

Carbon Footprint Reduction Strategies in the Context of Iran; A Quantitative Survey

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ABSTRACT

Nowadays in many countries all over the world the enhancing amount of carbon footprint in the environment has been created numerous challenges and problems. In Iran as a developing country in the Middle East different efforts have been done in order to decrease the amount of greenhouse gasses. One of the most important areas of research about these issues refers to the construction and construction related sites. Based on the importance of this issue and due to its great influences on the human body, and also its great negative impact on the living environment, during the current study researchers attempted to find out affecting factors and strategies regarding the carbon foot print reductions in the construction sites of Iran. According to the importance of this issue, researchers of this study have been implemented a literature review to identify most important factors regarding carbon footprint reduction factors in the construction industry. After identifying the related questionnaire based on the literature review, reliability and also validity of the questionnaire has been analyzed by SPSS software after applying the pilot study. 25 people in charge with construction management issues have been participated in the quantitative survey. After doing the data analysis, five most important strategies for reducing carbon footprints in the construction sites have been identified namely Change design to the green & sustainability, Optimization of concrete or steel, efficient use of construction plant, using recyclable materials, knowledge of structural designers about carbon reduction methods. Hopefully the results of the current study seems to be useful for a number of people who can benefit from the results namely researchers in the construction management issues in Iran to use the results of the current study in their future career, contractors and managers in the construction sites, and finally administrative executive in the ministry of road and transportation of Iran to use the findings of the study in their future programming.

KEY WORD: carbon footprint, construction industry, carbon footprint reduction, greenhouse gases.

1. INTRODUCTION

Several definitions regarding the carbon footprint has been posed by different researchers all over the world. By surfing on the net and also through literature review, researchers chose the following definitions regarding carbon footprints. Usually the term carbon footprint refers to the amount of carbon dioxide which usually emits through the use of fossil types of the fuels. In the business managements, it usually refers to the CO₂ that emits in the environment implicitly or explicitly due to their different activities; also it may refer to the fossil energy which may goes along the product to the market. (Grubb & Ellis; 2007)

According to the Wiedmann & Minx (2007) carbon foot print refers to the negative effects of several activities that usually human being do and its effect on environment, which usually relates to greenhouse type of the gasses that may usually measure by tons of carbon dioxide.

According to Baldwin (2006) Carbon foot print usually refers to the amount of CO₂ and also other types of greenhouse gasses which usually emits during the procedure of the human being life cycle. It usually stands for grams of CO₂ equivalent per kilowatt hour of generation (gCO₂eq/kWh), that usually has negative effects on the environment and also it causes global warning on different parts of earth.

According to Patel (2006) amount of carbon footprint usually estimates by measurement of different CO₂ which has been emitted from different vehicles of companies, business types of traveling and movements. Carbon foot print refers to the amount of released carbon dioxide in the environment which usually happens during the peoples' daily activities such as washing in laundry and driving to work (Weidema et al., 2007).

In general construction industry is very important in order to develop infrastructure of different countries, which directly relates to both transportation and also industrial sections of a country. Regarding the transportation part of the construction industry, it involves non-road types of vehicles like construction plants, cranes and excavators which covers 28% carbon footprint amount in the United States while 33% refers to industrial sectors and large construction type of industries, such as cement and also chemical products. As a conclusion, construction industry has been ranked as the third biggest Carbon dioxide emitter in US, with the

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amount of 131 million Metric Tons (MT) CO₂e or 2% of the total emissions in that country (USEPA 2008). Furthermore, usually construction industry causes problems for carbon reduction elements like destroying different forests that can eliminate Carbon dioxide of the atmosphere. In the situation that a construction project may not create large amount of Green House Gasses (GHGs), its total effect to the environment is relatively high (Truitt 2009).

Energy crisis and global warming are two main topics that have attracted several researchers in recent years. As the total amount of fossil fuels in the world is decreasing and the problems caused by global warming are increasing, the importance of renewable energy sources has remarkably raised and developed new concepts like green energy, green economy, green industry etc. Issues regarding Greenhouse Gas (GHG) emissions and improper wastes management which threatens biological diversity and climate change have always been linked to energy related developments such as generation, distribution and management of energy resources (Dhokhikah et al., 2012).

