

## **Construction Managers' Perception of the Factors Affecting Sustainability in Construction Projects**

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### **Abstract**

Sustainable construction is a comprehensive concept which requires long-term planning. Moreover, construction managers play a key role in leading, planning and scheduling of a construction project. As a result, sustainability of construction projects can be affected by construction managers' decisions. In addition, for greater development of sustainable construction, affecting factors should firstly be notified. Therefore, it seems necessary to investigate construction managers' perception of the factors affecting sustainability in construction projects. To quantify managers' perspective of construction sustainability, a survey involving 15 construction managers from Iran construction industry was employed. A statistical comparative analysis used to identify the most important factors affecting sustainability performance at project-level. The results show that most of the factors affecting sustainable construction can be addressed by management teams. The findings will be useful for managers to improve construction sustainability performance at project-level.

*Keywords: Sustainability Performance, Affecting Factors, Construction Managers, Project-Level*

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### **1.0 Introduction**

The Increased exploitation of natural resources caused by technology advancement and population growth besides limited resources, resulted in the increase of importance and concern for realizing sustainable development during recent decades [1]. In this regards, holding the United Nations Summit on Environment and Development in 1972, Agenda21, Rio Conference in 1992, followed by many other national and international meetings and conferences demonstrate the growing concerned for protecting the environment for the future generations by introducing sustainable development concept [2, 3].

On the other hand, according to CIB (1998), 54 percent of energy consumed in the U.S. is directly or indirectly related to the buildings and construction activities [4]. Also, the MOC report (1999) depicts that almost 25% of the energy consumed in China is directly caused by producing building materials and implementing construction activities. Meanwhile, the solid waste from destruction of buildings is 10 to 20 times by weight as much as the waste produced from the construction of new buildings [4]. Construction industry, which creates critical infrastructures to support other industries, provided over 6.4 million job opportunities in the United States in 2004 alone. Moreover, this industry as the largest employer in Europe (7.5% of total employment), has significantly contributed to the economy (9.7% of GDP and 47.6% of the Gross fixed capital formation in 1999) [5]. Considerable effects of construction activities on environmental, economic and social aspects, illustrate the potential to help implementing sustainable development. Thus, paying attention to the concept of sustainable development in construction projects seems necessary and justifiable.

As the first approach, basics and criteria must be notified. In terms of sustainable construction criteria and principles, some research has been conducted. In this regard, Kibert (1994) proposed six principles of sustainable construction based on which Miyatake (1996) provided a comprehensive perspective of sustainable construction and identified the important roles of technology development in realizing sustainable construction [6]. Also, Hill and Bowen

(1997) introduced a framework of key principles of sustainable construction for environmental management in the construction process [1]. Ofori (1998) provided a comment on the contents of Hill and Brown, and endorsed their stress on the importance of environmental considerations in construction [7]. Huang et al. (2001) created a framework for the appraisal indicators of sustainable construction at state-level in order to help a nation to pinpoint areas needing improvement [8]. In addition, Pulaski (2004) tried to express most important approaches in order to realize sustainable development in site operations. Shen et al. (2005) briefly identified variables affecting sustainable development ability as the basis to examine the sustainability of a construction project [4]. Also, a set of key assessment indicators were introduced by Shen et al. (2011) to evaluate the sustainability of an infrastructure project [9]. However, many other important indicators were not considered in their research.

Despite the existing studies on sustainable construction principles and indicators in different levels, no effort has been done to widely identify and prioritize the most significant factors affecting sustainable construction at project-level. However, sustainability performance improvement considerably requires identifying the main areas of impact. In addition, sustainable construction, which is a comprehensive and long-term concept, requires long-term thinking and planning. Thus, construction managers, who are usually responsible for making long-term decisions, play a key role in sustainability implementation. Therefore, this research aims to identify and prioritize the most important factors affecting sustainability performance of construction projects from construction managers' viewpoint.

