

Green Concrete – A Review

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ABSTRACT

Green concrete is made from eco-friendly wastes. It reduces CO₂ emission and creates least harm to the environment. It reduces water usage up to 20%. The major factors driving the green concrete market are due to the reduction of carbon footprints by about 40-50% during the production process, the rise in the construction activities in the developing nations and the major reason is the usage of less water. Apart from all this it also provides excellent thermal insulation, and high level of fire resistance that enables the structure built with green concrete. There is significant potential in waste materials to produce green concrete. Partial replacement of ingredients by using waste materials and admixtures shows better compressive and tensile strength, improved sulphate resistance, decreased permeability and improved workability.

Keywords: Green concrete, Fly ash, Recycled aggregates, Recycled Demolition aggregate, Glass aggregate, Blast furnace slag.

1. INTRODUCTION

Green concrete is revolutionary topic in the history of concrete industry; this was first invented in Denmark in year 1998. The size of construction industry all over the world is growing at faster rate. Green concrete is also cheap to produce because, waste products are used as partial substitute for cement, charges for the disposal are avoided, energy consumption in production is lower, and durability is greater. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Around 25% to 100% fly ash is used to produce the green concrete instead of a 100% mixture of Portland cement. Reduce amount of carbon Dioxide emission. Reduced the use of fossil fuels by increasing the use of waste derived fuels in the cement industry. The Structures do not impose much harm to the environment during their service life. The replacement of 50% of cement with slag led to improve tensile strength for recycled aggregate concrete.

II. LITERATURE REVIEW

Vinita Vishwakarma *et al* (2017) have investigated the waste materials from agriculture, industries, bio-waste, marine waste and e-waste can be recycled and used as a supplementary green concrete material. The waste products can be reused directly as a partial substitute of cement and save the energy consumption during the production of cement. The author also analysed the waste materials such as rice husk ash (RHA), saw dust ash (SDA), rubber crump, plastic waste, coconut husk and shell, textile waste (sludge and fibre) etc recycle of such types of wastes can be used as an admixture to make the Green Concrete structures. This will reduce the

quantity of cement used and CO₂ emission and reduce the global warming. The concrete structures prepared from the waste materials have lower environmental impact through reduced CO₂ emission and maintain all the specification of “Green Concrete”. For these inexpensive and environmentally friendly building materials, the scrap merchants should be educated and trained to segregate different types of waste to be used for the construction industries.

K.M.Liew et al (2017) have investigated the green concrete offers numerous environmental, technical benefits and economic benefits such as high strength, increased durability, improved workability and pump ability, reduced permeability, controlled bleeding, superior resistance to acid attack, and reduction of plastic shrinkage cracking. They also studied the Green concrete comes in various forms such as high-volume fly ash concrete, ultrahigh performance concrete, geopolymer concrete, lightweight concrete to mention a few. On the other hand, green concrete exhibit numerous advantages such as improvement in concrete properties, low carbon footprint, conservation of natural resources. Utilization of green concrete in large-scale infrastructure projects globally should be promoted. The demand for green concrete in construction industry is spurred by increased regulations to reduce carbon footprint, limit greenhouse gas emission and limited landfill spaces.

Roushan Kumar et al (2017) have studied it is a concept of thinking environment into concrete considering every aspect from raw materials manufacture over mixture design to structural design, construction, and service life. This was first invented in Denmark in the year 1998. GREEN concrete has nothing to do with colour. Green concrete is very Often and also cheap to produce, because for example, waste products are used as a partial substitute for cement, charges. The replacement of traditional ingredients of concrete by waste materials and by products gives an opportunity to manufacture economical and environment friendly concrete. Partial replacement of ingredients by using waste materials and admixtures shows better compressive and tensile strength, improved sulphate resistance, decreased permeability and improved workability.

Nurdeen M. Altwair et al (2011) have investigated the flexural performance of green engineered cementitious composites (ECCs) containing high volume of palm oil fuel ash (POFA). The author also analysed some available experiments to monitor the flexural performance by curing the concrete using four-point bending test. The experimental results show the flexural performance was assessed after 3, 28, and 90 days. The results suggest that there is a corresponding reduction in the first cracking strength and flexural strength of the ECC beams with the increase of water–binder ratios and POFA content. The flexural deflection capacity tends to increase with an increase in both the water–binder ratio and POFA–cement ratio. After 28 days, as the POFA/C increased from 0.4 to 1.2, the first cracking strength decreased from 7.7 to 5.3, 6.7 to 4.9, and 6.4 to 4.5 MPa at water–binder ratio of 0.33, 0.36, and 0.38, respectively.

