

Green Concrete: Invention, Application And Sustainability

Sanyukta P. Kulkarni

Abstract- Green concrete is a technological advancement in the construction industry as an effort to promote and practise sustainability. Green concrete makes use of at least one by product from the industry as its raw material. This reduces the exploitation on the raw natural resources and also saves fuel required for production. The debris collected is being efficiently used, thus reducing the disposing responsibility. One of the main advantages of using green concrete is that it promotes sustainability. Reduction in carbon emissions is a prime factor that gets considered. Developing countries are the most benefitted users of green concrete. The fly ash that gets generated as a by-product can largely be used to its maximum capacity as green concrete not only retains but also enhances the mechanical properties of concrete.

Index Terms- carbon-dioxide, constructional debris, developing countries, economic, energy efficient, fly ash, green concrete, sustainable

1 INTRODUCTION

CONCRETE has been employed in the construction industry from the early Roman period. Cement manufacturing produces and emits about 8-10% of total world carbon emissions (Suhendro, 2014). Global warming gases and heat are released into the environment when raw materials of cement- limestone and clay are crushed and heated in a furnace at very high temperatures (1500° C). Also, fuel consumed in the production of concrete results in reduction of the energy resources.

Another important issue faced is that concrete cannot be completely destroyed and also proposes limitations upon its reuse and recycling. Major targets for a cleaner technology production of concrete are:

1. Reduction of CO2 emissions
2. Reduction in energy and fuel consumption
3. Saving up on non-renewable energy and material resources (Agarwal, Garg, 2018)

Green concrete is a more sustainable and reliable material in the history of concrete industry. Denmark was the first country where green concrete was invented by Dr. W.G. in the year 1998. It is a concept of thinking of environment in every aspect of concrete technology - from production to destruction. At least one of the raw materials used in the production of green concrete is a waste material.

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It is possible and beneficial to use waste materials of other industries in the production of concrete while still maintaining high quality of the final product. The use of water is reduced by almost 20 %. During the last decade, society has become aware of the deposit problems connected with residual products and its impact of the environment. Restrictions on the use of such products and heavy taxes have been imposed. Some of these residual products are sustainable to be used as raw materials for the production of concrete. Well known residual products such as silica fume, fly ash and micro silica have proved to be the most effect raw materials.

The potential benefit of using green concrete to the society is huge. Production of green concrete has given hope for development of such a technology that will have less harmful impact on the environment while still maintaining high quality of the manufactured construction component.

Furthermore, some companies in concrete industry have recognized that reductions in harmful environmental impacts. As green concrete uses recycled aggregates and materials, the extra loads in landfills reduce and it also mitigates the wastage of aggregates. Use of green concrete also assures sustainability which emphasizes on long term economic considerations, affordability, durability and effectiveness (Admute, Nagarkar, et.al, 2017).

2 AIM

To understand the impact of the invention of green concrete, its uses and applications in India and its contribution towards sustainability w.r.t developing countries.

3 OBJECTIVES

1. Understanding the need of green concrete

2. Analyzing the properties of green concrete
3. Spread and use of green concrete in the Indian construction industry
4. Sustainable approach of green concrete

4 SCOPE AND LIMITATIONS

The discussions further on in the research focus on a case – India. The parameters of research focus on the past, present and future of green concrete in the region decided and finalized. A study of sites that have used green concrete as one of the project materials, features explained and suggested applications by the manufactures and research review by industry experts leads to the discussions in the following papers.

5 LITERATURE REVIEW

Green concrete is a product that was invented, rather produced, due the need of protecting the environment. Today's exciting trend is the 'green building' in our country. The society is largely benefitted from the use of green concrete for construction. Green Concrete is eco-friendly and protects the environment by using waste products like rice husk ash, micro silica, etc. for manufacturing. Use of green concrete helps in saving energy, reduces carbon dioxide emissions and requires less water. Green concrete requires lesser production cost as it uses waste products thus reducing the energy consumption in the production of per unit of cement. (Lekshmi, 2016). The construction industry has a high demand of energy and thus accounts for a massive environmental impact. Awareness regarding global warming and green house effects has made people to think about sustainable alternatives and for the protection of environment. Green concrete is capable for sustainable development. It reduces the use of natural resources thus helping to preserve the natural reserves of materials and fuel. A thorough study of the mechanical and chemical properties has revealed that green concrete is at a comparable scale with the regular concrete. The waste materials used are often used as a substitute to Portland cement, the largest produced manmade product. The lifespan of the structures built using green concrete is same as that of a structure built using regular concrete. The known benefits green concrete are that it will resist the spread of fire, ensure less harm to the environment and reduce power consumption required for production. Its use increases the durability of the facilities by up to 20 years. Green concrete is the term attributed to Ground Granulated Blast Slag (GGBS) mixed with fly ash. GGBS is a by-product of the iron and steel industry, produced through quenching the molten slag in water and then grinding it into a fine powder. Some of the commonly sought of properties of green concrete are fire repulsion, earthquake resistance, durability, heat insulation, easy maintenance, etc.

