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# ALTERNATIVES FOR GREEN CONCRETE

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***Abstract:*** Traditional mix concrete is a significant source of GHG (Green House Gases), less so in terms of GHG emissions per m3, but more so in terms of the large amount produced globally. New available technologies enable the use of various types of concrete and advanced methods of production that pose less of an environmental risk. The method of production and widespread use of concrete on construction sites enables the achievement of a significant number of LEED (Leadership in Energy and Environmental Design) points, lowering the carbon footprint and optimising energy usage. Concrete continues to be less harmful than the majority of other common building materials, but because concrete is used in construction in proportionally greater amounts than other building materials, advancements in the concrete production process and its use have a significant impact on the overall environmental burden associated with building construction. Concrete can be made environmentally friendly by combining various green technologies already in use and reducing energy consumption.

**Keywords—**Energy, Water, Integration, LECA, RAC

## 1. INTRODUCTION

Human activity's effects on the environment have long been a source of debate and worry. Over that time, impacts like pollution and the destruction or degradation of wildlife habitats and ecosystems have received a lot of attention. However, worries about greenhouse gases, resource depletion, and degradation of ecological services like water supply have grown significantly over the past few years. Buildings' construction, characteristics, use, and demolition are increasingly acknowledged as a significant source of environmental impact, including adverse effects on human health. Taking care of environmental issues involves buildings greatly. Around 40% of the world's greenhouse gas emissions and the same amount of waste are contributed by them. 39% of the energy used worldwide is used in those structures. This is a sizable percentage, especially when you consider that 68% of our electricity is used by buildings. This makes sense because electricity powers buildings, but using less energy every day would help the environment greatly.

Buildings and the built environment they are a part of produce impermeable surfaces that have significant effects on storm-water management, leading to significantly more run-off, less natural water storage, and more pollution. Buildings' construction, characteristics, use, and demolition are becoming more widely acknowledged as a significant source of environmental impact. With population growth and changes in other demographic and economic factors, such impacts are anticipated to worsen unless there is a significant transformation of building construction and operations. So it is simple to understand how going green can be very advantageous for all parties involved.

According to the IGBC (Indian Green Building Council), a green building is one that "uses less water, optimises energy efficiency, conserves natural resources, generates less waste, and provides healthier spaces for occupants than a conventional building."

In general, green building can be defined as integrated building techniques that significantly lessen a building's environmental impact when compared to conventional techniques. The majority of descriptions of green buildings concentrate on a few common factors, particularly siting, energy, water, materials, waste, and health. Serviceability or utility is another explicit design component for high-performance buildings, a category of environmentally friendly structures. Integration is one of the most important aspects of green construction. The green building approach is more comprehensive, focusing on the environmental footprint of a building over its life cycle, from initial design and construction to operations during the building's useful life to eventual demolition and its aftereffects. Individual elements can still be addressed separately, though. The creation of rating and certification systems to evaluate how well a building project satisfies a given set of green criteria is the result of the desire to integrate the various components of green building. Leadership in Energy and Environmental Design (LEED) is the most well-known system. It was created by the U.S. Green Building Council and places an emphasis on the indoor environment, site, water, energy, and materials.

## 2. OBJECTIVES

The following are the goals of the current study:

1) To identify available Green Concrete substitutes.
2) To research the characteristics of some green concrete alternatives.
3) Contrast these qualities with those of regular concrete.

## 3. DIFFERENT ELEMENTS OF GREEN BUILDING

### A. Energy

The key component of green construction is a decrease in energy usage. Energy use can be decreased in the following ways:

- By using energy-efficient lighting, ventilation, and appliances
- By using alternative, renewable energy sources, like solar energy, biogas, etc.

Due to the financial costs and negative effects on the environment caused by energy consumption, energy is frequently regarded as a crucial component. Concerns about pollution extend beyond its negative effects on human health to include its significant role in global warming. The improvement of energy efficiency in buildings using currently available technology can lower global energy demand.

