of a decision support system (DSS) as a useful aid in making quick and critical decisions during crucial material selection process. They stressed that the considered approach to encourage the wider scale use of low-cost green building materials in mainstream housing should enable design professionals to have easy access to adequate information on the available options, hence, making the selection results more reasonable and bringing more standardization to the material selection decision-making process at the design stage. Castro-Lacouture et al. [10] note that the application of green building support/assessment tools has been widely accepted as an effective and useful way of promoting green housing construction in the housing construction industry. Loh et al. [11] however, criticized the tool for providing partial assistance in the material selection process of the whole building design as it only considers the cost of roofing materials. They argue that material selection process depends on a number of other factors such as the location, zoning and environmental regulations, demographic characteristics, etc. Yang et al. [12] describe a Multi-Criteria Decision Support System for the Selection of Low-Cost Green Building Materials and Components. Bakhoum and Brown [13] in their researches, Developed a Sustainable Scoring System for Structural Materials Evaluation. Abeysundara et al. [14] present a matrix to select sustainable materials for buildings in Sri Lanka, taking into consideration environmental, economic and social assessments of materials in a life cycle perspective. Al-Geelawee and Hammadi [15] developed a system to determine factors that affect the selection of building materials according to sustainability principles. The research objective was achieved through two stages; the first stage included a theoretical study about sustainable building materials and their characteristics, while the second stage included a practical study to determine the relative importance of the factors that affect the selection of building materials. The results of practical study showed that environmental criteria got a high importance after economic criteria among the identified factors while social criteria got the last priority in the selection of building materials. Deepening on the results of practical study a methodology for applying sustainability principles in the selection of building materials was proposed.

III. RESEARCH METHODOLOGY

This research is in the category of applied research, because applied researches is the research that applies the theories, rules, principles and techniques that are developed in basic research to solve real and actual problems. This research focuses on finding solutions to immediate practical issues and so the research is practical. The results of this study are objective and specific, and the researchers themselves are typically involved in the application of the results. This type of research is used to apply a new way to have a better society.

IV. SUSTAINABLE CONSTRUCTION

Sustainable construction is defined as follows: "Managing a clean and healthy environment based on the effective exploitation of natural resources and ecological principles". In other words, sustainable building can be defined as: a building that has the slightest inconsistency with the natural environment around itself and in a wider area with the region and the world [16]. The purpose of the design of sustainable buildings is to reduce their damage to the environment, energy sources and nature, which generally includes the following rules [17]:

- Proper utilization of resources and energy
- Avoid reducing renewable sources
- Environmental Compliance
- Development of the natural environment
- Reduce of the consumption of toxic substances or damage to nature in the construction industry

V. SUSTAINABILITY CHALLENGES IN CONSTRUCTION PROJECTS

Sustainable construction has grown significantly in recent years and has created many challenges. These challenges include economic, technical and environmental challenges, energy, technology, building materials management systems, etc. [18-20], which could be due to the lack of proper management of resources and building materials.

A. Economic challenges

The low cost is a new concept that affects budgeting and finding support tactics to reduce the cost of construction. This system can be implemented using sustainable materials or native materials available with developed technologies and applications without reducing power, performance, and building productivity. Reducing the cost of materials and building materials is possible with the proper management of resource allocation. The cost of building a building can be divided into two parts, including the cost of building materials and labor costs. In buildings at a low cost, the cost of building materials can be reduced by using available and sustainable materials [21]. The low cost of maintaining the building is also another aspect of the economic construction system that builds on the life of materials and the type of maintenance they need. These samples should be considered when selecting materials in the project. Therefore, construction materials selection must be so maintenance costs be minimize. These costs include painting, restoration, renovation, insulation, and such maintenance, which have severe effects on the environmental system. Such methods lead to high productivity in economic implementation [8].