Bambang Suhendro et al (2014) have investigated the 8 to 10 percent of the world's total CO₂ emissions come from manufacturing cement. Green concrete is defined as a concrete which uses waste material as at least one of its components, or its production process does not lead to environmental destruction, or it has high performance and life cycle sustainability. Various efforts have been conducted by researchers to arrive at some alternatives that are able to significantly reduce high energy consumed and environmental impacts during fabrication process of cement. The cleaner technologies in concrete production, such as substituting relatively high percentage of cement by fly ash. Several efforts that have been done so far in implementing the concept of green concrete and material development of nano silica in Indonesia have also been reported.

Janez Turk et al (2015) have investigated the green concrete mixes were prepared from three different types of industrial by-products, i.e. (1) foundry sand, and (2) steel slag, both of which were used as manufactured aggregates, and (3) fly ash, which was used as a mineral admixture. Some green concrete mixes were also prepared from a recycled aggregate, which was

obtained from reinforced concrete waste. In this way a circular economy could be established, so that the materials loops could be closed, as well as reducing the amount of waste which needs to be landfilled. The sustainable use of resources is especially important in the concrete production industry, since concrete is, worldwide, the most consumed building material (Gursel et al., 2014; Marie and Quiasrawi, 2012; Van den Heede and De Belie, 2012). However, it was concluded that the results of the alternative scenarios are, in general, not very sensitive to the delivery distances of the alternative materials.

Jing Yu et al (2016) have studied using a high dosage of fly ash in concrete is an effective approach to control the heat release rate, reduce the material cost and enhance the sustainability. However, ultrahigh-volume fly ash (UHVFA) concrete, with fly ash replacing over 60% of the binder by weight, often exhibits low compressive strength at an early stage, which limits the material to non-structural or semi-structural applications. Mechanical properties up to 360-day age were recorded, and the cementing efficiency factor of the fly ash was studied. The utilization of POFA was also observed to improve the resistance of concrete to chloride ion penetration [5,6], reduce heat development, increase resistance to acidic environment [4] and improve sulphate resistance of concrete [7,8]. The POFA-HSGC exhibits lower compressive strength at 1, 3 and 7 days especially at higher POFA contents, but the opposite trend is shown after 28 days of water curing period. The POFA-HSGC records lower porosity, initial surface absorption, rapid chloride permeability, gas permeability and water permeability in particular at higher POFA content and at longer water curing period. This could be translated into potentially superior durability performance.

Mohammed S. Imbabi (2013) have studied every tonne of Ordinary Portland Cement (OPC) that is produced releases on average a similar amount of CO₂ into the atmosphere, or in total roughly 6% of all man-made carbon emissions. Emission reduction is also needed to counter the impacts on product cost of new regulations, green taxes and escalating fuel prices. Fly ash, Blast furnace slag and silica fumes are three well known examples of cement replacement materials that are in use today that, like OPC, have been documented and validated both in laboratory tests and in practice. Carbon-reducing cements, if they could be developed for commercial-scale application, probably offer the safest, most economical and elegant Carbon Capture and Storage (CCS) technology. The use of other fossil fuels such as biomass, on the other hand, can be an effective fuel substitute, producing CO₂ emissions that are about 20–25% less than those of coal. There is still a huge demand for cement and the industry contributes greatly to the economy and employment prospects of its host nations. But without change, the cement industry will decline.

Tomasz Blaszczyński (2015) have investigated the CO₂ is major gas just after steam causing this problem. The anthropogenic one is being real problem. It is because the fact that people are working hard to make CO₂ grow. Unfortunately, there is no technology to reduce carbon dioxide emission of clean Portland cement. According to data published in 1993 by founder of this technology, prof. Joseph Davidovits, is possible to reduce CO₂ emission from 40% to even 90% due to ordinary cement. This is possible because of fact, that geopolymers cement does not require calcium carbonate for binding. Author speculated that in next two decades worlds cement production will grow 3.5 times. From 1 billion of tones in year 1994 till 3.5 billion of tones in year 2014. Additional resources given by authorities and government on global, national and even local fields would really accelerate research which should be performing to implement new green binders.

M.A. Megat Johari et al (2011) have studied the engineering and transport properties of high-strength green concrete (HSGC) containing up to 60% of ultrafine palm oil fuel ash (POFA). The ultrafine POFA obtained was then utilized in the production of HSGCs with POFA replacement levels of 0%, 20%, 40% and 60% by mass of ordinary Portland cement. The results

show that the treatment processes undertaken results in a highly efficient pozzolan. These by-products are normally used as fuel to heat up boiler for generation of electricity in palm oil factories. Nonetheless, these studies somehow indicated the limitation of the POFA used, as the highest compressive strength was obtained at a POFA replacement level of 20% and the highest 28-days compressive strength obtained for the concretes containing POFA was in the range of 60–86 MPa. hence, it is possible to produce HSGC utilizing high volume of ultrafine POFA with promisingly superior properties and durability performance.