### B. Water

Reduced water use in structures can help with water resource management, particularly in arid regions and in response to periodic drought elsewhere. Reduced-flow plumbing fixtures, wastewater recycling, and rainwater harvesting are a few examples of ways to reduce.

The management of rain, on-site water, and run-off may also apply to how the structure and surrounding land are used.

### C. Materials

A building's construction and operation materials should not have a direct or indirect negative impact on the environment. The selection and application of materials has an impact on embodied energy, resource depletion, pollution, and health. Products that are "green" or "environmentally preferable" can lessen the impact. These materials may contain a significant amount of recycled material, be made from renewable biological resources, or be produced using low-energy, low-pollution processes. They may be made to lessen health risks from VOCs like formaldehyde, which include volatile organic compounds (VOCs). The material should be easily accessible in the area.

### D. Waste

By using materials more effectively and recycling waste products, waste from conventional demolition and construction processes can have a smaller negative environmental impact. Numerous air pollutants can be reduced by using high-efficiency boilers and furnaces. Paper and other operational solid waste can be recycled or processed in other ways to have less of an impact on the environment.

### E. Health

The effects of buildings on health can be influenced by a number of factors. Some actions have clear health consequences, such as using materials free of asbestos, heavy metals, volatile organic compounds, or other potentially toxic substances. However, other elements, like lighting, climate control, and ergonomic design, can also significantly affect how well building occupants are able to maintain their health.

### F. Siting

The location of a building can have a big impact on how environmentally friendly it is. For instance, placing structures close to transportation hubs can promote the use of public transportation while minimising the effects of private vehicles. To reduce negative effects on ecological services and native species of plants and animals, site selection may also take into consideration the ecological sensitivity of potential sites. The building's heating and cooling needs are influenced by the building's axes and surfaces, as well as by how close it is to trees and other vegetation.

### G. Serviceability

Even if a building has a significantly smaller environmental impact than other buildings, it is unlikely to be worthwhile for its cost if it does not serve its inhabitants well. Therefore, a key component of green building is productivity and other utility measures. There is some proof that living in green buildings can increase employee productivity. While this element is explicitly stated as a goal for high-performance buildings, it is not typically thought of as a separate component in green building design.

### H. Integration

Integration is one of the most important aspects of green construction. Although the aforementioned factors could and frequently are addressed separately for each stage in a building's life cycle, the green building approach focuses on how the group of factors affects a building's environmental footprint over the course of its life cycle, from site selection, initial design, and construction, to operations during the building's useful life, through eventual demolition, and its aftereffects. With its emphasis on the entire structure, this method can help determine a building's overall environmental impact. Additionally, it enables planners to develop an integrated strategy by explicitly assessing and balancing among potentially incompatible goals as well as by looking at how various components and stages interact.

## 4. MAJOR ADVANTAGES OF GREEN BUILDINGS

### A. Environmental Benefits

1. Reduction of emissions. Pollutants emitted by electricity generated from fossil fuels put human health at risk and contribute to climate change. They also lead to problems with air quality like smog and acid rain. Energy efficiency is increased and harmful emissions are decreased when green building practises like solar powering, day lighting, and facilitating public transportation are used.
2. Water Efficiency. Reusing rainwater through a rainwater harvesting system significantly lowers water usage.
3. Management of stormwater. Storm water runoff has the potential to pollute water sources, erode waterways, and cause flooding. Overflow can be managed and used by collecting and reusing storm water, using permeable building materials, and installing green roofs.
4. Moderating the temperature. The urban heat island effect is primarily caused by the heat-retention capabilities of tall structures and urban building materials like concrete and asphalt. By carefully considering building design and site selection, as well as by planting trees to go along with new developments, these conditions may be mitigated.
5. Waste minimization. In the United States, a significant amount of solid waste is produced by construction and demolition. Deconstruction of buildings rather than complete demolition results in significant reductions in waste generation.

### B. Economic Benefits

A common misconception about green construction is that green premium is expensive to be taken into account from economic standpoint. Studies have revealed that costs of green buildings are not significantly higher than standard development initiatives. The incorporation of green design from beginning of project can typically avoid higher construction costs. Green construction also offers number of financial benefits.

