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Green Concrete – A Sustainable Solution

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Abstract: ***Concrete which is a structural material consisting of particulate substance, like fine and coarse aggregate, cement and water, that is bonded together in a standard mix ratio. Concrete is one of the most used construction materials around the world for building construction. For shaping a building, concrete is having a mandatory role but the usage of concrete causes for environmental impacts likes global warming. Cement is the major constituent material in the concrete and the reactions happening in the concrete is exothermic reaction, it is heat generating reaction and evolvement of gases which is harmful and causes environmental imbalance. Production of concrete is one of the vital factors for global warming as it accounts for 30% of the total CO_2 released in the atmosphere. Recycle and reuse of waste materials from industries is becoming very popular to overcome these environmental issues. In order to compensate these effects, an eco-friendly concrete must be substitute, this compensating concrete is known as green concrete. Due to the development in the sustainable construction, engineers and architects are stimulated to figure out the materials which are more sustainable for construction. This paper reveals about the green concrete, its materials & selection, advantages and disadvantages of green concrete technology.***

Keywords: concrete, environment, construction, green

1. Introduction

Green concrete is an environmentally friendly concrete, which was first invented in Denmark in the year 1998. It is a type of concrete that is used to create the construction materials having a lesser effects on the environment. The concrete comprises of industrial wastes and in organic polymer in a separate mix. Fly ash, blast furnace slag are the industrial wastes with cement mixture are used for the production of green concrete. Globally, large utilisation of electricity, energy, water and material is for the building construction. Buildings account for 18% of global emissions today, which is equivalent of 9 billion tones of CO2 annually. In this circumstances if we are unable to figure out an alternative method for carbon dioxide emission, the emissions could be double by 2050[3], according to the United Nations Environment Program. Green concrete building practices aim to reduce the environmental impact of building. Green concrete is similar to conventional concrete but the energy consumption is low for green concrete while comparing with conventional concrete. During the production process energy consumption is very low and durability will be higher in the case of green concrete.

Recently engineers are aware about the climatic change and impact of greenhouse gas emissions on our environment. Concrete is one of the most widely used construction material. It has substantial sustainability benefits. Cement concrete consists of Limestone (Calcium Carbonate CaCO3). At the time of production process, the ingredients are heated up to about 800 - 10000C. During this process the carbon dioxide is get free. On an average around 1kg of cement liberate about 900gms of carbon dioxide into the atmosphere. Carbon dioxide emission in traditional cement will be higher. Due to this fact ordinary cement, which is often known as Portland cement. But lamentably this cement causes serious environmental issues, which is due to the involvement of cement clinker in a reaction called calcinations. The reaction is

$$5CaCO3 + 2SiO2 \rightarrow (3CaO,SiO2)(2CaO,SiO2) + 5CO2$$

In European countries the cement industry are forced to get down the level of CO2 and tries to make this possible. Restriction of carbon dioxide is not there where it should be. In developed countries like Europe or North America are trying to produce very less cement due to whole world production. Lamentably there is no technology to reduce evolvement of carbon dioxide from clean Portland cement.

2. Green Concrete- Selection and its Materials

According to Roodman and Lenssen [7] building and construction activities around the world consume 3 billion tons of raw materials each year which is around 40% of total global use. The usage of green concrete materials in construction boost the conservation of reducing nonrenewable resources[8]. Green concrete materials for building construction can be defined as:

- The material needs to be sustainable during their whole life-cycle, and also the materials upheld can be quantified by the LCA methodology.
- It may not insecure and unsafe for human health, i.e. it doesn't leads to negative effects in terms of indoor air quality. In particular, they must not cause indoor pollution (volatile organic compounds, hazardous fibres dispersion, radon emission.

2.1 Selection Criteria For Green Material

2.1.1 Resource Efficiency:

- **Recycled Content**: Recycle content includes material products which are from post industrial content, with a leaning for post consumer content.
- **Natural and renewable:** The resource materials harvested from sustainably managed sourced and preferably have an independent certification (e. g. certified wood)
- **Resource efficient manufacturing process:** In this process products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste.