## **2.0 Definitions**

### **2.1 Sustainable Development**

The concept of sustainability was inherently perceived by the first human civilizations. They understood the importance of using resources on a sustainable basis and the fact that life-support systems are required for the survival of human life on the earth. World Commission on Development and Environment expressed that, even though, new civilizations have recently commenced exploring sustainable forms of development, old civilizations have tried sustainable consumption of resources for thousands of years. In the present developed world, public awareness of environment increased in 1960s and this international concern was reflected in the United Nations conference on environment in Stockholm in 1972. Also, the idea of Eco-Development; which was the precursor of the concept of sustainable development, was emerged from this conference as 'an approach to development aimed at harmonising social and economic objectives with ecologically sound management' [1]. In the same year, the Club of Rome published "The limits to Growth", a document which emphasized that concerns about pollution, environmental degradation and natural resource depletion were crucial to the long-term future of humanity. The limits-to-growth perspective challenged the pro-growth perspective and since it threatened previous ideas and theories, was subjected to severe reactions. Finally, a synthesis of these conflicting perspectives was emerged in the perspective of sustainable development. The International Union for the Conservation of Nature and Natural Resources (IUCN)" published "World Conservation Strategy" in 1980. The strategy marked a significant shift in conservation, from focusing solely on the practice of fencing off nature reserves to viewing conservation and development as integrated concepts. This strategy defined development as 'modification to the biosphere to satisfy human needs' and conservation as 'the management of human use of the biosphere to yield the greatest sustainable benefit for present and future generations [1].

According to the definition presented by Bruntland (Table 1), development is not limited to a specific area, but it can be used in all areas and for everyone or everything in the present and future. Also, this definition is based on two concepts:

- The concept of "Needs" includes conditions to provide an acceptable standard life for all humans.

- The concept of “Limits” of environment capacity to meet the present and future needs.

Sustainable development is mainly managing the relationship between meeting human needs and protecting the integrity of the biosphere. Indeed, to satisfy the society demands in such a way that critical environmental limits are not exceeded [10]. For the common future, the best attitude is meeting needs along with preventing restrictions to increase or preferably causing to decrease.

**Table 1:** Several Definitions of Sustainable Development

<b>Reference</b>	<b>Definition</b>
-World Commission on Environment and Development (WCED), Bruntland, 1987	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
-Caring for the Earth, IUCN/UNEP 1991	Improving the quality of human life while living within the carrying capacity of supporting ecosystems
-International Council for Local Environmental Initiatives, ICLEI 1996	Development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built and social systems upon which the delivery of those systems depends
-Amsterdam Treaty, 1997	Determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development and within the context of the accomplishment of the internal market and of reinforced cohesion and environmental protection, and to implement policies ensuring that advances in economic integration are accompanied by parallel progress in other fields
-(Sage, 1998)	Refers to the fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the Earth’s natural systems
-Forum for the Future, UK’s Sustainable Development Association (Parkin, 2000b)	A dynamic process which enables human all people to realize their potentials and improve the quality of their life in ways that simultaneously protect and enhance the Earth’s life-support systems

## **2.2 Triple Bottom Line**

Sustainable development is defined based on three main themes of economic, social and environmental (Fig. 1) which is known as Triple Bottom Line:

### **2.2.1 Social Sustainability**

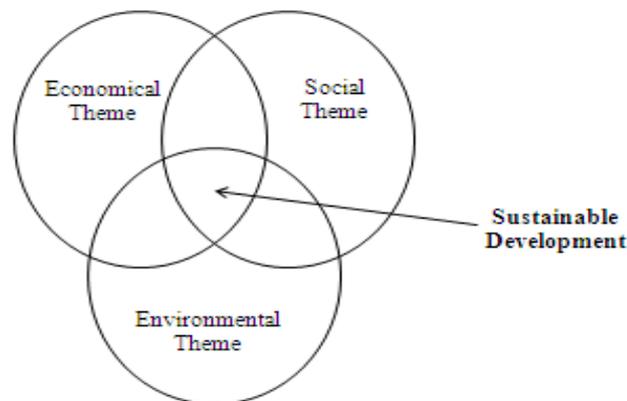
The social sustainability is providing an appropriate level of prosperity; including physical and psychological, for community members. This field of sustainable development includes subgroups and issues such as peace and social security, trust, training, developing awareness, knowledge and skills, employees’ health and safety, recruitment, communications, work environment efficiency, creating opportunities for leisure-cultural activities, reduction of crime commitment and providing services for disabled people.