Greenhouse gases include steam, Carbon Dioxide, Nitrogen oxide, Sulfur Dioxide, Methane, Ozone Of lower atmosphere, Chlorofluorocarbon, and Perfluorocarbon. These gases are available naturally in atmosphere, but unnatural activities of human and the pollutant resulting by them increases the amount of such gases extraordinarily. Then it leads in unnatural concentration of these gases in atmosphere and causes the Global Warming. The sources of Greenhouse gases are called the springs of Greenhouse gases. CO₂ is the criteria to determine the amount Greenhouse gases Global Warming and other Greenhouse gases potential of warming is estimated in compare to it. The approved framework of the Climate Change convention among most of countries throughout the world, seeks to resolve the international Global Warming. Despite the above mentioned fact it has no control over the aims of Greenhouse gases decrease process (Farokh et al., 2012).

Different studies in the field of construction industry reflects that traditional approaches of construction planning cannot be useful for emitting CO₂ and most of the participants of the related survey (53%) mentioned that they do not prefer to use those strategies for Carbon emissions in the construction sites (USEPA 2008). It may refers to the fact that developing and also installing old emitting vehicles seems to be time-consuming and also expensive and sometimes it may have unfavourable consequences like cost and different trade-offs among emission, cost and also productivity (USEPA 2009).

Construction industry has been considered as one of the largest direct or indirect consumers of the fossil fuels. As a result amount of the CO₂ which have been emitted through the atmosphere by excessive usage of fossil fuels and consequently the environment seems to be threatening for the society and general health. On the other hand most of the contractors as well as employers do not pay enough attention to the amount of carbon emission. Different people in charge with construction activities who care about the environment and ozone layer depletion usually have general confuse for choosing the most practical and effective strategies for reducing carbon footprint in the construction sites. Researchers of the current study attempted to investigate the most effective and practical strategies of reducing carbon footprint. To this aim, two strategies in order to reduce the amount of carbon footprint in the construction industry namely: Identifying strategies of reducing carbon footprint in construction sites, according to the related literature, and Assessing the efficiencies of strategies to reduce carbon footprint in the construction projects based on the construction managers and also contractors' perceptions.

Due to the importance of decreasing carbon footprint in the construction projects, researchers of the study investigated about the carbon footprint in the construction sites. Consequently objectives of the current study have been designed according to the mentioned strategies. In the current study, researcher tried to investigate carbon footprint causes in the construction sites of Iran. To this aim, researcher did a literature review in order to find different affective factors of causing carbon footprints in the construction sites. After identifying the problematic factors of carbon footprint production, researcher did a pilot study to investigated reliability and also validity of the questionnaire. By approving reliability and also validity of the questionnaire researcher started to do the data collection. By collecting the required data, implication of the current research to the field of construction activities has been reflected at the end of the paper.

Iran has been considered as one of the fast developing countries in the construction activities, and different activities in the construction sites have been done during the recent years. It goes without saying that in such a country with high amount of construction activities, the amount of carbon footprints may increase in the construction related activities. To this aim researcher motivated to conduct a survey regarding the carbon footprint sources and different factors of its reduction among the people in charge of construction related activities in Iran. Hopefully the obtained results of the study seems to be useful for different people in charge with construction related activities of Iran in order to reduce the amount of carbon footprint in the Iranian construction sites.

2. LITERATURE REVIEW

2.1. Different ways of reducing carbon foot prints in the construction sites

For most of the organizations usually it is a big problem for findings different ways of carbon reduction. Different strategies can be used in order to reduce carbon footprint in the construction sites and also enhance

construction safety. During the recent years, different people in charge did lots of activities in order to reduce carbon foot print amounts in the construction sites. In this study, researchers have been considered four most effective strategies of reducing carbon footprint in the construction sites namely:

1. Change in designing to the Green & Sustainability
2. Carbon footprint estimation
3. Efficient use of construction plant
4. The 3R concept; Reduce, Reuse, Recycle

2.1.1. Change in designing to the Green & Sustainability

Change in designing to the green and sustainability can be divided into three concepts namely: Green design concepts, ecological design and the role of structural designers' knowledge about carbon footprint. The mentioned items have been explained in detail in this section.

2.1.1.1 Green design concepts

For lots of civil also mechanical engineers, the concept of sustainability refers to the development of environmental activities that can save environment as well as saving natural and recyclable resources. The concept of sustainability have been emerged in 1960s through inventing different types of solar panels as well as visionary creations and also by considering different features of ecosystems in 1970s (Bachman, 2004).

