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Classification of Green Concrete for Sustainable Solutions

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ABSTRACT

Sustainable development has a vital significance and importance to the performance of all our activities and the companies themselves. The construction industry addresses all stages of a structure or building, from the production, transportation and placement of materials to the design, construction, operation and demolition and recycling of them.

In ready-mix concrete industry, one of the main concerns is to note that the product is sustainable and which product may be classified as green, which in turn constitutes a capital contribution to efforts to achieve a sustainable construction. Currently, there is no approved methodology or criteria for the classification of green products, however, the general characteristics are established they must have the goods to qualify as truly green and sustainable. This article proposes a methodology to classify sustainable concretes according to various factors and criteria that range from the exploitation of the material until its incorporation into the construction process.

INTRODUCTION

Sustainable development now has a significance and vital importance for the performance of all our activities and the companies themselves. In the construction industry all stages of the complete cycle of a structure or building are addressed, from the production, transportation and placement of materials to the design, construction, operation and even demolition and subsequent recycling of them. Under social perspective, economic and environmental sustainability becomes especially important.

Users of the construction industry depend on our ability to develop solutions to help society to become more sustainable, providing intelligent solutions that mitigate adverse effects of their processes. In the ready-mixed concrete industry, a major concern is to say what product is sustainable or which product may be classified as green, which in turn constitutes a capital contribution to achieve sustainable construction. [Wilson, 2006]

Currently, there is no approved methodology or criteria for classification of green products, however, it is established the general characteristics that products must have to qualify as truly green and sustainable.

SUSTAINABILITY IN BUILDING MATERIALS

Even in the "greenest" projects, most of the products used aren't green by themselves, but are used so that together they reduce the environmental impacts of construction. Therefore sustainable concretes seek to contribute to reducing the environmental impacts generated in the construction cycle.

To determine the environmental impact of building materials four stages are considered that correspond to a life cycle structure [Struble, 2008]:

1. Material production
2. Construction
3. Life
4. Demolition

Every building material is produced from a combination of raw material with associated energy consumption and waste. Therefore it should be considered if the raw material is renewable, if it is limited, how much energy is required to produce, how much waste is produced during its production, what impact does its waste has on the environment, etc.

The process of building a structure requires energy consumption and generates wastes that are based on the materials used. Therefore, material with as small as possible environmental impact must be considered, requiring less energy use, so that the construction process is more efficient, secure and generates little or no waste.

The structure's lifetime has a direct impact on sustainability, which is controlled directly by the durability of materials used and the convenience of being able to be repaired or renewed. Also, at this stage the energy performance and energy used during its operation must be considered, due to the fact that each material used impacts the performance of the structure.

In the final stage, considerations should be taken as the percentage of the structure that can be reused, the amount of material that can be recycled, what is the impact of waste produced during the demolition, which materials can be disposed of, etc.

SUSTAINABILITY OF THE CONCRETE

The ready-mixed concrete is made with aggregates (sand and gravel), hydraulic cement, water and chemical admixtures. Eventually mineral admixtures are incorporated in place of a portion of the cement. To determine the impact on sustainability that has the ready-mix concrete, we should analyze the impact of each of its components on the manufacturing stages of the material, and for every stage of life of structures. [Struble, 2008]

The impacts due to the extraction of aggregates are:
- Small amount of energy used in extraction.
- Waste as dust and water.
- Dust can be used in other processes or disposed of as landfill.
- Depletion of natural resources.

The impacts due to hydraulic cement are:
- CO_2 emissions during manufacturing.
- Use of energy.

The impacts of water are:
• Small amount of energy extraction.
• Natural resource depletion, particularly where there are shortages.

The impacts of concrete manufacturing are:
• Energy use in materials handling, mixing and transport.
• Generation of waste and small amounts of dust, concrete and contaminated water wasted which can be recycled or reused.

The impacts during construction are:
• CO_2 emissions during the transportation and equipment for concrete placement and finishing of concrete.
• Energy use during concrete placement.
• Using wood formwork, which can be disposed of in landfills or steel formwork which are reused.
• Generation of wastes such as dust, water and concrete.
• Exposure of workers to high risk activities.

The impacts during the construction lifetime are:
• The role as a transmitter of energy and energy storage properties.
• The durability of the structure.
• Work environment.

The impacts of the demolition or end of life are:
• Energy use for demolition.
• Waste generation of concrete that can be recycled for use as aggregate for concrete pavement or base.
• Generation of wastes such as dust and concrete fragments that can also be used as fillers.

CRITERIA FOR CLASSIFICATION OF SUSTAINABLE CONCRETES

Based on the impacts described above, a methodology was designed for classifying sustainable concretes. The methodology establishes 8 items or factors to assess every concrete and once they have been evaluated using the rating scale provided in Table 1 to give a score. [Building Green, 2006]

Factors to evaluate

Recovered material content, recycling or waste

Waste, recovered and recycled material used in the concrete mix must be determined with respect to the total weight of the mix. Examples of recovered materials are bricks, pipes, wood, etc., and items of post-consumer recycled materials are: tires, PET, crushed concrete, crushed glass; recycled pre consumed (after an industrial process) materials as fly ash. Similarly, the incorporation of alternative aggregates that do not come from quarries. [California Integrated Waste Management Board, 2009].