- **Locally available:** Building materials, components, and system found locally or regionally saving energy and resources in transportation to the project site.
- **Salvaged, refurbished, or remanufactured:** rehabilitate discarded material from a dump renovating it, repair it and change the aesthetic and physical appearance and change its value.
- **Reusable or recyclable:** figure out the resource materials materials that can be easily destructed and reused or recycled.
- **Durable:** Materials that are longer lasting or are comparable to conventional products with long life expectancies.

2.1.2 Indoor Air Quality (IAQ):

- **Low or non -toxic: The construction** Materials that emit few or no CFC's, reproductive toxicants, or other harmful gas.
- **Minimal chemical emissions:** Products that have minimal emission of Volatile Organic Compounds (VOCs). Products that also maximize resources and energy efficiency while reducing chemical emissions.
- **Moisture resistant:** Material Product that with stand moisture or retard the growth of biological actions in building which may later cause for efflorescence.
- **Healthfully maintained:** Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.
- **Systems or equipment:** Products that promotes IAQ by identifying indoor air pollutants or enhancing the air quality.

2.1.3 Energy Efficiency

Green concrete materials tries to retard the amount of energy consumption required to operate a home or office. They assimilate alternative forms of energy, thermal efficiency, and energy waste reduction to minimize the energy footprint.

2.1.4 Water Conservation:

Water conservation efficiency is specifically predominant in commercial structures. For green concrete , products needs to be manufactured by using different methods and ideas that prevent pollutants from entering into the local water supply. Products reduce water waste by managing internal systems for maximum efficiency and use. These materials will also assist with the recycling of non-potable water for use in site irrigation systems.

2.1.5 Affordability

By considering the product life cycle of Green concrete structures or Buildings the costs wanted to be comparable to conventional building materials. These materials and are within a project-defined percentage of the overall budget.

3. Materials for Green Concrete

1) Conventional Ingredients	2) Replacement Material For Concrete
Cement	Municipal solid fly Ash, Sludge Ash, Recycled Glass ,Silica Fume
Coarse Aggregates	Recycled aggregate, Waste ready mix concrete,
Fine Aggregates	Waste glass fine recycled aggregate, Demolished brick waste, Quarry dust, Marble powder waste

3.1 Fly Ash As Cementitious Material

Fly ash is a supplementary cementitious material in the production of cement concrete. It is a byproduct of combustion of crumble coal in electric power generating plant. The colour of the flyash in Indian power station are grey, but having the appearance of cement. Fly ash are classified into class C and class F flyash, which is on the basis of amount of calcium, silica, aluminum and iron content in the ash. Class F fly ash is often used at dosages of 15% - 25% by mass of cementitious material and Class C fly ash is used at percentage of 15% to 40% by mass of cementitious material. Amount of dosage percentage varies with the reactivity of the ash and the desired effects on the concrete (Helmuth 1987 and ACI 232 1996).

Fly ash is a fine powder and most of the fly ash are pozzolanic, which means it's a siliceous or siliceous-and-aluminous material that can be chemically reacts with calcium hydroxide (CaOH) to form cement. When rumble or powdered coal burnt , it generates heat and the remaining contains 80% fly ash and 20% bottom ash.. The Portland cement reacts with water to form hydrated calcium silicate (CSH) and lime. When appropriate flyash reacts with lime to form calcium silicate, which is the same cementing material product as getting from Portland cement. Generally, fly ash is added to structural concrete at 15-35 percent by weight of the cement, whereas up to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements. Theoretically it is possible to substitute 100% of Portland cement by fly ash, but replacement levels above 80% generally require a chemical activator. Fly ash used in structural concrete in order to increase the workability of plastic concrete and increase strength and durability of hardened concrete.

3.2 Silica Fume

Silica fume, it's a byproduct of producing silicon metal or ferrosilicon alloys. This byproduct as result of reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon. It is one of the most beneficial uses for silica fume is in concrete. Due to its chemical and physical properties, it is a very reactive pozzolanic material. Concrete containing silica fume can have very high strength and can be very durable. Widely Norway is one of the world's largest producers of silica fume with 1981 estimated tonnage of about 120,000 tonnes, and total worldwide production of silica fume is estimated at about 1 million tones[4].