B. Environmental factor

After a decade of effort from the first ISO publication, environmental issues and environmental management systems (EMS) in construction projects are still far away from achieving sustainable development through EMS project executives [1]. The problems of this sector to achieve sustainable development by the environmental sector in general are summarized in two areas: the non-matching of materials produced in factories with environmental standard systems (EMS) and the irreversibility of materials Manufacturing to manufacturing cycle [22]. On the other hand, the materials and building materials sector have the greatest impact on the greenhouse gas emissions of CO2. Generally, 30% of greenhouse gas emissions from CO2 and 40% of natural resource destruction in the world are due to the effects of construction materials [23]. The main goal of the development of the support system for selecting materials is to optimize the implementation of environmental issues of building materials by using reversible systems in such a way that the building materials are used for the best form of implementation in the building with the least contaminated and comparable levels And finally classified and labeled [23-27]. Sustainable construction products with the aim of creating a cyclical environment will reduce the risks of waste and irreversible production, which will reduce energy consumption in factories and reduce the use of natural resources to save. The use of renewable materials on non-renewable materials or materials with a long-term renewable capability is always preferred and preferred in construction projects [28]. The importance of renewable materials in green building materials is reflected in the reversibility of these materials, so that they, in their reuse, minimize pollution and health damage to residents and environmental issues [24]. The science of reversibility of materials has two basic requirements: one is to ensure the implementation of these materials in the building and the other to ensure that no contamination and physical damage are caused to humans due to the reuse of recycled materials in reversible materials [23]. In fact, reversibility of material must protect their fundamental foundations, including the implementation of climate, energy and environmental hygiene, in their re-use [29]. About the construction materials reversibility system, it should be noted that not only in these materials, corrective actions should be carried out in accordance with their catalogs and their standards for the return to initial properties, but also from the addition of chemical compounds and water-based adhesives In factories in the production of products to avoid their property in the construction of buildings [30].

C. Technical factor

Lightweight construction materials make shipping easy and timely delivery on site, as well as simplifying the ability to store materials. The term lightness in building materials means that more material can be moved over a specific period of time, which results in the storage and reduction of the duration time of the work. Most lightweight construction materials have a very good environmental relation, so that when used with this kind of materials, the negative effects on nature and the environment will be minimum [26]. For example, lightweight concrete can be used as insulation material in construction work. In some cases, such materials with cyclic ability can be used as other purposes, such as coal. Proper choice of construction materials will lead to the life of these materials in the manufacturing industry, which ultimately will increase the life span of the structure [23]. Long life and durability is one of the most important issues in terms of materials, construction components. This type of system is directly related to the selection and implementation of materials in

relation to the particular climatic conditions of that environment. Only the climatic condition is not the only item of material selection for long-term construction projects, and environmental changes and impacts from the use of these materials are very important [29]. The presentation of the framework for having effective factors in the process of selection and selection of materials provides a logical model for grading the functional and behavioral characteristics of construction materials science. These factors are among the key factors in the factories to provide qualitative and functional grades of materials with various environmental impacts that play a key role in the implementation of sustainable building systems. Labeling programs are evaluated using the Framework for General Development Strategic Development (FSSD). Information for developing this framework is found through comprehensive studies of sustainable development science in the manufacturing industry and targeted studies on the documents developed in this industry. The framework shows that this methodology is used for stage-by-stage decision-making strategies in companies [31], municipalities [18], as well as for complex buildings and massive materials [19].