Natural resources conservation and increase in the lifetime of the structure

Products that contain rapidly renewable material should be considered. Exceptionally durable products, which require little maintenance or whose physical or mechanical properties help to reduce the use of additional raw materials should also be considered.

Some examples of these products are those that reduce the use of raw materials such as pigmented concrete with surface hardeners or white concrete. Concrete can also be considered to make foundations and more slender structures to reduce the use of materials. Durable concrete that increases the lifetime of structures is also considered under this heading. [Froeschle, 1999]

Reduction of use toxic products and other harmful emissions

Whether concrete add products reduce the use of toxicants or other harmful emissions should be evaluated; whether incorporated solutions or alternatives to reduce or avoid use of hazardous substances harmful to health It is particularly important also to determine if the concrete reduces pollution by maintaining the structure or uses substances that reduce the ozone in the atmosphere, if used in permeable pavements to prevent water pollution, physical barriers to termites, bacteria, pesticides, etc. [California Integrated Waste Management Board, 2009].

Energy and water savings

The products which by their physical properties contribute to the reduction and/or maintenance of heating and cooling loads of the structure are considered as energy savers. Some examples are: insulated concrete, lightweight concrete, insulating glass systems or thermal panels. Also, within this category are considered products by their physical properties or performance to contribute water saving, for example, products used in systems for collecting rainwater, equipment with outstanding efficiency levels (appliances, bathroom furniture, etc.). With energy savings products that help reduce the heat island effect like green roofs, concrete pavements, architectural concrete with light colours, etc. should be considered. [California Integrated Waste Management Board, 2009].

Contribution to safety and healthy work environment

To evaluate this aspect, it should be considered if the concrete helps to ensure a healthy environment, for example, which does not release pollutants into the building, which does not allow the entry, development and dispersion of pollutants; which could remove pollutants that promote an atmosphere of safety and health during construction, which promotes the brightness in the interior, which controls the emission of noise, which promotes improvement of welfare of the community, etc.

Products which reduce waste generation, both in the construction phase of the structure and operation and demolition are also considered.

Contribution to reduce CO_2 emissions

Products that reduce CO_2 emissions due to new technology or practice (during the process of obtaining their raw material, in their manufacturing, installation or at any stage of their life

cycle) should be considered in order to award points. This reduction of CO_2 emissions to the atmosphere must be countable.

Providing points in green rating systems

It should be necessary to determine if product or concrete provides a minimum green points on a sustainable rating system, like LEED certification.

Other highlights of the product or the company

The manufacturer or product performance is crucial and it must be consistent with the products that given manufacturer produces, so evaluation of whether there are any outstanding aspects of the manufacturer as the incorporation of an environmental management system, design improvement initiatives, efforts to reduce waste, to minimize pollution, the use of raw materials from quarries or sources that do not generate environmental liabilities, etc. should be considered.

Rating scale

After examining the eight aspects, the score is determined for each concrete under evaluation as shown in Table 1.

Table 1 Evaluation criteria

Factors	Evaluation criteria	Points
1. Recovered, recycled or waste material content.	At least 10% on the weight of the mixture	3
2. Natural resources conservation and increase in the lifetime of the structure.	1 feature for natural resources = 1 point 1 feature for lifetime = 1 point	2
3. Reduction of the use of toxic products and other harmful emissions.	1 feature	1
4. Energy and water savings.	1 feature for energy = 1 point 1 feature for water = 1 point	2
5. Contribution to safety and healthy work environment.	1 feature	1
6. Contribution to reduce CO_2 emissions.	1 feature	3
7. Providing points in green rating systems.	At least 5 % from total points in some green recognition systems	1
8. Other highlights of the product or the company.	1 feature	1

From the eight items mentioned in Table 1 a product can obtain a total of 14 points. To classify as sustainable concrete, it must reach at least 9 points. It is necessary when assigning

a score to a particular aspect that it has the objective evidence and demonstrates the technical support that ensures that the concrete has that feature.

CONCLUSIONS

The proposed classification methodology is a good start to define what truly green concrete is and which have an outstanding performance in sustainability. Thus the marketing of sustainable products has a solid foundation to encourage green market within construction.

The methodology itself provides the basis for researchers of ready-mix concrete industry to develop concretes that comply to specific standards and meet characteristics mentioned before, and every time these concretes will be overcome in order to have greener concretes to generate more sustainable solutions to the construction industry.

With the aspects established in this classification, the concrete industry can start working to reduce environmental impacts associated with the exploitation, production, transportation and placement of materials in the design, construction, use, maintenance and disposal of structures and infrastructure developed with concrete.

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