The grain size of silica fume are more fine and hence it fills the voids in between the cement grains making the silica fume concrete more cohesive which enhance by thixotropic nature of silica fume cement paste . Spherically shaped silica fume particles give ball bearing action when energy is applied to silica fume concrete mix causing the mix flow easily. When the pozzolanic material like silica fume are assimilate the normal concrete the durability and mechanical properties can be can be improved. Due to the reaction with silica fume and free calcium hydroxide causes for the hydrate formation of extra calcium silicate hydrate (C – S – H) causes for the gel formation in concrete.

Highway bridges, parking decks, marine structures and bridge deck overlays are subject to constant deterioration caused by rebar corrosion current, abrasion and chemical attack[5]. Silica fume will protect concrete against deicing salts, seawater, traffic and heavy impact and also it eliminate rebar corrosion and concrete deterioration which reduces the expenses.

- Very low permeability to chloride and water intrusion
- Extremely high electrical resistivity (20 to 100 times greater than ordinary concrete)
- Increased abrasion and impact resistance on decks, floors, overlays and vertical structures
- Superior resistance to chemical attack from chlorides, acids, nitrates and sulfates

3.3 Fly Ash Aggregate

India produces approximately 120 million tones of fly ash annually. Fly ash based lightweight aggregate offer potential for large-scale utilization in the construction industry. One of the main disadvantage of normal concrete is the high self weight of the concrete. Density of the conventional concrete is of the order of 2200 to 2600 kg/m3. The fly ash light weight concrete whose densities varies from 300 – 1850 kg/m3. There are many advantages for the light weight concrete due to the low density, they are:-

- Helps reduction in dead load
- Increase the progress of building
- Lowers haulage
- Lowers handling cost.

In the case of light weight concrete beams and columns of framed structure carry loads of floors and walls it will result in considerable economy and also it is having lower thermal conductivity. Fly ash light weight concrete has become predominant in recent years due to the tremendous advantage over normal concrete. Structural light weight concrete is a special type of aggregate which is comparatively lighter than conventional concrete. This light weight concrete having 28 compressive strength more than 17 Mpa and 28 day air dried unit weight. These fly ash aggregates have a specific gravity range of 1.20–1.47, a bulk density range of 650–790 kg/m3 and very high absorption from 16–24.8% [11]. Light weight shows higher moisture movement than the normal or conventional concrete. Due to the fact that light weight concrete having large percent of air, it's a perfect material with respect to sound absorption, sound proofing, and for thermal insulation[1].

Light weight aggregate differentiated into two, they are:-

1) Natural light weight aggregate
   Eg:- pumice diatomite, scoria, volcanic cinders, rice husk
2) Artificial light weight aggregate
   Eg:- foamed slag, bloated clay, expanded perlite, sintered fly ash

3.4 Quarry Dust/Stone Crusher Waste As Fine Aggregates

The fine aggregate is the dominant material in the concrete. The river deposits are the most common source of fine aggregate. The purpose of the fine aggregate is to aid in producing workability and uniformity in the mixture of concrete. Bu today the availability of river sand become extinct due to the overuse and exploitation and become very costly. In this circumstances it's the time to think an alternative material for partially or fully substituting sand, that substituting material is quarry dust. The Quarry dust may be used in the place of river sand fully or partly.

Quarry dust, is a by-product releases from the cutting and crushing process of stone which is a concentrated material to use as fine aggregates. Due to the exploding of mountain, rock will be crushed to small size stones and along with this dust type particles called quarry dust will be formed. This quarry dust is useless and form air pollution. In this situation this quarry dust can be used in building works, which will decrease the cost of construction and the construction material would be saved and the natural resources can be used properly. Besides, waste can be used to produce new products or can be used as admixtures so that natural sources are used more efficiency and environment is protected from waste deposits. It has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking.

Quarry dust showing good strength when it is partially or completely used. when the percentage of Quarry Dust gradually increases, the Compressive strength of concrete will also increase with condition that percentage of Quarry Dust should not exceed 50%[10]. Quarry rock dust concrete experiences better sulphate and acid resistance and its permeability are less, compared to that of conventional concrete. When river sand and quarry dust are compared the specific gravity and sieve analysis result shows that the quarry dust can be used as alternative to sand. The specific gravity of quarry implies that it lies in between 2 to 2.7 which is comparatively same as that of sand. . However, the water absorption of Quarry Rock Dust concrete is slightly higher than Conventional Concrete So in this context we can conclude quarry dust can be used as effective replacement against sand as partially or completely in concrete.