### **2.2.2 Environmental Sustainability**

The philosophy of environmental sustainability is to deliver the earth to future generations in a way better than what we had. According to this definition, human activities can result in a sustainable environment, if they live without destroying environment and over consuming natural resources. So, materials must be totally made from recycled materials or renewable resources, waste recycling must be done completely, renewable and clean energy resources such as wind, solar, nitrogen and geothermal energy must be used in order to conserve energy, natural diversity must be protected and the emission of greenhouse gases must be reduced.

### **2.2.3 Economic Sustainability**

Economic sustainability returns to economic boom and reduction of financial losses, lowering expenses and accelerating investment return. Some issues such as investing on human resources and facilities to create competitive economy, job opportunities, dynamic local economy, enhancing added value to the earth and crating markets and new economic opportunities are related to the concept of economic sustainability.



**Figure 1:** Sustainable Development Themes

## **2.3 Sustainable Construction**

The term of sustainable construction is generally used to express the responsibility of construction industry in achieving sustainable development [1]. In other words, sustainable construction is a way of helping the achievement of sustainable development in construction industry and is based on three main bases of environmental protection, social welfare and economic prosperity [11]. Environmental sustainability is concerned with the extraction of natural resources and built environment which includes construction activities that can cause severe adverse impacts on the environment. Social well-being is related to human feelings: security, satisfaction, safety and comfort and human contributions: skills, health, knowledge and motivation. Finally, economic sustainability is relevant to project financial gains for the benefits of the clients, constructors, public and the government [11]. Table 2 illustrates several important definitions of sustainable construction.

**Table 2:** Several Definitions of Sustainable Construction

<b>Reference</b>	<b>Definition</b>
-1st International Conference on Sustainable Construction, Kibert, 1994	The creation and responsible management of a healthy built environment based on resource efficient and ecological principles
-Huovila, 1999	In its own processes and products during their service life, aims at minimizing the use of energy and emissions that are harmful for environment and health and produces relevant information to consumers for their decision-making
-CIB, 1999	Official definition: a way of building which aims at reducing (negative) health and environmental impacts caused by the construction process or by buildings or by the built-up environment More precise definition: the reduction in the use of natural resources and the conservation of the life support function of the environment by construction processes, buildings and the built-up environment under the premise that the quality of life is maintained
-Chang et al. 2000	Low environmental impact, high contact with the environment, amenities and health
-Plessis et al. 2002 (Agenda 21 for Sustainable Construction in Developing Countries)	A holistic process aiming to restore and maintain harmony between the natural and the built environments, and create settlements that affirm human dignity and encourage economic equity
-Huang and Kou, 2002	Environmentally friendly construction for achieving sustainable coexistence with the natural environment throughout the stages of planning, design, construction and service life, stressing environmental ethics including consumption of minimal energy and resources, harmony with the environment and sharing with later generations
-Architecture and Building Research Institute, 2003	Architectural design geared towards human health and comfort, pursuing coexistence with the global environment, and fostering the sustainability of the people's living environment. Buildings should consume relatively few natural resources and manufacture relatively little waste

### **3.0 Methodology**

#### **3.1 Affecting Factors Identification**

Previous investigations have not properly identified factors affecting the achievement of sustainable construction. Therefore, recent studies were precisely reviewed to identify factors affecting sustainable construction in order to become an appropriate reference for all the future studies. Some of the existing research studied and classified the sustainable construction criteria. These criteria may exactly be the affecting factors or may contribute to recognize and extract the factors by a little change in existing attitude. For example, the factor of "Utilizing Clean and

Renewable Energies” was understood from “Renewable Energies” as a sustainable construction criterion. Moreover, some of the other studies which provided some solutions for sustainable development implementation were used as a reference to extract the affecting factors. For instance, the factor of “Neighborhood Disturbance” has been derived from a research suggested pre-fabrication method. It has been suggested as an appropriate solution to achieve sustainable construction because the neighbors’ comfort can be maintained as a benefit of this method. Also, some studies have presented the assessment indicators which can be literally considered as the factors affecting sustainable construction. Finally, through studying previous research and integrating the factors affecting sustainable construction, 64 factors identified and classified into 5 groups as illustrated in Table 4. Moreover, some of the factors identified by the experts’ opinions denoted as Experts.