1. Savings on energy and water. The resource efficiency offered by green design and technology results in dramatic decreases in operation costs that swiftly recover any additional project costs and continue to offer dramatic long-term savings. Money that would have been spent on utility costs can now be used for other things.

2. Reduced strain on infrastructure. Buildings that are energy and water efficient put less strain on infrastructure of their neighbourhood.

### C. Social Benefits

1. Better Health. Respiratory issues, allergies, nausea, headaches, and skin rashes are significantly exacerbated by poor indoor environmental quality (IEQ), which is caused by inadequate air circulation, poor lighting, mould growth, temperature variations, carpeting and furniture materials, pesticides, toxic adhesives and paints, and high concentrations of pollutants (typically 10 to 100 times higher than outdoors). Ventilation and non-toxic, low emitting building materials are prioritised in green construction in order to create healthier and more comfortable living and working spaces.
2. More wholesome lifestyles and activities. The preservation of natural environments, which offer variety of recreational and exercise opportunities, is crucial component of sustainable design. In addition to reducing local traffic and promoting personal health and fitness, green buildings aim to make it easier to use public transportation and alternative transportation to driving, such as bicycling.

## 5. EXPERIMENTAL INVESTIGATION

### A. Leca Concrete

An experimental investigation was carried out to look at properties of Leca concrete's density, compressive strength, and water absorption in order to define its fundamental features.

### B. Properties of LECA

### 1. Absorption value of LECA

When aggregate is dry, water absorbs into it, lubricating particles but not participating in reactions. As a result, workability is likely to be affected, as well as w/c ratio. Calculating total amount of water to add to mixes must account for water absorption. The absorption value is difference, expressed as percentage of dry weight of aggregate, between saturated surface dry aggregate and very dry sample. Leca was sampled, and it was submerged in water for 24 hours. After 24 hours, water was removed, 50 gram of leca were extracted, and sample was baked at 100 °C for 24 hours before being weighed.

$$\text{Absorption value} = \frac{B-C}{C}$$

Where B= weight of saturated and surface dry aggregate

C=Weight of oven dried sample

### 2. Dry Bulk density

The weight of aggregate needed to fill container with given volume is referred to bulk density. This unit volume, which is expressed in kg/lit or kg/m$^3$, is made up of volume of solid material as well as volume of voids. The thoroughly mixed aggregate fills measure to about 1/3rd of capacity, depending on size of aggregate. The rounded end of tamping rod is now used to tamp aggregate with 25 strokes. A further 25 strokes of tamping are applied after adding another similar amount of aggregate. At this point, the measure is fully filled, tamped 25 times, and the excess aggregate is struck off using tamping rod as straight edge. The bulk density is calculated in kg/m$^3$ and aggregate's net weight is determined. To measure bulk density, we used container with capacity of 3 lit and tamping rod with a diameter of 16 mm and length of 60 cm.

### C. Mix for LECA concrete

Since Leca concrete is not well known, we experimented with various mixes to find the best one. For that, we initially tried the following mix.

***Table 1: Trial Mix 1 for LECA concrete***

| Material | Specifications | Qty |
|---|---|---|
| Cement | Ambuja PPC | 749 gms |
| Fine aggregates | | 2252 gms |
| Coarse aggregate | Leca | 1501 gms |
| Admixture | Plasticizer | 5 ml |
| Water | | 300 ml |

However, the mixture created by this mix design was not homogeneous. We cast a single cube for testing purposes, and when we removed it from the mould after 24 hours, the cement paste and aggregates had not been properly bound together. So we tried another mix design a few days later. The table below displays the mix design for each m3 of concrete.

