



Approaches for sustainable cement production – A case study from Turkey



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ABSTRACT

One of the keys to achieve the sustainable construction goals in green projects is to select appropriate building materials for construction. Such projects aim to use eco-friendly materials that encourage the consumption of recycled and renewable materials, locally manufactured with less harmful gas emissions with long and durable profiles. Using these eco-friendly materials is also helpful for obtaining higher rates during the application processes of green building certificates. As the demand for sustainable materials increases globally, the construction material producers need to supply materials that can be used in environmentally responsible buildings without compromising ecological conditions. In particular, cement production has a huge impact on the environment because of releasing high amount of CO₂ during production processes. This paper aims to express the sustainability of building materials in Turkish construction industry through analyzing cement production of a Turkish cement company where alternative fuels, raw materials, by-products and energy efficient methods are used for sustainable development.

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1. Introduction

According to Annual Energy Outlook prepared by Energy Information Administration of U.S. Department of Energy (DOE) [1,2], construction sector is recognized as the largest source of carbon emissions worldwide and impacts of buildings on releasing CO₂ emission is 39%. Three billion tons of raw materials, which correspond to 40–50% of the total flow in the global economy, are used in the manufacturing of building products and components worldwide each year; and these are extracted, processed, transported, used in construction, and finally disposed [3]. Although, effect of building sector in the final energy consumption is high, but in the same time building sector has the largest potential for reduction of Green House Gases (GHG) emission [4].

Negative environmental impacts arise from several construction activities, manufacturing of building materials and transportation. All of these are consuming energy, generating emissions linked to global warming, acid rain and smog [5]. Due to significant impacts, mitigation efforts have emerged in the past decade. The main objectives of these efforts are to preserve the natural resources as much as possible while providing benefits in environmental, social and

economic perspectives. On the other side, construction sustainability performance is indispensable to the attainment of sustainable development [6]. For this purpose, green building and sustainability concepts are gaining more attention among construction-related societies. Increasing demands for minimizing the consumption of water and energy, considering appropriate materials for more eco-friendly buildings force the companies to improve the aspects of construction phases. Sustainability has become an important decision factor in the selection of building materials. Therefore, it is important to provide more data on the level of emission generated during the production of building materials so that clients, design consultants, contractors and end-users can make more informed decisions on materials selection [7]. In addition, a universal energy efficiency index (UEEI) for buildings is needed [4]. With the realization that economic development and the environment are linked, engineers, architects and project managers strive to avoid adverse impacts on society and the environment by adopting sustainable development concepts during design and implementation of development projects [8].

“Sustainability” principles are frequently considered in the construction industry, especially in the U.S. and the EU. The efficient usage of existing limited resources and construction of environmental-friendly buildings have gained importance. Sustainable buildings use resources such as energy, water, materials and land more efficiently than buildings that are simply built to

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code [9,10]. The construction industry is becoming more involved in “green” projects and consequently many green structures are being constructed in different parts of the world. Today, the public is better informed on sustainability, much more focused on energy and expect to see results [11].

Several certificate systems are established to organize the standards of green construction in various countries. British system which is developed by Building Research Establishment (BRE) is known as BREEAM (Building Research Establishment Environmental Assessment Method), while another system is developed in United States by U.S. Green Building Council (USGBC) and known as LEED (Leadership in Energy and Environmental Design). There are some other certification systems improved in different countries like Japan, Canada and Australia. Among these systems, LEED is the most preferred system worldwide and according to USGBC projects directory, 10,088 buildings are certified and 25,431 buildings are registered for LEED certification [12]. To increase the global applicability, USGBC also established a roundtable working team consisted of 20 countries to consider the regional approaches and global consistency.

LEED certificate system involves seven categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environment quality, and innovation and design. The categories have different weights and choosing proper materials is important for obtaining higher ratings for the buildings which are evaluated and weighted based on their potential impacts on the environment. The “materials and resources” category accounts for approximately 14% of all points. A correct selection of materials must be done in order to save energy, as well as to reduce CO₂ emissions [13]. Selecting inappropriate materials can be expensive and may preclude the achievement of the desired environmental goals [14]. The “materials and resources” category gives credit and encourages the use of recycled materials, rapidly renewable materials, locally manufactured environmentally responsible materials. The major properties of these sustainable materials include zero or low offgassing of harmful air emissions, zero or low toxicity, addition of reused and recycled content, high recyclability, durability, longevity and local production. Such products also promote resource conservation and efficiency [9].

