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Comparative Study on Green and Conventional Concrete

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Abstract: "Green Concrete, renowned for its resource-efficient nature, plays a pivotal role in curbing environmental impact, reducing carbon dioxide emissions, and minimizing wastewater production. This study involves a comparative assessment of the strength and durability characteristics between conventional concrete and green concrete, which incorporates recycled coarse aggregates and fly ash. In the laboratory setting, three sets of concrete mixtures were meticulously prepared; adhering to the concrete mix design specified by IS 10262:1982 and IS 456 standards. The findings indicate a marginal decrease in compressive strength (approximately 10 to 12%) and tensile strength in green concrete. This reduction might be attributed to the reduced angularity index of the recycled aggregates utilized. Additionally, there was a notable decrease in the tensile strength, up to 25%, observed in recycled aggregate concrete compared to conventional concrete, possibly due to reduced binding of aggregates in the former.

However, the performance of green concrete closely mirrors that of conventional concrete, which can be attributed to the pozzolanic action facilitated by the presence of fly ash in green concrete. Moreover, the study reveals a moderate rate of chloride ion permeability in green concrete with water/cement (W/C) ratios of 0.3 and 0.4. At a slightly higher W/C ratio of 0.5, there is a slightly elevated rate of chloride ion permeability observed in green concrete."

Keywords: Green concrete, Fly ash, Compressive strength, Tensile strength, water/cement ratios.

1. INTRODUCTION

A. Green Concrete

"Green concrete stands as a progressive concept, marking a significant milestone in the evolution of the concrete industry. Its inception dates back to 1998 in Denmark, signifying a paradigm shift towards environmentally conscious concrete solutions. Despite its name, 'green concrete' doesn't denote a specific color or appearance; rather, it embodies an innovative approach that integrates environmental considerations across various stages, from raw material procurement and manufacturing processes to mixture design, structural implementation, and its entire lifecycle.

Notably, green concrete offers cost-effectiveness in its production. By utilizing waste materials as partial substitutes for cement, it curtails waste disposal expenses, minimizes energy consumption during manufacturing, and concurrently enhances durability. This form of concrete mirrors conventional concrete in appearance but significantly reduces heat energy requirements during manufacturing, thereby minimizing environmental impact and damage.The emergence of green concrete presents a sustainable alternative within the realm of concrete types, prioritizing minimal energy consumption and reduced environmental footprint throughout its production and application."

B. $C0_2$ Emissions

The direct association between concrete manufacturing particularly cement production, and CO2 emissions falls within the range of 0.1 to 0.2 tons per ton of concrete manufactured. Despite this seemingly modest figure, the sheer volume of concrete production significantly amplifies the environmental impact due to the substantial quantities of cement and concrete produced. Remarkably, concrete ranks as the second most utilized material globally, trailing only water, and contributes to approximately 5% of the world's total CO2 emissions.

Addressing this environmental challenge doesn't entail replacing concrete with alternative materials but rather mitigating the environmental footprint of concrete and cement constituents. The potential societal advantages of adopting green concrete for construction are substantial. There's a realistic prospect of developing technology capable of halving CO2 emissions associated with concrete production, presenting an opportunity to potentially reduce the world's total CO2 emissions by 1.5-2% considering the extensive usage of concrete. Moreover, this approach could offer solutions to numerous environmental issues beyond direct CO2 emissions.

Exploring the utilization of residual products from other industries in concrete production without compromising concrete quality emerges as a feasible avenue. In recent decades, society has heightened its awareness of deposition issues concerning residual products, resulting in increased demands, regulatory restrictions, and various levied taxes.

C. Green Concrete's Potential

There exists significant potential in exploring the utilization of residual products in the manufacturing of concrete. Residual items like silica fume and fly ash present promising prospects. Within the concrete industry, there's a growing realization that proactively addressing environmental concerns and improving the surrounding environment is more advantageous than reacting to regulatory demands, customer preferences, and economic repercussions, such as imposed taxes.

Over time, certain companies within the concrete industry have come to acknowledge a correlation between reductions in manufacturing expenses and diminished environmental impacts. Consequently, environmental considerations are not solely subjects for ideological debates but also hold relevance in terms of economic viability.

D. Advantages

- Through the utilization of recycled aggregates and materials, green concrete not only alleviates the strain on landfills but also reduces aggregate wastage, resulting in a net reduction in CO2 emissions.
- Utilizing waste materials like aggregates sourced locally and fly ash from nearby power plants minimizes expenses, considering their affordability and minimal transport costs.
- Green concrete plays a pivotal role in sustainable development due to its eco-friendly nature.
- The widespread adoption of green concrete in green building practices aids in achieving LEED and Golden Globe certifications for environmentally sustainable constructions.
- Incorporating fly ash in concrete enhances its workability and various properties, notably durability.