Green concrete is a flexible material and renders to easy handling and speedy construction. Added benefit is the protection of the environment; an objective for its development. Use of by-products and waste materials of other processes had greatly benefited the land-fill conditions of the countries that promote this product. Amount of construction waste has greatly reduced and it also caters to the non-destructible setback of concrete to a considerable extend. The developing countries are the most benefited users of this product. They require large amount of cement and concrete for developing the necessary infrastructure. The waste and by-products formed during the process of production can be used to its full benefit for making the further developing infrastructure environment-compatible.

6 RESEARCH GAP

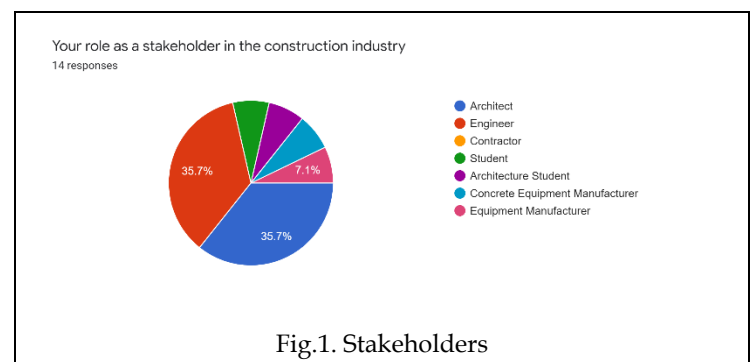
The lack of awareness among the architects and engineers is refraining the developers from taking advantage of the available resource at very cheap rates. The builder lobby, too, is lacking the knowledge and is unaware of the wide-scale applications of green concrete.

7 HYPOTHESES

Lack of awareness among the professionals of the construction industry about green concrete has restricted the efficient use of green concrete.

8 METHODOLOGIES

Survey of the stakeholders of the concrete industry is the primary source.



Secondary sources like research papers on similar topics, articles by scientists, environmentalists and researchers, websites and brochures of companies producing green concrete have been used. Data reports of the properties of green concrete with fly ash used as a waste raw material. Case studies of structures that have used green concrete as a construction material have been conducted.