Another significant advantage of green design refers to its compatibility to the nature and its cooperation with natural resources. The advantage of using sustainability refers to its minimal dependence and disturbance to the environment. On the other hand green buildings use restrained technologies that can satisfy recyclable cycle of materials that has lowest ecological bad effect on the environment (Bachman, 2004).

2.1.1.2 Ecological design

Usually ecological design refers to the different effects that a building may has on the natural environment of the district. Ecological design seems to be very important for crating relationship between all of the activities which relates to the activities of human being and also natural ones. One of the most important features of ecological design refers to bioclimatic design that has been proposed by Ken Yeang (1996).

2.1.1.3 The role of structural designers' knowledge about carbon footprint

When different people in charge with structural designing know about the current effect of carbon impacts of available materials, they can make some decisions about reducing carbons. Regarding lots of the buildings, different construction managers usually use appropriate choice of concrete and also steel due to the emissions of carbon foot print in the environment. By considering this, the main task of construction designers is to reduce the harmful effect of the mentioned materials.

In both of the cases regarding the steel and also concrete types of the structure, by doing material optimizations the construction designers can reduce the carbon negative effects significantly. In order to optimize steel, there are several strategies such as:

- Applying more labour-intensive (and possibly more expensive) choices like lighter columns with the plates which have more continuity at joints in comparison with bigger columns sized in order to minimize several fabrications.
- Choosing braced frames for lateral-load resisting structures in the position of moment struggling frames, which has more substantially and also bigger steel quantities. According to Webster et al. (2011), regarding the 9-story building in Los Angeles, which has been designed a braced-frame lateral system in place of a moment-resisting frame decreased the structural quantity of steel by 37%, with an equal decrease in Global Warming Potential (GWP).
- Using castellated beams in comparison with conventional wide flanges.
- Examining catenary structures in place of trusses for long-span roofs.

In order to optimize the concrete it should examining thin-shell arched or folded-plate structures in place of linear and planar elements. In case of concrete we can consider different factors to reduce effects of the carbon by improving the materials, like replacing with complementary cementing materials like fly ash and slag. There are also other ways for reducing the carbon-intensive cement content namely:

- Not using over-specifying concrete strength and planning and identifying for 56 days when possible.
- Use of bigger-sized aggregates for decreasing the paste quantity.

Additionally quantities of steel reinforcement quantities can be decreased dramatically while it is not necessary. As an example, we can eliminate reinforcement in slabs-on-grade through the use of more closely spaced control junctions.

2.2. Carbon footprint estimation

Nowadays different people in charge with construction activities usually try to find out the amount of released greenhouse gasses in the environment in order to apply different activities to avoid it its happening in the future. Several methodologies in the field of for carbon footprint calculations believe that emerging has been considered as an important equipment for managing greenhouse type of the gases.

2.2.1 Significance of the of carbon foot printing concept

Carbon footprint has been considered as a quantitative amount of GHG which usually releases from several types of the human being activities which can help the emission management and also assessing several mitigation measures (Trust, 2007). By considering the amount of emissions, one can identify its main sources and also emission districts, in order to prioritize reducing and also reducing its effect. By doing so, different managers in different sections can create opportunities for environmental efficiencies and also decreasing the costs. It is usually essential to report amount of carbon footprint to the third party in order to legislative the required things, also for improving their brand (Trust, 2007; McKercher et al., 2010).

2.2.2 Estimating carbon footprint amount

In order to assess the amount of carbon footprint, amount of GHGs which has been embodied in life cycle of the products should be estimated and also added. Usually life cycle includes all of the involved different phases for a producing like its production right from the bringing of raw material to the last packaging, delivery, use, and also to the final phases of distribution. This kind of analysis also called 'cradle to grave analyses'. Life cycle assessment (LCA) usually provide a complete glance of input and also output, by considering air pollution problems, investigating about water use and wastewater production, consuming energy, released GHGs and other related factors like cost-benefit initiatives. This kind of evaluations is usually called as environmental LCA (Pandey et al, 2011).

2.3. How to use construction plant efficiently

Usually several strategies have been used for efficient use of construction plant and also equipment namely:

1. Selecting appropriate machine for a related task and also avoiding machines with over sizes.
2. Choosing plants that are more logical form the fuel consumption point of view.
3. Plants should be fixed correctly.
4. The carbon fuels should be sustainable.
5. Using plant professionally (in order to minimize time and also appropriate power)

This kind of activity usually focuses on managing the plants as efficiently as possible. Additionally, it allows several contractors and customers to use fuel efficient plant.