VI. MANAGEMENT OF MATERIALS SELECTION IN CONSTRUCTION PROJECTS

Material management is an essential operation to improve the efficiency of construction projects. Materials management should be considered in all phases of the process and throughout production and manufacturing. The importance of this is because of poor management of materials can often affect the entire time, quality and cost of a project. Material planning and control is an important category, especially in order to ensure that the quality and quantity of materials and equipment, in particular in terms of time, are appropriate, reasonable and affordable as soon as they are needed [16,17]. Material management in construction projects is referred to as a set of planning, identification, procurement, storage, delivery and distribution of materials, and material management. The main objective of material management is to ensure that suitable materials are in the right place at the right time with the lowest cost. Material management is achieving factors such as proper quality, proper quantity, the availability of materials at the right time and place, appropriate materials, effective material planning, effective production scheduling, making decisions about making or purchasing, and how to The use of appropriate materials, the provision of specifications and material standards, the cooperation in product design and development, the forecast of demand and the amount of materials, the quality control of purchased material, the use of value analysis and value engineering, the development of skills workers in the management of materials [32- 35].

VIII. MATERIALS SELECTION

Selection of materials for a construction project requires considerations of aesthetic appeal and initial and ongoing costs, life cycle assessment considerations (such as material performance, availability and impact on the environment) and the ability to reuse, recycle or dispose of the material at the end of its life.

Materials must be used sustainably – this means the present use will not compromise future use by running out or harming the environment at any time. Few materials fully meet this criteria. The aim when selecting materials should therefore be to use:

1. Materials from renewable or replaceable sources
2. recycled materials
3. Materials that are in plentiful supply.

IX. SUSTAINABLE MANAGEMENT OF MATERIALS

Sustainable management of materials means providing a platform for the sustainable use of materials, Also, the integration of measures to reduce the negative effects on the environment and the preservation of natural resources during the life cycle of materials (and not just at the waste production and recycling stage), given the economic and social productivity, is the most important principle in the sustainable management of materials. Among the major policy sustainable management of materials can be mentioned the following [34]:

- Protecting natural resources (materials, water, energy, land, air and ecosystems)
- Designing and managing materials, products and processes for sustainability, with an emphasis on the life cycle of materials
- Applying all necessary facilities and policies for social, economic and environmental sustainability
- Involve all sectors of society and make them sensitive to environmental issues

The use of sustainable management of materials will have many benefits, most importantly, which will enable policymakers to take a systematic look at the environmental and material cycle of the industry, and to consider local, national and international impacts (cycles Cradle to graveyard) [19-20].

X. LIFE CYCLE OF MATERIALS

As described in ISO14040:2006 Life-Cycle Assessment – Principles and Guidelines, LCA is “a

systematic set of procedures for compiling and examining inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle." This includes all stages from the time materials are extracted through manufacture, transportation, storage, use, recovery, reuse, and disposal. The purpose of the LCA is to evaluate the potential environmental impacts associated with inputs and outputs and interpret the results of the inventory and impact phases in relation to the objectives of the study. Updated rating systems, such as LEEDv4, reward project teams that utilize whole-building LCA via a new Materials and Resources credit. LCA analyzes the burdens throughout the entire building life cycle, quantifying the embodied environmental impacts of the building and its constituent materials.

The quantitative data gleaned from LCA provides a basis by which architects and construction professionals can provide building owners with practical means and measures for initiating ecological building practices. As described by Kathrina Simonen in her book Life Cycle Assessment, "All building results in environmental impacts. …

The challenge of developing truly sustainable or even regenerative buildings has led to a desire to understand building and construction from a systems-based perspective." As Simonen adds, "Understanding a building or product from the perspective of its entire life cycle is the first step in developing sustainable and regenerative buildings." LCA results answer a multitude of questions that can inform material selection and major design decisions, especially when used early and often during the design process [36].