***Table 2: Trial mix 2 for LECA concrete***

| Material | Specifications | Qty | unit |
|---|---|---|---|
| Cement | | 430 | Kg/m³ |
| Silica fume | | 20 | Kg/m³ |
| Natural sand (fine aggregate) | | 595 | Kg/m³ |
| Aggregate | Leca | 665 | Kg/m³ |
| Admixture | Super plasticizer | 4 | Kg/m³ |
| Water | | 220 | Kg/m³ |
| Water/ cement ratio | | 0.5 | |
| Corrected water/ cement ratio | W/( C +2S) | 0.45 | |

Twelve-story Colosseum Park office building in Oslo, which was constructed in 1998, used this mix design. So we created a 500 gram mixture for the trial. The following table lists the ratios of the various materials.

***Table 3: Proportion for trial mix 2 (casting 1) for LECA concrete***

| Material | Specifications | Qty | unit |
|---|---|---|---|
| Cement | | 500 | Grams |
| Silica fume | | 30 | Grams |
| Natural sand (fine aggregate) | | 683 | Grams |
| Aggregate | Leca | 589 | Grams |
| Admixture | Super plasticizer | 4 | ml |
| Water | | 253 | ml |
| Water/ cement ratio | | 0.5 | |
| Corrected water/ cement ratio | W/( C +2S) | 0.45 | |

Three cubes with a 7.07 cm dimension have been cast. The outcomes were decent. Therefore, the same mix design was chosen for additional research.

***Table 4; Proportion for trial mix 2 (casting 2) for LECA concrete***

| Material | Specifications | Qty | Unit |
|---|---|---|---|
| Cement | | 13.2 | Kg |
| Silica fume | | 767 | Grams |
| Natural sand (fine aggregate) | | 18.1 | Kg |
| Aggregate | Leca | 14.9 | Kg |
| Admixture | Super plasticizer | 130 | Ml |
| Water | | 6.63 | L |
| Water for absorption | | 2.2 | L |
| Water/ cement ratio | | 0.5 | |
| Corrected water/ cement ratio | W/( C +2S) | 0.45 | |

By using this mix we casted 6 cubes of 10 cm X 10 cm X 10 cm dimensions.

### D. Density of Concrete

For the thermal test, we created a wooden mould with measurements of 30 cm X 30 cm X 2.5 cm. It weighed 0.568 kg when empty. It was then filled with concrete and weighed once more.

$$\text{Density} = \frac{weight\ of\ concrete}{volume}$$

## 6. RESULTS AND DISCUSSION

### A. PROPERTIES OF LECA

#### ○ Absorption value of LECA

Leca was sampled, and it was satuarted in water for 24 hours. After 24 hours, the water was removed, 50 grammes of leca were extracted, and the sample was baked at 100 °C for 24 hours before being weighed.

**Table 5: Observation for Absorption of LECA**

| | |
|---|---|
| Initial weight of the saturated and surface dry aggregate (B) | 50 grams |
| Final weight of oven dry sample (C) | 42 grams |
| Difference ( B – C) | 8 grams |

Absorption value = $\frac{B-C}{C}$

Absorption value = $\frac{(50-42)}{50}$ *100 % = 16 %

#### ○ Dry Bulk density

To measure bulk density, we used a 3 liter container and a 60 cm long, 16 mm diameter rod.

**Table 6: Dry Bulk Density of LECA**

| Sr No. | Observation | |
|---|---|---|
| 1 | Capacity of measure | 3 liters |
| 2 | Weight of measure | 2.51 kg |
| 3 | Weight of measure + loose aggregate | 3.493 kg |
| 4 | Weight of measure + compacted aggregate | 3.50 kg |
| 5 | Loose Bulk Density | 324.66 Kg/m³ |
| 6 | Rodded Bulk Density | 333.32 Kg/m³ |

Calculations of Loose Bulk density = $\frac{(3.493-2.51)}{0.003}$ = 324.66 Kg/m³

Calculation of Rodded Bulk Density= $\frac{(3.50-2.51)}{0.003}$ = 333.32 Kg/m³

As a result, Leca aggregate has a much lower bulk density than natural aggregates, which are typically used in conventional concrete.

## B. PROPERTIES OF LECA CONCRETE

### Slump Test

The LECA concrete's slump value was discovered to be 45mm. It was hardly practical. Longer presaturation times can result in high workability.