III.MATERIALS FOR GREEN CONCRETE

- ✓ Recycled Demolition Waste Aggregate
- ✓ Recycled Concrete Aggregate
- ✓ Blast Furnace Slag (BFS)
- ✓ Manufactured Sand
- ✓ Glass Aggregate
- ✓ Fly Ash

a) Recycled Demolition Waste Aggregate: The usage of construction and demolition waste aggregates helps in reducing the depletion of natural aggregates and problems related to mining the aggregates. It is found that the quality of natural aggregates is better compared to the construction and demolition waste aggregates. Thus, demolition waste aggregates have limited usage. But the reduced cost of manufacture of concrete with the help of construction and demolition waste aggregates must be gained appreciation. The life cycle of construction materials can be made more performing with the help of recycled construction demolition waste. This has made the recycling amount of construction and demolition waste material by an amount of 90%.



Fig 1. Recycled Demolition waste aggregate

b) Recycled Concrete Aggregate: Recycled aggregate is produced by crushing concrete, and sometimes asphalt, to reclaim the aggregate. Recycled aggregate can be used for many purposes.



Fig 2. Recycled concrete material (RCM)

The primary market is road base. For information on recycling asphalt pavement into new asphalt pavement. See Asphalt Pavement Recycling. Aggregate consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder. Inert solid waste is concrete, asphalt, dirt, brick, and other rubble. Recycled aggregate comes primary from PCC and AC from road rehabilitation and maintenance, demolition, and leftover batches of AC and PCC.

c) Blast Furnace Slag (BFS): Slag cement is a hydraulic cement formed when granulated blast furnace slag (GGBFS) is ground to suitable fineness and is used to replace a portion of Portland cement. It is a recovered industrial by-product of an iron blast furnace. Pelletized blast furnace slag has been used as lightweight aggregate and for cement manufacture. Foamed slag has been used as a lightweight aggregate for Portland cement concrete. Granulated blast furnace slag has been used as a raw material for cement production and as an aggregate and insulating material. Ground granulated slag is often used in concrete in combination with Portland cement as part of blended cement. Ground granulated slag reacts with a calcium by-product created during the reaction of Portland cement to produce cementitious properties.



Fig 3: Blast furnace slag (BFS)

d) Manufactured Sand: Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. Moisture is trapped in between the particles which are good for concrete purposes. Higher concrete strength compared to river sand used for concreting. Minimum permissible silt content is 3%. ... Though M Sand uses natural coarse aggregates to form, it causes less damage to the environment as compared to river sand.



Fig 4. Manufactured Sand for concrete

e) Glass Aggregate: When glass is crushed and screened to pass through a 5 mm sieve, it closely resembles natural sand and has engineering properties similar to other fine aggregate materials. Hence, the waste glass aggregate (WGA) is given due consideration as a feedstock substitute for construction aggregates. With respect to the durability of glass cement-based materials, the inclusion of glass aggregates effectively improved the surface resistivity and sulphate attack and improvement increased with the amount of sand replacement.



Fig 5. Recycled glass aggregate

f) Fly ash: Fly ash is a by-product produced during the operation of coal-fired power plants. The finely divided particles from the exhaust gases are collected in electrostatic precipitators. These particles are called Fly ash. Fly ash is most used pozzolanic Material all over the world. The volume of fly ash is produced is about 75 million tons per year, the disposal of which has becomes major concern. About only 5% of the total fly ash is utilized in India, the remaining of which has to be disposed. About 1.5 tons of raw materials is needed in the production of every ton of PC, at the same time, about 1 ton of CO₂ is released into environment during the production.



Fig 6. Fly ash

Table 1. Replacement Materials For Green Concrete

Sl. No	Traditional ingredients	Replacement materials for green concrete
1.	Cement	Eco-cement, sludge ash, municipal solid waste fly ash
2.	Coarse aggregates	Recycled aggregates, waste ready mix concrete, waste glass, recycled aggregates with crushed glass, recycled aggregates with silica fume.
3.	Fine aggregates	Fine recycled aggregate, demolished brick waste, quarry dust, waste glass powder, marble sludge powder, rock dust and pebbles, artificial sand, waste glass, fly ash and micro silica, bottom ash of municipal solid waste.

IV.CONCLUSION

Eight to 10 percent of the world's total CO₂ emissions come from manufacturing cement. Green concrete is defined as a concrete which uses waste material as at least one of its components, or its production process does not lead to environmental destruction, or it has high performance and life cycle sustainability. There is significant potential in waste materials to produce green concrete. The replacement of traditional ingredients of concrete by waste materials and by products gives an opportunity to manufacture economical and environment friendly concrete. Partial replacement of ingredients by using waste materials and admixtures shows better

compressive and tensile strength, improved sulphate resistance, decreased permeability and improved workability. The cost per unit volume of concrete with waste materials like quarry dust is lower than the corresponding control concrete mixes. A detail life cycle analysis of green concrete by considering various parameters is very much necessary to understand the resultant concrete properties.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.

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