Different construction sites usually use fuel efficient plant process. Usually there is a special need for trainers, in order to reinforce contractors and sub-contractors requirements (Ko, 2010).

2.4. The 3 R concept; Reduce, Reuse, Recycle

The best and also common way for reducing the amount of carbon footprint of humans Reduce, Reuse and also Recycle (RRR). It can be done by recycling different packing materials; it can be done by selling the recyclable materials to the industry that are searching for unused materials with lower prices in order to create competitive situation. Not any material should be disposed in the soil (Padmavathi, 2013)

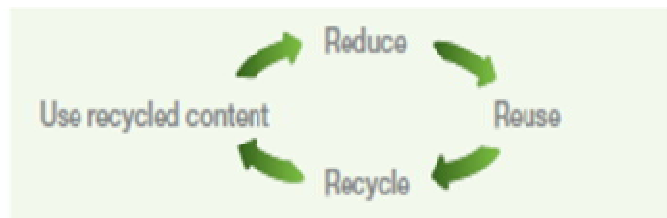


Fig. 1: Common ways to reduce the carbon foot printing

The 3 R are usually deals with better efficiency of resources by considering the following principles:

1. Reduce that is to eliminate waste production, by stopping to use that material in the construction sites.
2. Reuse that is using the possible used materials in the other sites.
3. Recycle which means using materials for producing new materials.

In this procedure, usually refers to the 3 Rs 'loop', which refers to the identification and also using the related materials with high qualification for recycling in order to be used in the future projects (National Specialist Contractors Council, 2007).

By using recyclable type of materials, the amount of energy consumption and also CO₂-emissions can be decreased dramatically.

- Decreasing the use of environmental materials.

Using illegal and also waste materials and also using and high amount of natural resources has negative ecological effects.

- Decreasing health problems which has been caused by unlawful deposits

Pest proliferation can significantly decrease if CDW (Construction and Demolition Waste) is reduced; reused, recycled and slight amounts are left on controlled landfills

- Improving air quality

Usually emissions which have been caused by manufacture and uncontrollable removal or fiery can be reduced dramatically (Spies, 2009).

3. METHODOLOGY

Based on the literature review which has been done by the researchers of the current study, several affecting factors for reducing carbon foot print have been identified. During the current research, researchers attempted to find out most effective factors of carbon reductions in the environment during the construction management activities. To this aim, the researchers have been conducted a survey study among different people in charge with construction activities such as construction managers as well as contractors and developers. By collecting the required data from the participants, different factors which had higher mean index have been identified as the main problematic factors for construction activities in the context of Iran. To this aim the prepared questionnaire that has been designed from the literature review of the study has been distributed among 25 people in charge with construction management activities.

As it has been mentioned earlier, the questionnaire of the current study has been designed based on the literature review. In order to examine reliability as well as validity of the questionnaire, researchers have been factor analysis and also Cronbach’s Alpha, which will be explained in the following section.

3.1. Aim & objectives

During the current study, researchers investigated about the carbon footprint reductions in the constructions of a developing country, Iran; to this aim they have the following objectives:

1. To identify strategies to reduce carbon footprint in a construction sites based on the literature review.
2. To evaluate the efficiencies of strategies to reduce carbon footprint in the construction projects based on the construction managers and also contractors’ perceptions.

3.2. Reliability & Validity of the questionnaire

In order to check the reliability and also validity of the study, researchers conducted a pilot study before the implementation of the main study. To this aim, a sub-sample of 5 participants have been selected for conducting the pilot study. For examining the reliability of the study, Cronbach’s Alpha analysis has been run while for examining the validity factor analysis has been implemented. The results of the pilot study will be presented in this section.

Cronbach's Alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Table1. Reliability analysis index

According to the Field (2009), when the reliability number which has been extracted through the SPSS software is $\alpha \geq 0.9$, the reliability of the questionnaire is excellent, while it is $0.8 \leq \alpha < 0.9$, the reliability is good, while it is $0.7 \leq \alpha < 0.8$, the reliability is acceptable, while it is $0.6 \leq \alpha < 0.7$, the reliability is questionable, while it is $0.5 \leq \alpha < 0.6$, the reliability is $0.5 \leq \alpha < 0.6$ and finally when it is $\alpha < 0.5$, the reliability is unacceptable.