This approach allows decision makers and wider forecasts for policy makers in the life cycle of materials. This will prevent the transfer of problems to future generations or damage to the life chain. Also, by involving stakeholders in the production and distribution of materials, it is possible to implement better local policies and attract support from different groups [29]. Figure 1 shows this assessment key factors.
From fig.1 we could understand that Life cycle assessment considerations include:

- extraction and manufacture
- sourcing
- construction/installation
- use and performance
- End of life /waste disposal/recycling/reuse[36]

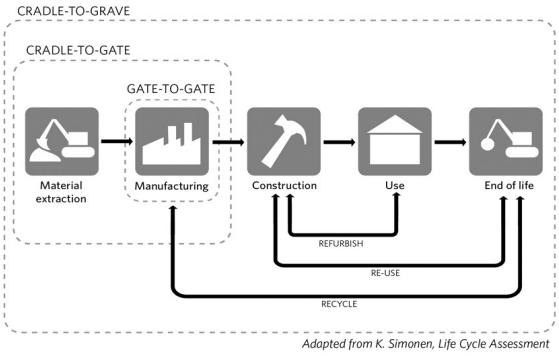


Figure 1: Cradle to grave cycle in building materials [36]

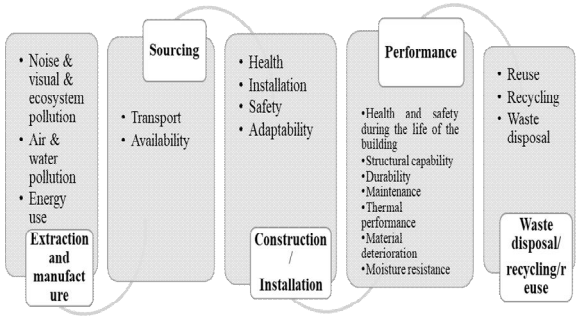


Figure 2. Key factors in choosing materials process (Life cycle assessment considerations)

Each section of this Life cycle assessment have considerations that they will been introduced in fig 2. And these considerations will be described in table 1.

XI. EFFECTIVE CRITERIA FOR SELECTING SUSTAINABLE MATERIALS

The necessity of concluding and providing indicators for the selection of sustainable materials in construction can be examined in different areas. In other words, perhaps the main reason for the need for such a system would be the same broad domain affecting the process of selecting materials. Each section or main criteria can also be divided into sub-criteria. Selected criteria should consider all dimensions of the principles of sustainable development and be comprehensible and comprehensible in a wide range of materials options, as well as for engineers, architects and construction professionals. As a model for selecting sustainable materials in construction, after extensive evaluations of studies and research, indicators and criteria are presented in the form of a template of Figure 3. As can be seen, the main indicators are categorized in five groups (1) technical, (2) economic, (3) health and environmental, (4) design management, (5) social. In each area the relevant sub-criteria are presented.

CONCLUSION

In this research, with the aim of examining the most important criteria for selecting sustainable materials

in construction projects by providing a template and sub-criteria, first we introduced the sustainability challenges in the construction industry and then tried to manage them. Therefore, after extensive studies and assessments, to review the details of the life cycle of materials, the most important sustainability indices selected materials and in every field, the following criteria were presented. The life cycle of materials showed that the construction of a building material from the discovery stage, then the stages of production and construction, installation and use, and eventually reaches the final stage of its life. People are beginning to realize that environmental impacts do not come from operations alone.

As the value of LCA in the context of sustainable building practices is becoming more widely acknowledged, architects need to find the tools and resources to conduct analyses throughout the entire life cycle of a project in order to gain the greatest benefit for both the owner and the environment as a whole. If there's one takeaway from the lessons of this course, it is the imperative architects have to influence their clients, staff, or students to care