### **3.2 Relative Importance Determination**

At this stage, in order to determine the most important factors, a questionnaire survey was set and given to a group of experts including construction managers in the construction industry of Iran.

#### **3.2.1 Survey Setting**

Initially, a comprehensive framework containing the affecting factors was set to ask experts’ opinions. Construction Managers were invited to indicate the significance of each factor in improving sustainability performance of construction projects, using a five point Likert scale. The scores of 5, 4, 3, 2, and 1 considered to represent very high, high, medium, low and very low significance in achieving sustainable construction, respectively. At the end of the survey, a list of effective factors definition was provided to clarify researchers’ purpose and uniform participants’ views. Thus, possible problems and uncertainties in understanding effective factors could be eliminated by referring to the list.

#### **3.2.2 Expert Group**

The success of a survey clearly rests on the combined expertise of the participants who make up the expert panel. There are two key aspects to panel composition: panel size and panel member qualifications. A panel of 10–50 participants was previously recommended, whereas reasonable results can be obtained with a homogenous group of 10–15 experts. It is generally regarded that as the number of members increases, the reliability of a composite judgment increases. Thus, an expert panel of 15 construction managers with more than two decades experience from different construction projects were employed to indicate the significance of each indicator (Table 3). This number was felt to be sufficient with a composition of highly qualified panelists [12].

**Table 3:** Construction Managers’ Area of Expertise

<b>Area of Expertise</b>	<b>Number</b>
Construction Management	5
Environmental Engineering	3
Geotechnical Engineering	2
Transportation Engineering	2
Water Resources Management	3
<b>Total</b>	<b>15</b>

### 3.2.3 Survey Distributing and Data Gathering

The surveys distributed among the experts through a two-round method. In the first round, experts' comments and consultations were received, some factors were eliminated or merged and some others were added to the list of factors. Then, the effective factors were again distributed among the experts in a format similar to the first round. At the end of second round, after collecting surveys and analyzing data, the average values were calculated as the relative importance of factors affecting sustainability performance of construction projects (Table 4).

**Table 4:** Relative Importance and References of the Identified Affecting Factors

Affecting Factor	Importance (1 to 5)	Ref No.*	Affecting Factor	Importance (1 to 5)	Ref No.
<b>Workforce &amp; Materials</b>			<b>Project Control &amp; Management</b>		
Motivation	4.4	13	Management Quality	4.5	4,24
Workers Commitment	4.3	10	Utilizing Clean and Renewable Energies	4.4	15,25
Sustainability Performance Monitoring and Controlling	4.1	4,12	Utilizing Reduction Techniques for Energy Consumption	4.4	15,25
Materials Durability and Service Life	3.9	14,18	Greenhouse Gases Emission and Amount of Dust Fallen	4.3	9,16,18,22
Materials Availability	3.4	14,19	Energy Efficiency	4.3	18
Using Multipurpose Materials	3.3	18	Cleaning up Contaminated Water and Land	4.1	8,19
Crew Size and Composition	3.1	14,15,16	Energy Consumption	4.1	22
<b>Design Specifications &amp; Engineering Documents</b>			Using Clean Technologies, Tools and Materials	4.1	4,14,18,23
Considering Sustainability Principles in Design and Contract	4.3	12	Waste Management	4.0	14,23
Design Alteration during Execution	3.8	14	Job Satisfaction	4.0	11
Architectural Quality	3.8	18,20	Resources Consumption	4.0	14
Public Design	3.1	8,21	Working According to Schedule	3.9	Experts
Design Complexity	2.8	22	Use of Non-Drinkable Water	3.8	8,21
<b>Project &amp; Work Characteristics</b>			Competitiveness	3.6	1,15
Environment Degradation	4.4	13	Water Recycling	3.6	24
Productivity	4.3	22	Maintenance Management	3.6	22
Product Quality	3.8	11,17	Corporation's Capital	3.5	9
Project Profit	3.8	4	Job Stability	3.5	22
Execution Complexity	3.6	22	Efficient Use of Materials	3.5	22
Harmony between Natural and Built Environments	3.6	8	Environmental Accounting	3.4	Experts
Product Lifetime	3.5	17	Accessibility and Communication	3.3	4
Required Skills on Workforce	3.4	14	Employing Sub-Contractors	3.1	1
Direct Costs	3.3	15,18	Corporation's Credit	3.0	Experts
Land Use	3.3	22	Employment Creation	3.0	18,22
Maintenance Costs	3.3	18	Site Discipline	3.0	18,20
Neighborhood Disturbance	3.3	14	Developing Green and Open Space	2.4	23,24
Project Time	3.3	14	<b>External Environment</b>		
Public Traffic Disruptions	3.3	14	Bio-Diversity	4.3	4
Scale of Serviceability	2.9	9	Local Economy	4.1	4,8
Contractors' Claims	2.8	Experts**	Considering Sustainability Principles in Housing Policy	4	15
Flexibility and Lack of Monotony	2.6	23	Investor & Operator Confidence	3.8	26
Air Quality	2.4	18	Environmental Pollution Lawsuits	3.4	16
Work Space	2.1	18	Global Warming	2.6	24
			Ozone Depletion	2.6	20