Reliability Statistics	
Cronbach's Alpha	N of Items
0.992	8

Table 2. Analyzing the reliability of the questionnaire

As it has been shown in the table 2, the Cronbach's Alpha of the study is 0.992 and based on the Field (2009), the reliability of the questionnaire is excellent.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.89
Bartlett's Test of Sphericity	Approx. Chi-Square	289.69
	df	15
	Sig.	0.00

Table 3. Factor analysis of the questionnaire of the study

According to the above table Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.89. Usually as this measure goes closer to 1 the validity of the test seems better. When the KMO is near 1, a factor or factors can probably be extracted, since the opposite pattern is visible. Therefore, KMO "values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.89 and 0.9 are great and values above 0.9 are superb" (Field, 2009). The KMO amount of our questionnaire is .890 and we can conclude that the validity of our questionnaire is great.

4. Findings of the study

After the data collecting the required data, researchers have been analyzed the data through the SPSS software. The percentage of answering to each item as well as the mean index of each factor has been presented in Table 4.

	Items	Percentage				M.I
		Not Important	Less Important	Important	Very Important	
1	Change design to the green & sustainability	12%	16%	20%	52%	3.12
2	Decreasing the use of environmental resources	28%	32%	20%	20%	2.32
3	Optimization of concrete or steel	16%	20%	24%	40%	2.88
4	Selecting appreciation machines	24%	24%	20%	32%	2.60
5	Ecological design	20%	20%	32%	28%	2.68
6	Efficient use of construction plant	16%	16%	20%	48%	3.00
7	LCA evaluation	20%	36%	24%	20%	2.44
8	Avoid usage of illegal materials	20%	24%	32%	24%	2.60
9	Using recyclable materials	16%	20%	28%	36%	2.84
10	Choosing proper materials	16%	24%	36%	24%	2.68
11	Measuring GHG released	24%	24%	28%	24%	2.52
12	Knowledge of structural designers about carbon reduction methods	16%	20%	20%	44%	2.92
13	Carbon footprint estimation before the operation stage	16%	16%	20%	48%	2.72
14	Green Fuels	20%	32%	24%	24%	2.52
15	Applying 3R	16%	24%	28%	32%	2.76
16	Choosing plants from the fuel consumption point of view	16%	16%	20%	48%	2.72

Table 4. Results of the survey

Based on the findings of the current study and by considering the mean index related to each factor, five factors which had higher mean index have been identified as the effective factors of reducing carbon foot print in the construction sites of Iran. Based on the findings of the study and according to the mean index five main factors with the highest mean index have been identified as the main effective factors for carbon footprint reductions in the construction activities namely: Change design to the green & sustainability, Optimization of concrete or steel, Efficient use of construction plant, Using recyclable materials, Knowledge of structural designers about carbon reduction methods.

5. Conclusion and discussion

During the current years and based on the importance of reducing the amount of carbon foot print in the construction site, different scientists all over the world tried their best in order to investigate about decreasing the amount of carbon foot prints in the construction sites. Based on the importance of this issue for the environment and its harmful effects for the human being, researchers of the current study attempted to investigate the perceptions of the people in charge with construction activities regarding the effective factors for reducing carbon footprints in the environment. To this aim 25 people in charge with construction activities such as contractors and also project managers have been surveyed during this study by a questionnaire which has been extracted from the literature. Based on the mean index regarding each item, five factors with the highest amount of mean index have been identified as the most affecting factors of carbon reductions in the construction sites namely; Change design to the green & sustainability, Optimization of concrete or steel, efficient use of construction plant, using recyclable materials, knowledge of structural designers about carbon reduction methods. Based on the experience of the participants of the current study, the mentioned factors can reduce the amount of carbon footprints in the context of Iran. Based on the same structure of the construction sites in the Middle East countries, the results of the current study may be applied in the other countries of that region. Hopefully the results of the current study seems to be useful for a number of people who can benefit from the results namely construction managers and contractors of the construction sites of Iran and also Middle East countries to benefit the results in their ongoing and also future projects, administrators in the ministry of way in Iran and Middle countries to develop their programs based on the carbon footprint reduction activities and finally researchers in the construction activities of the third world countries.

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