9 SURVEY QUESTIONNAIRES

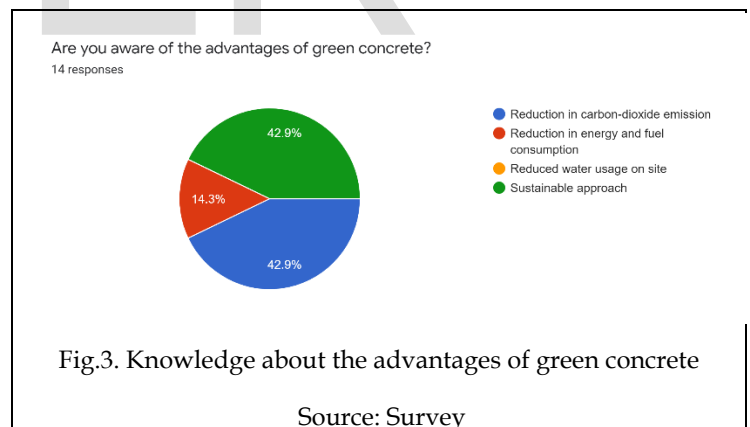
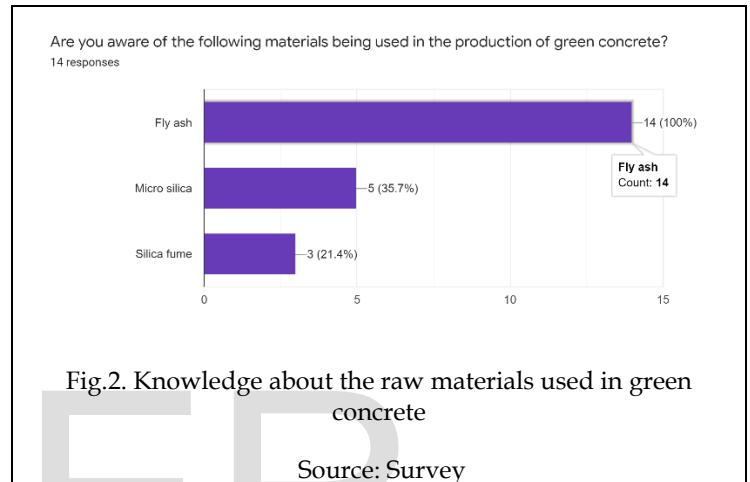
1. Your role as a stakeholder in the construction industry
2. Have you used green concrete in any of your projects?
3. Are you aware of the following materials being used in the production of green concrete?
 - a. Fly ash
 - b. Micro silica
 - c. Silica fume
4. Are you aware of the advantages of green concrete?
 - a. Reduction in carbon-dioxide emission
 - b. Reduction in energy and fuel consumption
 - c. Reduced water usage on site
 - d. Sustainable approach
5. Identify policy barriers in the use of green concrete in the construction
 - a. Code restrictions
 - b. Prescriptive specifications
 - c. Concern with possible EPA rules on fly ash
6. Identify market obstacles
 - a. LEED specifications
 - b. Client policy
 - c. Competitive pressures
 - d. Shortage of stock Transportation
7. Economic barriers
 - a. Higher material cost
 - b. Market differentiation
 - c. Lengthened construction schedule
 - d. Increased design cost
8. Do you risk any safety precautions with the use of green concrete?
 - a. Fire
 - b. Earthquake

c. Loading capacity

d. No

10 SURVEY ANALYSIS

The responses collected from the survey indicate that the awareness about the various properties of green concrete is less among the stakeholders. The stakeholders have only partial knowledge about the vast expanse, scope and benefits of this material.