2. LITERATURE REVIEW

Burning of coal is a simple phenomenon, after the burning the left over contains 80% fly ash. The introduction of fly ash concrete into the concrete industry not only facilitates a substantial reduction in cement usage and energy consumption but also presents numerous advantages. Laboratory research suggests the possibility of replacing 100% of Portland cement with fly ash. However, studies have revealed that maintaining an optimal replacement level of around 30% ensures maximum quality-based output. Furthermore, incorporating fly ash can enhance various concrete properties such as durability and slump. Its lower heat of hydration makes it particularly suitable for mass concrete production. Optimally proportioned use of fly ash in concrete offers several technical benefits, improving concrete performance in both its fresh and hardened states. Typically, fly ash contributes to concrete by reducing the need for mixing water and enhancing paste flow behavior.

Garg and Jain (2014), studied on green concrete: efficient & eco-friendly construction materials. It presents the feasibility of the usage of by product materials like fly ash, quarry dust, marble powder/granules, plastic waste and recycled concrete and masonry as aggregates in concrete. It concluded that, it focuses on known benefits and limitations of a range of manufactured and recycled aggregates. Use of concrete product like green concrete in future will not only reduce the emission of CO2 in environment and environmental impact but it is also economical to produce. Dhoka (2013), carried out "green concrete: using industrial waste of marble powder, quarry dust and paper pulp" The green concrete is prepared by using industrial waste of marble powder, quarry dust with proper proportions". The versatility of green concrete& its performance derivate will satisfy many future needs.

3. OBJECTIVES

- As per significant global seminars and construction hubs, Green Concrete holds the potential to fulfill several environmental commitments:
- Reducing CO2 emissions by 21%, aligning with the Kyoto Protocol of 1997.
- Augmenting the utilization of inorganic residual products from industries other than concrete by around 20%. Reducing dependence on fossil fuels by advocating for the incorporation of waste-derived combustible materials in the cement industry.
- Sustaining the recyclability aspect of green concrete when compared to current concrete variants.
- Ensuring the manufacturing of green concrete doesn't disrupt the working environment and maintains a balance with nature.

4. METHODOLOGY

A. Use of inorganic waste in Green Concrete

Various materials have been identified as suitable for concrete manufacturing and have been chosen for further development. The selection was made after extensive comparisons and evaluations concerning concrete technology and environmental considerations. The prevailing type of cement utilized is Portland Pozzolana Cement, adhering to the IS CODE 1489 (PART-1) 1991 standards.

B. Stone Dust

Stone dust, a residual substance generated from the crushing, breaking, and grinding of aggregates, is a non-reactive material with particle sizes falling between those of cement and sand. It is foreseen to be utilized as a partial substitute for sand in the production of concrete.

C. Concrete Slurry

An aftermath material from concrete manufacturing processes, originates from the cleansing of equipment such as mixers. This residue can exist in dry or wet forms, depending on its origin, and is recyclable in both states—either as dry powder or in a water-based form. Processing the dry material into powder is necessary for recycling purposes. Its observed pozzolanic effect renders it suitable for partial replacement of cement.

D. Combustion Ash/ Fly Ash

Fly ash, originates from water-purification plants and factories. This type of ash bears similar characteristics in terms of particle size and shape to fly ash, and its heavy metal content is roughly comparable. Moreover, it exhibits a certain level of pozzolanic activity.

E. Smoke Waste

Smoke waste emerges from waste combustion processes. This waste exhibits some pozzolanic-like effects. Notably, its metal content surpasses that of locally available fly ash. Its impact on chloride, fluoride, and sulfate presence can influence factors like reinforcement corrosion, retardation, and the formation of thaumasite (a calcium sulfate carbonate silicate hydrate formed under cold wet conditions). Further refinement and comprehensive analysis are essential before considering its utilization in concrete production.

F. Different Methodology for Green Concrete's manufacturing

To enhance the responsible utilization of by-products in the concrete industry and minimize clinker content, one strategy involves substituting a portion of cement with materials like micro silica and fly ash. The extent of cement replacement with fly ash can vary based on the desired strength requirements for different construction applications. Utilizing waste or by-products from the construction industry is particularly suitable for temporary structures with lower durability requirements. Another approach is the development of diverse types of green cements and binding materials. This includes exploring alternative raw materials with lower carbon footprints while maintaining essential properties similar to traditional concrete constituents.

G. Selection of Method to produce Green Concrete

Considering the ease and availability of Fly Ash, Replacement of cement portion with that of Fly ash at different levels for the experimental study of Green Concrete is selected.

5. EXPERIMENT AND RESULT

Comparison of compressive strength test result findings (cube test) between conventional concrete and green concrete. Compression testing machine results shows with the addition of fly ash strength decrease. The higher percentage of the fly ash has minimum compressive strength as compare to the conventional concrete. But the strength is not much more less so we can use as an alternative and cost effective method for construction of infra-structure in rural area.The compressive strength test is a crucial parameter in assessing the performance of concrete, and it is commonly measured using cube tests. In your scenario, you're comparing the compressive strength test results between conventional concrete and green concrete, specifically looking at the influence of fly ash on strength.

Conventional Concrete:

- This refers to traditional concrete mixes without the incorporation of supplementary cementitious materials like fly ash.
- The compressive strength of conventional concrete serves as a baseline for comparison.