Table 1: Key factors in choosing materials

Extraction and manufacture	Impact of extraction: noise, visual pollution, air pollution, water pollution, chemical emission, release of CO_2, damage, ecosystems, water use, energy use.
	Energy and resource use: The total energy used in the extraction, production, transportation and construction of a building material is the embodied energy of that material. As high consumers of energy, buildings have a significant impact on our environment.
	Byproducts and emissions: The processes for the production of building materials can cause pollution and emissions of CO_2 and other greenhouse gases.
sourcing	Material sources: The source of materials must be considered to keep transport costs and resultant emissions to a minimum. The heavier or more bulky materials are, the greater the transport costs will be – where possible, heavy and bulky materials in particular should be sourced locally.
	Availability: Availability may influence material selection decisions. Long delivery lead-in times must be allowed for as delays may cause project hold-ups and cost and energy losses.
	Cost: Cost considerations must include the initial cost of purchase and the life cycle costs of materials. Life cycle costs include maintenance, replacement, demolition and disposal. Maintenance cost considerations must also factor in additional environmental costs such as the emission of volatile organic compounds (VOCs) when repainting.
	Transport to site: The further materials must be transported, the greater the financial and emissions costs will be. Heavy or bulky products will have greater transport costs than lighter weight materials.
construction / installation	Health and safety during construction/installation: Some materials such as solvents and chemicals release VOCs, and materials that release dust and other airborne pollutants may be harmful to people during installation or application.
	Ease of construction/installation: Complicated installations with close tolerances can result in greater wastage or even rework being required.
	Adaptability: The more adaptable a material, the less waste will result from changing needs or tastes.
performance	Health and safety during the life of the building: Adequate ventilation can mitigate some of the effects of gas emissions, but materials should generally be selected to minimize adverse effects to occupants
	Structural capability: Materials must be selected or designed for their ability to support the loads imposed by the building over the whole life of the building. An appropriate structural system and correct selection of structural materials can reduce excess material use and waste and increase the building's adaptability for other uses.
	Durability: A highly durable material may provide the most sustainable solution if it reduces maintenance or replacement requirements but a material should also be appropriate to the expected life of the building.
	Maintenance: elements with higher maintenance requirements are likely to have lower initial costs but they may also have higher whole-life and environmental costs. The level of maintenance of a building element may also be determined by the performance requirements of the Building Code, particularly with regard to durability and weathertightness.
	Thermal performance: Building design and material selection must contribute to good thermal performance and reduced energy demand by including insulation and thermal mass in the building.
	Moisture resistance: Selected materials must be protected from moisture. Some materials have a natural moisture resistance while others must be fully protected from moisture.
	Material deterioration: Some materials deteriorate rapidly, particularly in a moist environment or if they are continuously wet, generally due to the growth of corrosion of some materials, so it is essential that materials selected have the durability required for their area of use.
waste disposal/recycling/reuse	Reuse: Materials that can be reused after the useful life of the building will reduce the need for new materials to be produced in the future. How materials are installed and fixed can have an effect on the ability to reuse them, so the shorter the expected life of the building, the greater should be the reliance on screw or bolt fixing rather than adhesive and other permanent fixings.
	Recycling: Materials that can be recycled will reduce the need for new materials to be produced, and the energy required to reconstitute materials is generally much less than required for new production.
	Waste disposal: Building design and site management should aim to minimize waste, thereby reducing waste disposal and the release of pollutants. The impact of the disposal of materials at the end of their serviceable life must be considered.