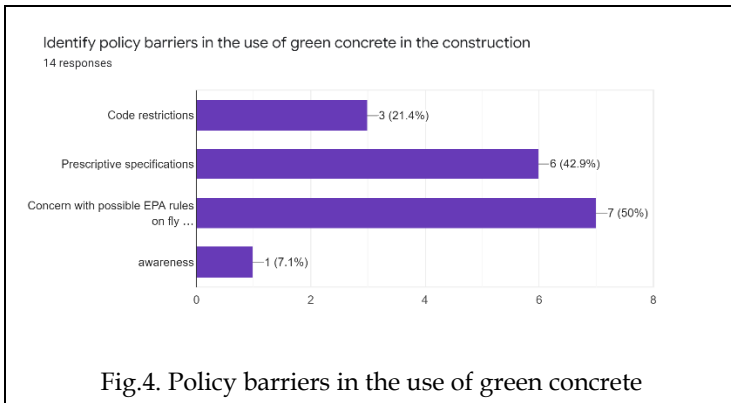


Fig.4. Policy barriers in the use of green concrete

Source: Survey

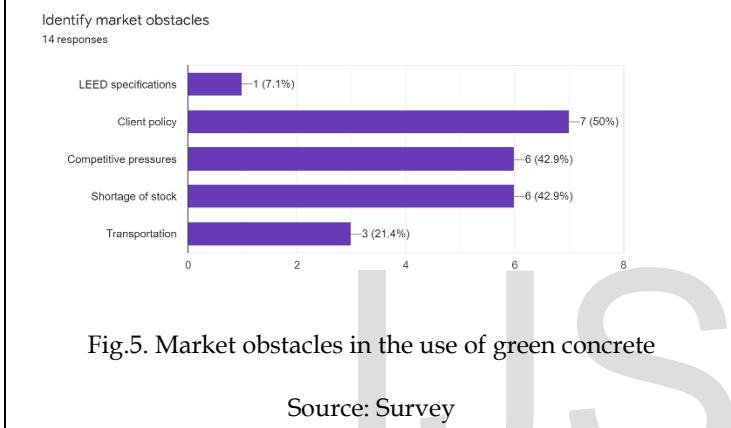


Fig.5. Market obstacles in the use of green concrete

Source: Survey

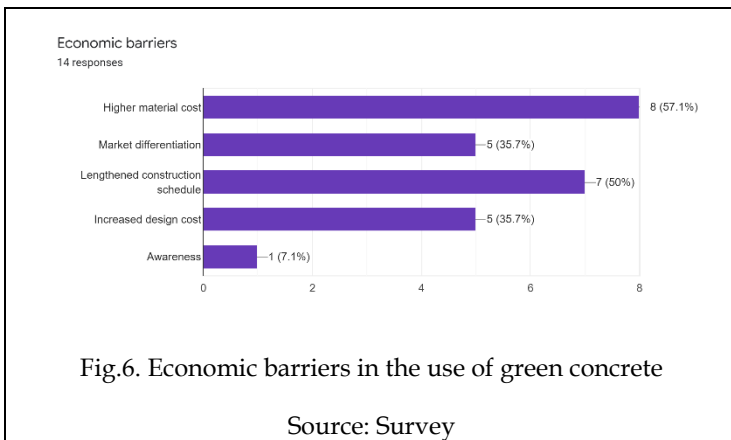


Fig.6. Economic barriers in the use of green concrete

Source: Survey

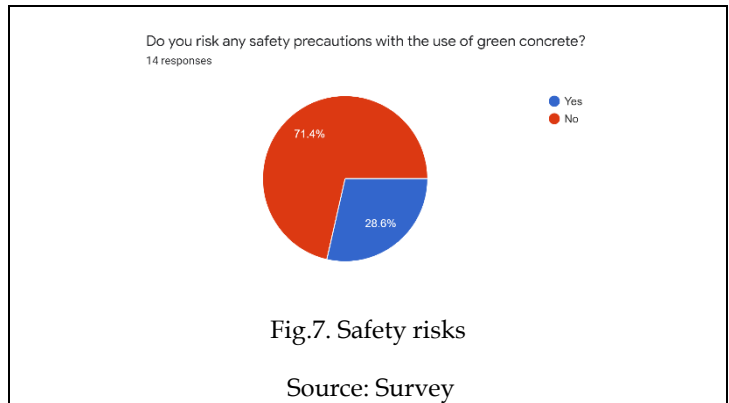


Fig.7. Safety risks

Source: Survey

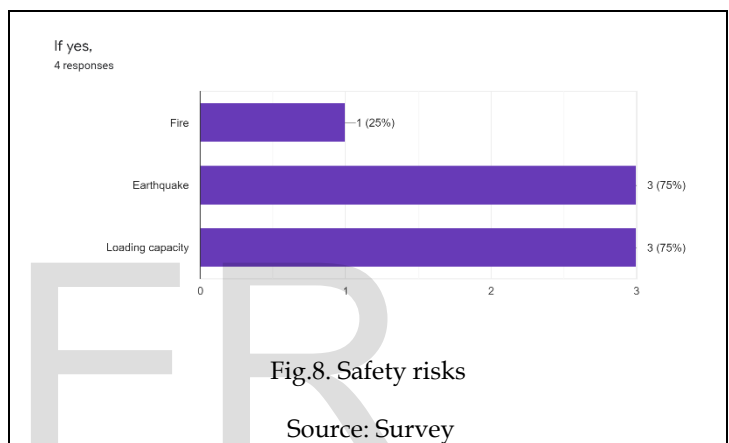


Fig.8. Safety risks

Source: Survey

11 RESEARCH

Many structures have been constructed using green concrete and have stood the test of time. Use of green concrete is not only restricted to the construction of buildings but also in many other construction categories. The research aims at discussing the various attempts of using green concrete in the structures and the benefit of using this revolutionary product. The paper also focuses on the sustainable characteristics of green concrete and its manifold benefits on the environment.

FLY ASH

Fly ash is considered to be one of the best components that can be used in the production of green concrete. The use of this by-product offers environmental advantage by reducing the energy investment in processing virgin materials. Also, fly ash being difficult and hazardous to dispose, thus can be effectively used towards the manufacturing of a sustainable product.