**Figure 1; Slump test of LECA concrete Compressive strength**

**Results for Mix 2, casting 1**

**Table 7: 3 days Compressive strength of LECA concrete**

| Cube No | Load P (kN) | Compressive Strength |
|---|---|---|
| 1 | 26.25 | 5.25 Mpa |
| 2 | 27.30 | 5.46 Mpa |
| 3 | 27.20 | 5.44 Mpa |
| Average strength after 3 days | | 5.383 Mpa |

Calculations of compressive strength = $\frac{P}{A}$

Value of A= 50 cm² = 5000 mm²

This mix design was taken for further investigation.

Results of cube after 7 days for Mix 2, Casting 2

**Table 8: 7 days Compressive strength of LECA concrete**

| Cube No | Load (kN) | Compressive Strength |
|---|---|---|
| 1 | 97 kN | 9.7 Mpa |
| 2 | 93 kN | 9.3 Mpa |
| 3 | 97 kN | 9.7 Mpa |
| Average strength after 7 days | | 9.57 Mpa |

Calculations of compressive strength = $\frac{P}{A}$

Value of A= 100 cm² = 10000 mm²

**Table 9: 28 days Compressive strength of LECA concrete**

| Cube No | Load (kN) | Compressive Strength |
|---|---|---|
| 1 | 145 kN | 14.5 Mpa |
| 2 | 145 kN | 14.5 Mpa |
| 3 | 150 kN | 15 Mpa |
| Average strength after 28 days | | 14.67 Mpa |

Density Of concrete

Weight Of empty mould = 0.568 kg

Weight of mould with concrete =3.884 kg

Difference = 3.884 – 0.568 = 3.316 kg

Inner dimensions of mould = 30cm X 30 cm X 2.5 cm

Volume of mould = 0.002286 m³

So wet Density of Concrete = $\frac{3.316}{0.002286}$ = 1450.568 kg /m³

## 7. RECYCLED AGGREGATE CONCRETE

- Slump test

The slump value of the recycled aggregates concrete was discovered to be 78 mm, indicating that the workability of the concrete made from this mix is medium.

- Compressive strength

Compressive strength of the 15 cm cubes after 7 days was found as below.

**Table10: Compressive strength of RAC at 7 days**

| Cube No | Load (kN) | Compressive Strength |
|---|---|---|
| 1 | 290 kN | 12.88 MPa |
| 2 | 330 kN | 14.66 MPa |
| 3 | 300 kN | 13.33 MPa |
| Average strength after 7 days | | 13.62 Mpa |

Compressive strength after 28 days was found as follows.

**Table 11: Compressive strength of RAC at 28 days**

| Cube No | Load (kN) | Compressive Strength |
|---|---|---|
| 1 | 520 kN | 23.11 MPa |
| 2 | 520 kN | 23.11 MPa |
| 3 | 540 kN | 24 MPa |
| Average strength after 28 days | | 23.40 MPa |

## 8. CONCLUSION

This report presents several eco-friendly concrete manufacturing options. We can lessen impact on environment by using these concrete instead of regular concrete. For RAC and LECA concrete, evaluation is conducted.

The density of LECA concrete is 1450 kg/m$^3$, which is significantly lower than that of conventional concrete. Therefore, LECA concrete is referred to Light Weight Aggregate Concrete. As a result, less Portland cement will be used. Therefore, less CO2 will be released into the atmosphere. Concrete can thus be made environmentally friendly. Because LECA concrete is lightweight, dead load will be reduced, allowing Portland cement and other natural materials to be preserved and foundations to be designed for less dead load. Therefore, LECA concrete can be used in many applications in place of conventional concrete where very high strength is not necessary. We can maintain the building's average temperature by using LECA concrete because it is insulating material.

Instead of using natural aggregates, RAC concrete uses recycled aggregate. Recycled aggregate allows us to conserve natural resources. Additionally, since we can reuse leftover concrete, issue of disposing of waste material is also avoided. We can get good amount of strength by using, allowing us to use concrete in variety of locations.

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