\* According to the numbers assigned in the References section

\*\* The affecting factors identified using Experts' opinions

#### 4.0 Results and Discussions

Construction managers believed that the factors which exert most influence on sustainability performance of construction projects include management quality, utilizing clean and renewable energies, utilizing reduction techniques for energy consumption, motivation, environmental degradation followed by greenhouse gas emission, energy efficiency, bio-diversity, workers' commitment, considering sustainability in design and contracts, and productivity (Fig. 2). The highest importance for managers' quality which originates from managers' knowledge and experience, confirmed the considerable effect of managers on sustainability implementation. It is because managers can change the direction of a construction project by making specific decisions. Indicating factors such as utilizing clean and renewable energies, environmental degradation, greenhouse gases emission and bio-diversity demonstrate the necessity of concentration on environmental aspect of sustainability for better implementation of sustainability in construction projects. In addition, the factors of utilizing reduction techniques for energy consumption and energy consumption depicted the significance of energy management from the construction managers' viewpoint. The great relative importance for motivation and workers' commitment proves the considerable impact of workforce and social aspect of sustainability for improving sustainability performance of construction projects. Considering sustainability principles in design and contracts, as an important affecting factor, provides a proper framework for better implementation of sustainability principles during the construction process. Moreover, construction managers believed that productivity notably influence on sustainability performance of construction projects. It is because productivity, which directly influence on time and costs of a construction project, may improve the different aspects of sustainability especially economic sustainability by reducing time or costs of a construction project. On the whole, it can be gathered from Fig. 2 that the factors related to the project control and management registered a high importance in improving sustainability performance of construction projects from the construction managers' perception.

