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Concrete Sustainability Issues

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ABSTRACT

Concrete continuous dominance as the building material of preference is as a result of its strength, durability, versatility and sustainability. But the large consumption of this material has put a danger on its sustainability as a large amount of natural resources are consumed annually. In addition, the production of concrete and its components is very energy intensive and contribute a large amount of carbon dioxide emission into the environment. As rapid urbanization is happening all over the world coupled with the increase in population, it is expected that the higher demand and production of concrete will ensue. Further increase in the production of concrete will lead to a consequential consumption of more resources and contamination of the environment. In order to ensure that the sustainable integrity of concrete is regained while meeting the continuous demand of concrete, it is critical to find ways in which the factors that pose a sustainability threat to this unique material can be eradicated. This paper explores the major sustainability issues related to concrete and some possible solutions to how these issues can be resolved. It was concluded that a more sustainable concrete can be produced in the future by finding alternatives to the current components of concrete and the introduction of greener technology for the construction process

1. Introduction

Sustainability awareness of various aspects our existence is becoming more significant as time pass by, and every industry, process and material is being scrutinized. The construction industry is one of the major backbones of the society is also exposed to the sustainability scrutiny, especially on its materials and processes. Concrete is the most used building material, and the most produced artificial material in the world (Mehta and Monteiro, 2013) also falls under this sustainability assessment. Portland Cement Association (2010) has estimated that about $1m^3$ of concrete is produced per person on the planet annually. This high production of concrete means that a correspondingly large amount of raw materials is being consumed for its production. In addition, a large amount of energy is also used for its production processes. Concrete is mainly composed of cement paste and aggregate. The cement paste is made up of cement and water, and the aggregates used can be classified as fine and coarse aggregate. It is imperative to mention that cement and concrete are not the same as this has been used interchangeably by the outside audience. Thus, as mentioned earlier, concrete is made up of binder, aggregate and water while cement is the main binder used in concrete.

In order to foster more awareness both within and outside the concrete industry, this explored the current sustainability issues associated with concrete and possible ways to overcome this issues. Effects of the components of concrete alongside its construction process are briefly explored. It is anticipated that this paper will give a quick overview to stakeholders in the concrete industry, and also provide basic information to scientists working to proffer solutions to current problems in the construction industry

2. Sustainability Issues

2.1. Ordinary Portland cement

The main binder used in concrete is ordinary Portland cement (OPC). However, the production of OPC has been to be attributed to being one of the major contributors to the world's human-induced carbon dioxide emission, with a contribution between 5 – 8% (Scrivener and Kirkpatrick, 2008). For every ton of OPC produced, an approximate amount of carbon dioxide is emitted into the environment. The carbon dioxide emissions are from the calcination product and the burning of fossil fuels. This makes OPC the highest contributor of embodied carbon and energy to concrete and finding ways to reduce its embodied carbon and energy will lead to making concrete a more sustainable building material.

The sustainability issue related with OPC can be reduced or eliminated by partial to total replacement of OPC, clinker replacement, and use renewable fuels for its production (Barcelo et al., 2014). Several kinds of research on the partial replacement of OPC with supplementary cementitious materials (SCMs) have ensued over the years. And the use of SCMs as partial replacement of OPC has been found to also

enhance the strength and durability of the concrete (Thomas, 2013).
Also, the advent of “no OPC” binders such as geopolymers and alkali activated materials have been reported to result in more reduction in the embodied carbon and energy of the resulting concrete (Provis, 2014). It is worth to mention that huge reduction in embodied energy and carbon of “no OPC” binders is only achieved when no heat curing is involved and activators with low embodied energy and carbon are used.

2.2. Water

Water serves a vital role in the production of concrete right from cleaning the raw materials, to mixing, curing and cleaning of equipment used for making concrete. Though the embodied carbon and energy of water is very small and sometimes calculate as non-significant in most cases, its high usage for concrete’s production makes it one of the sustainability issues in concrete. The concrete industry consumes about 1 billion cubic of water yearly making it the highest consumer of fresh water (Asadollahfardi et al., 2016). This high consumption of fresh water poses a threat of a shortage of water for humans and animals consumption especially in arid areas of the world.

An alternative to fresh water for concrete is the use of recycled wastewater from both residential and industrial processes (Asadollahfardi et al., 2016). However, in some cases, obtained wastewaters have to be treated to prevent any alteration with the hydration reaction in concrete. In addition, untreated wastewater can pose a durability threat to the concrete in the long run. Therefore, it is necessary to determine the suitability of using wastewater from various sources on the properties of concrete.

2.3. Aggregates

Aggregates make up about 50 – 70% by volume of the concrete, and the high consumption of concrete has led to a consequential high exploration of different sources of aggregates. As the demand in concrete continues, continuous over-exploration of these deposits continues. The mining of aggregates creates several deformations in the environment, and the processes involved are highly energy intensive.

In order to tackle the sustainability issue related with aggregates, finding ways to utilize the wastes generated by various industries will help over exploration of these resources, and will also ensure that the industry can meet the future demand of aggregate for concrete’s production. Several wastes can be used as aggregate (i.e. coarse and/or fine aggregate) in concrete. Examples are sawdust, palm kernel shell, recycled concrete, etc. (Shafigh et al., 2014). The use of these alternative aggregates in concrete also propagates a sustainable and efficient management waste system for different industrial by-products.

2.4. Construction process

The production of concrete is very energy intensive, and energy is being consumed right from the processing of raw materials to curing of poured concrete. Production of concrete can be made more sustainable through the use of technology such as ultra-high strength concrete (UHSC) and self-compacting concrete (SCC). UHSC creates a sustainable pathway due to the high reduction in material and energy usage (Tang, 2004). Also, the use of SCC instead of the conventional OPC concrete eliminates energy usage and carbon dioxide emission from the vibration of concrete mixtures during placement. However, the use of SCC requires a higher amount of binder which might lead to a detrimental increase in carbon emission and cost if OPC is used. Therefore, the use of other alternative binders for SCC is the most sustainable as more reduction in emission, energy usage and cost will be achieved.

3. Conclusion.

Solving the sustainability issues related to concrete is practical. However, more research is still required to determine the properties of the concrete deemed sustainable. Also, the involvements of the industry with the research community will foster more rapid development of sustainable concrete.

In general, to reduce significantly or eliminate the detrimental sustainably issues of concrete; the most effective pathway will be the use of "no OPC" binder alongside with incorporation of waste products as aggregates. Use of green construction processes and recycled wastewater will also contribute to concrete sustainability. However, the implication of these initiatives on the strength and durability of concrete has to be studied before applications on large scale.

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