The demand for the assessment of the environmental characteristics of building materials has also started in Turkey. As of December 2012, 53 buildings have received certificates, 29 rated by LEED [12] and 24 by BREEAM [15]. Turkish Green Building Council is working on a national green building assessment certification system and a beta version has recently been announced for residential buildings. It is clear that the movement of green building in Turkey will accelerate in the close future and more building investors will prefer their buildings to be rated by a green building certification system. This will increase the demand in materials produced according to sustainability principles. In Turkey, some building material producers have already started implementing these principles in their production processes and certificated their products by different type of labels expressing the environmental attributes of their products. With the deployment of green design and sustainability concepts, companies producing building materials need to supply materials that can be used in environmentally responsible buildings without compromising ecological conditions. It is becoming important for materials to consider sustainability throughout their life cycle starting from first production phase.

Production processes of cement have a huge impact on the environment because they are responsible for releasing significant amount of CO₂ emissions. Cement plants already account for 5% of global emissions of carbon dioxide, the main cause of global warming [16,17]. As pointed out in CEMBUREAU Environmental Product Declaration for Cement, 899 kg CO₂ is released during the production of 1000 kg cement [18]. According to Cement Sustainability

Initiative (CSI), which was established in order to reduce CO₂ emissions from cement production by 23 major cement producers with operations in more than 100 countries, it is estimated that 80% of the future emissions from cement plants will take place in developing economies [19]. There is a tendency for decreasing the CO₂ emission of cement production, thus decreasing the environmental impact. CSI members pledged to work with stakeholders to develop a protocol for measuring and reporting CO₂ emissions from cement manufacturing. Working together with European Cement Research Academy (ECRA), The European Cement Association (CEMBUREAU) completed the Environmental Product Declaration (EPD) for Portland cement (CEM I) and defined their prime purpose is to provide measurable and verifiable input for the environmental assessment of construction works [18]. This study aims to express the sustainability of building materials in Turkish construction industry through a case study analyzing cement production.

2. Case study: a Turkish cement company

Turkey plays a major role in the production of building materials, and consequently, the impacts of the global environmental problems are also experienced in this country [20]. Building materials' industry being an energy intensive sector is affected by risks and opportunities revealing from climate change and energy concerns. Turkey's energy outlook shows a dramatic gap between energy production capacity and consumption. For instance, in 2010 this ratio of energy production over consumptions has been announced as 29.7%, and import dependence as 71.5% [21]. Despite of the increasing cement production within the country, the environmental impacts and sustainability aspects are still less considered.

The production capacity of cement sector in Turkey was merely 20,000 tons in 1911. In its 100th year, Turkish cement sector has reached a usable production capacity over 80 million tons [22]. Turkey ranks first in Europe and 4th in the world after China, India and USA [23]. Turkey also holds the first place in exports according to 2010 data.

In this study, sustainability of building materials in Turkish construction industry is analyzed through one of the most prominent cement companies in Turkey. The Company operates its activities in 3 cement plants, 5 cement terminals, 39 ready mixed concrete plants and 4 aggregate plants. The Company issued the first sustainability report (Global Reporting Initiative-GRI B level) [24] in the sector indicating its economic, environmental and social performances between 2007 and 2009. The second sustainability report disclosing 2010 and 2011 performances was recently published in 2011 [25]. The sustainability performance of Company's operations is conducted through 6 pillars:

1. Occupational health and safety.
2. Use of waste as a resource.
3. Climate change.
4. Reducing other environmental impacts.
5. Sustainable construction solutions.
6. Biodiversity.

Taking into consideration of “materials and resources” category in the certification systems, the Company aims to contribute higher ratings from this part. The improvements on sustainability approach can be listed as follows:

- Alternative fuels.
- Alternative raw materials.
- Reducing the rate of clinker usage in cement.
- Energy efficiency.
- Recycled and alternative materials in ready mixed concrete.

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