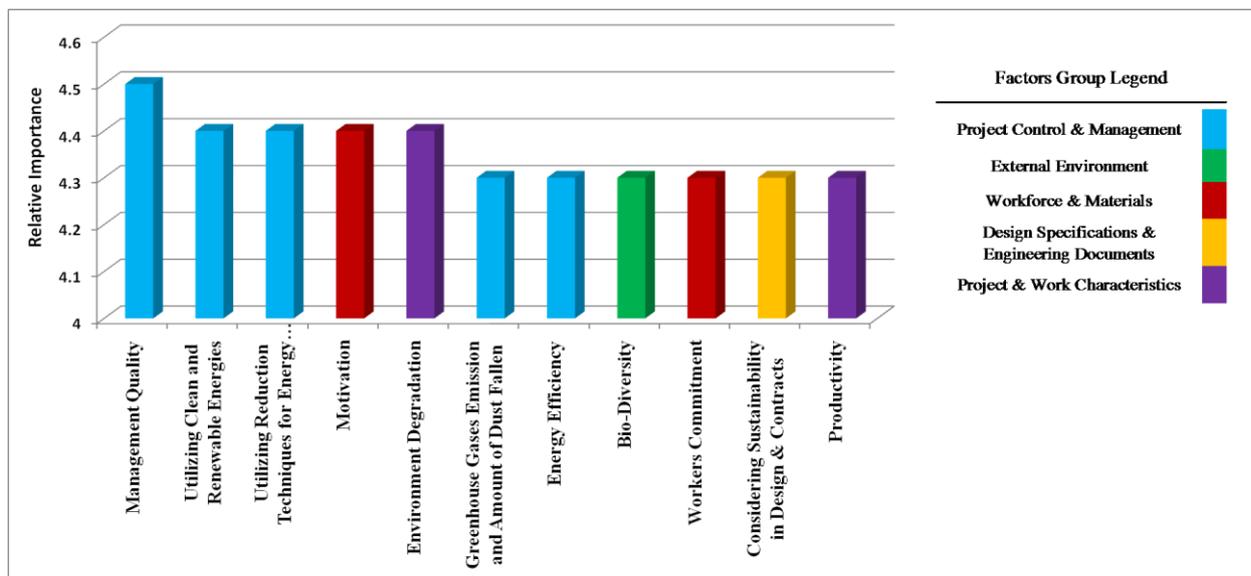
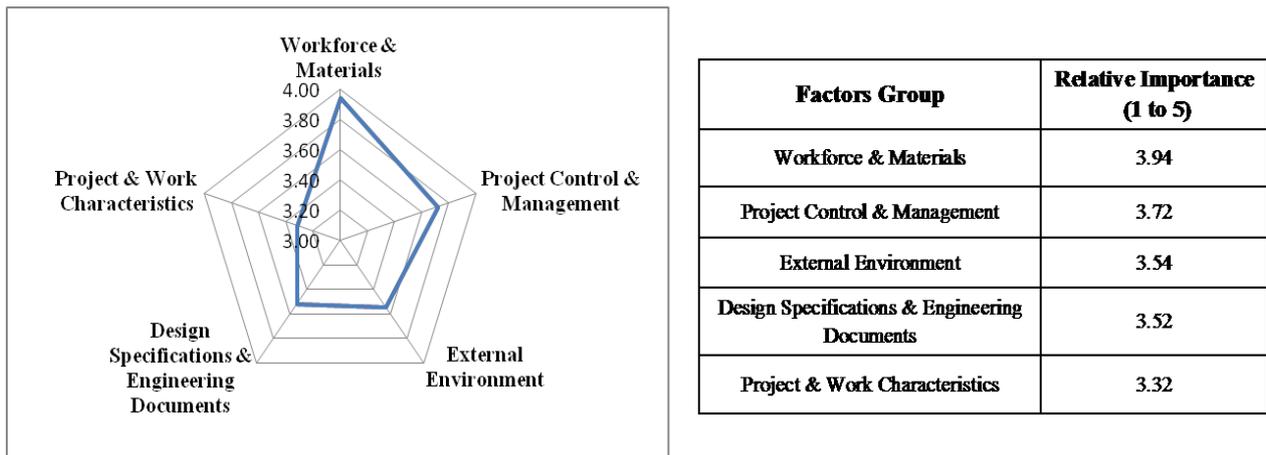


Figure 2: Most Important Factors



**Figure 3:** Relative Importance of the Factors Groups

## 5.0 Conclusion

The great change in people’s demand for natural resources accompanied by technology advancement during recent decades resulted in the increase of importance and concern for realizing sustainable development. In addition, considerable effects of construction activities on environmental, economic and social aspects of sustainable development illustrate its potential to help implementing sustainability. Thus, many studies conducted to interpret the concept and principles of sustainable construction but the lack of developing a comprehensive framework for identification of most important areas affecting construction sustainability is seen. The researchers believe that managers need to recognize the factors affecting sustainability of construction projects based on which can appropriately select the best strategy. Therefore, this study has widely identified factors affecting sustainable construction from the construction managers’ viewpoint.

Construction managers perceived that the factors related to “Workforce and Materials” and “Project Control and Management” make a great contribution to improving sustainability performance of construction projects (Fig. 3). Thus, it is rational to emphasize on these special areas in their decision-making for sustainability improvement. Totally, the represented framework can provide a richer understanding of construction sustainability and contribute to mitigate the management challenges in identifying strategies for sustainability improvement.

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