Following are the advantages of using fly ash as a component of green concrete:

1. Fly ash particles are almost spherical and can get easily mixed with the targeted mixing consistency.
2. Fly ash particles create a lubricating effect when the concrete achieves a plastic stage.
3. High density of fly ash reduces bleeding and also prevents cracks.
4. Fly ash releases less heat while curing and thus prevents thermal cracking.
5. Increases workability of the mixture.
6. Easy to pump and can also be transported to long distances.
7. Any desired finish can be easily achieved.
8. Allows for greater working time and also prevents slump loss.

Another advantage of fly ash is that it is light weight and durable. Bulky and deep sections can have hollow interiors due to the increased strength by fly ash.

Statistical data states that out of the total produced fly ash, only 35-40% of it gets reused. This wastage of such a valuable by-product shall be prevented.

Fly ash is used the re-used raw material used in the production of mortar and green concrete. To analyse the properties of green concrete against mortar (to be then used as concrete), samples of mortar with varying percentage of fly ash and green concrete are compared.

Sample	Binder		Sand	Gravel
	Cement	Fly ash		
Mortar Mix I	0.2	0.8	2	0
Mortar Mix II	0.2	0.8	2	0
Mortar Mix III	0.15	0.85	2	0
Green concrete	0.2	0.8	1.14	2.06
M30	1	0	1.87	3.38

Mortar samples and green concrete are compared for flexural and compressive strength against different curing intervals. The test results show clearly that green concrete is as effective as any other sample of mortar tested.

Mix	Curing condition	Compressive strength	Flexural strength
		(MPa)	(MPa)
Mortar Mix I	7 days	13.4	1.5
	28 days	24.3	2
	7 days Equivalent Heat Curing	37.8	2.9
	28 days Equivalent Heat Curing	47.9	4.2
Mortar Mix II	7 days	10	1.2
	28 days	16.6	1.9
	7 days Equivalent Heat Curing	27.6	2.7
	28 days Equivalent Heat Curing	37.4	3.6
Mortar Mix III	7 days	7.8	1
	28 days	13.5	1.5
	7 days Equivalent Heat Curing	27.5	2.5
	28 days Equivalent Heat Curing	40.5	3.9
Green Concrete	7 days	7.7	0.8
	28 days	13.7	1.2
	7 days Equivalent Heat Curing	27.9	2.2
	28 days Equivalent Heat Curing	34.4	2.6
M30 Concrete	7 days	40.3	N.A.
	28 days	54.7	N.A.

Fig.9. Compressive strength and flexural strength of the samples studied

The test results clearly show that green concrete is capable of sustaining the compressive as well as flexural strength as that of any other sample tested.

12 APPLICATIONS OF GREEN CONCRETE

Green concrete has wide range applications in the construction industry. along with constructing regular buildings, it can be used for many other structures as well. It is used in dams, bridges, RCC structures, special slabs, load bearing structures, etc.



Green concrete dam



Green concrete bridge



Green concrete column

13 ADANTAGES OF GREEN CONCRETE

Reduction in CO2 emissions

Very low production cost due to the use of by-products

Saves energy and water

Helps in recycling industry wastes

Improves workability

Has higher strength and durability than normal concrete

Helps and promotes sustainable development

14 GREEN CONCRETE AND SUSTAINABILITY

Green concrete helps to reduce the harmful environmental impact usually caused during the production and use of regular concrete. This material can thus be considered as a sustainable material. Green concrete requires less energy and fuel for production. The water required on site is also less than regular concrete. The major advantage of using green concrete is that it reduces the carbon-dioxide emissions. Green concrete is made of new raw materials namely fly ash, recycled concrete aggregates and aluminium can fibres. Fly ash is a waste product from coal power plants and is commonly disposed of in ponds and sent to landfills. Through research it was discovered that fly ash has the potential to replace cement, a material with large environmental impacts due to air pollution from the cement plants. In order to reduce consumption of raw materials and to minimise the wastes generated from demolished concrete structures, crushed concrete can be reused as aggregates.

Finally, green concrete concept cannot stand alone. It needs to be backed up by a sustainable design concept taking into account the full life-cycle and also the aspects of energy performance of the building and maintenance. Concrete is one of the few building materials offering decades of practically maintenance-free service life but it requires proper design to meet the requirements of the users over a full life-cycle. Therefore, we still have a job to do implementing sustainable design concepts in order to serve the society.

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