3.5 Marble Waste As Filler Material

Concrete is the dominant construction material, whose production exceeds billions of cubic meters annually. The usage of marble powder into concrete would make significant environmental and economic contributions[2]. In the marble quarry marbles are cut down by different techniques. During this operation 20- 30% marble becomes

waste as powder. This powder leads to various environmental and health issues, in this context the reuse of these material has been emphasized. So these wastes can be used to produce new products and hence that resource can be used effectively.

Self-compacting concrete is a common example of waste material incorporation, that is marble powder into concrete as a filler material. Alyamaç and Ince [6] showed the feasibility marble powder usage as filler in self-compacting concrete and designed a practical concrete mixture to increase the use of marble powder in self-compacting concrete. After that marble powder has become extravagantly used as filler in self-compacting concrete. Subsequently, marble powder is used successfully to develop self-compacting concrete that incorporates a rubber aggregate [9]. Marble Dust powder have the ability for increasing the performance of the hardened concrete. Many of the researchers have recommend that self-compacting concrete containing marble powder is more durable than reference concrete The self-compacting concrete produced with marble powder is the innovative concrete.

Marble powder is also used in the concrete in order to increase the strength and durability of concrete. It shows improvements in the mechanical strength, freeze-thaw durability, and abrasion resistance of the concrete. The use of marble powder as a replacement for aggregate, whereas marble powder is used as a replacement for fine sand in conventional concrete. Many of the test results shows that the use of this waste marble dust up to 50% replacement with the fine aggregate is recommendable. And also the compressive strength of concrete is increased by the incorporation of waste marble powder up to 50% by weight instead of sand and besides any addition of waste marble powder results for decreasing of compressive strength.

4. Advantages and Disadvantages

4.1 Advantages

- **Green concrete is having better workability than normal concrete**
- **Reduction of carbon dioxide emission**
- *Industrial waste*

In spite of using 100% Portland cement mixture, this type of eco-friendly material uses between 25% and 100% fly ash are high amounts of this industrial waste product. Industries use thousands of acres for disposal of flyash

Therefore, green concrete represents a good way to use fly ash, saving several acres of land.

- **Green concrete using reusable and environmentally friendly materials**
- *Reduce energy consumption*

By using less Portland cement and more fly ash, we will be able to reduce the amount of energy you use to produce the material. The materials used in developing Portland cement necessitate a greater amount of natural gas or coal to heat. On the other hand, fly ash already exists as a byproduct of another industrial process. Therefore, you do not need to expend much energy when using it to develop green concrete

- **Good fire and thermal resistant**
- **Green concrete requires less maintenance and repair**
- *High ROI rates*

Due to the fact that green concrete buildings are build from eco-friendly construction materials, they have increased return on investment rates. These buildings, properties sell at high prices.

4.2 Disadvantages

- By using stainless steel, cost of reinforcement for the green concrete building increases.
- Green concrete structures having less life span comparing with normal concrete building.
- Split tensile strength of green concrete is lower than normal concrete.

Conclusion

Green concrete is the sustainable solution for the construction. Today, It is very evident to protect our natural resources, so in this scenario the technology of Green concrete is the perfect break through for the construction. In this concrete the ingredients using are of eco friendly materials which are all discussed in this paper. By using these type of materials the strength parameters and properties of the green concrete are comparatively equal with the normal concrete. One of the main focusing point is, this sustainable concrete can eliminate or reduce the carbon dioxide emission by 30 % comparing with conventional concrete. It is due to this fact this concrete is widely encouraging for civil construction and also helps to reduce the amount of waste materials and get rid of fly ash and other industrial bi- products to a extent. In this concrete reprocessing use of waste material such as fly ash , fly ash aggregate quarry dust etc, consumes less energy and becomes economical in use. And also it is having good thermal and fire resistant. This concrete requires less maintenance and repairs and having better workability than conventional concrete. So green concrete technology will be best suitable substitute instead of conventional concrete.

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