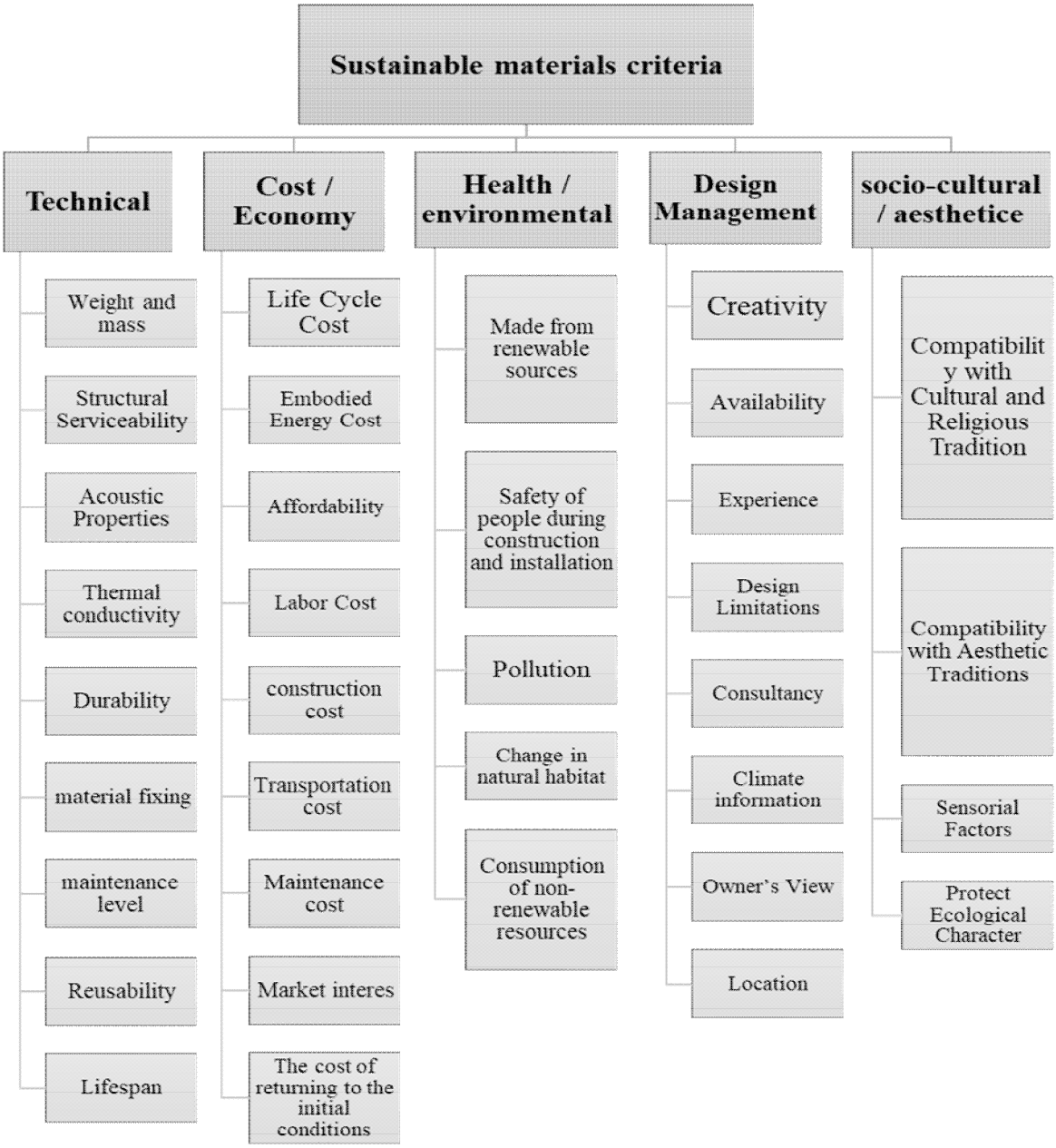


Figure3. The most important factors affecting the stability of building materials

about LCA. Accordingly, sustainability indicators should be provided for sustaining from the beginning of the life cycle. For this purpose, five main technical indicators with 9 sub-criteria, an economic with 8 sub-criteria, an environmental with 5 sub-criteria, management with 8 sub-criteria, the social index was introduced with four sub-criteria in the form of a model. As the most important sub-criteria to consider in selecting materials for sustainable construction, one can mention the following:

- Maintenance level
- Weight and mass of materials
- Acoustic Properties
- Life Cycle Cost
- Maintenance / fixing
- The cost of returning to the initial conditions
- Protect Ecological
- Compatibility with Aesthetic Traditions
- Creativity
- Availability

The presentation of the framework for having effective factors in the process of selection of materials provides a logical model for grading the functional and behavioral characteristics of construction materials science. These factors are among the key factors in the factories to provide qualitative and functional grades of materials with various environmental impacts that play a key role in the implementation of sustainable

building systems.

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