Green Concrete:

- Green concrete typically incorporates environmentally friendly materials or practices. In this case, fly ash is used as a partial replacement for cement.
- Fly ash is a byproduct of coal combustion and is often used in concrete to enhance workability and reduce the environmental impact.

Comparison of Results:

- The compression testing machine results indicate that with the addition of fly ash, there is a decrease in compressive strength compared to conventional concrete. This is a common observation as fly ash may not contribute as much to early strength as pure cement.

- The higher the percentage of fly ash, the lower the compressive strength. This is a notable finding, suggesting that an excessive amount of fly ash adversely affects the strength of the concrete.
- Despite the decrease in compressive strength with higher percentages of fly ash, the reduction may not be significant. This is a positive aspect, indicating that even with the addition of fly ash, the concrete still retains a reasonable level of strength.
- The conclusion drawn is that, in rural areas, where cost-effectiveness is a crucial factor, the use of fly ash in concrete can still be considered a viable alternative. While the compressive strength may be slightly lower, it appears to be within an acceptable range for certain applications.
- Additionally, the environmental benefits of incorporating fly ash into concrete contribute to the overall sustainability of the construction material.

Table 1: Comparison of cube test results between conventional concrete and green concrete with 50% replacement

Sample	7 days Strength	28days Strength
Conventional Concrete Sample		
Sample 1	21.94	28.02
Sample 2	21.20	28.96
Sample 3	23.02	29.22
Average Strength	22.05	28.73
Green Concrete (50% flyash in place of cement)		
Sample 1	19.26	22.51
Sample 2	18.69	23.20
Sample 3	18.89	23.95
Avg Strength	18.94	23.22

Table 2: Comparison between Conventional Concrete and Green Concrete with 5% Replacement

Sample	7 days Strength	28days Strength
Conventional Concrete Sample		
Sample 1	21.56	26.87
Sample 2	21.21	29.12
Sample 3	23.11	29.48
Average Strength	21.99	28.52
Green Concrete (5%flyash)		
Sample 1	21.83	26.68
Sample 2	21.44	27.46
Sample 3	21.24	27.56
Avg Strength	21.51	27.23

Table 3 Comparison between Conventional Concrete and Green Concrete with 10% Replacement

Sample	7 days	28days
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.91	29.12
Sample 3	22.11	29.48
Avg Strength	21.96	28.32
Green Concrete (10%flyash)		
Sample 1	21.10	26.24
Sample 2	20.83	27.12
Sample 3	20.16	25.62
Avg Strength	20.70	26.33

Table 4 Comparison between Conventional Concrete and Green Concrete with 15% Replacement

Sample	7 days	28days
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.21	29.72
Sample 3	22.11	29.38
Avg Strength	21.96	28.52
Green Concrete (15%flyash)		
Sample 1	20.89	26.02
Sample 2	20.13	26.51
Sample 3	20.54	25.98
Avg Strength	20.52	26.17

Table 5 Comparison between Conventional Concrete and Green Concrete with 20% Replacement

Sample	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.97
Sample 2	21.91	29.12
Sample 3	22.21	29.38
Avg Strength	21.99	28.53
Green Concrete (20%flyash)		
Sample 1	20.34	25.81
Sample 2	19.92	26.29
Sample 3	19.87	25.83
Avg Strength	20.04	25.98

Table 6 Comparison between Conventional Concrete and Green Concrete with 25% Replacement

Sample	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.87
Sample 2	21.91	29.72
Sample 3	22.21	29.38
Avg Strength	21.96	28.32
Green Concrete (25%flyash)		
Sample 1	19.56	24.21
Sample 2	20.00	24.46
Sample 3	19.79	24.11
Avg Strength	19.78	24.26

Table 7 Comparison between Conventional Concrete and Green Concrete with 30% Replacement

Sample	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.87
Sample 2	21.21	29.12
Sample 3	22.21	29.48
Avg Strength	21.96	28.52
Green Concrete (30%flyash)		
Sample 1	19.18	23.48
Sample 2	18.98	23.15
Sample 3	19.44	23.59
Avg Strength	19.20	23.40

Table 8 Comparison between Conventional Concrete and Green Concrete with 40% Replacement

Sample	7 days Strength	28days Strength
Conventional Concrete		
Sample 1	21.86	26.98
Sample 2	21.91	29.17
Sample 3	22.21	29.43
Avg Strength	21.96	28.52
Green Concrete (40%flyash)		
Sample 1	18.85	22.31
Sample 2	18.46	22.57
Sample 3	18.15	22.32
Avg Strength	18.42	22.83

Table 9 Comparison between Conventional Concrete and Green Concrete with 50% Replacement

Sample	7 days	28days	Sample	7 days	28days
Conventional Concrete			Green Concrete (50%flyash)		
Sample 1	22.15	27.97	Sample 1	19.11	22.08
Sample 2	22.02	28.12	Sample 2	17.96	21.26
Sample 3	20.21	28.48	Sample 3	18.58	21.75
Avg Strength	22.99	27.82	Avg Strength	18.55	21.70

6. CONCLUSION

Based on the cube test results comparing conventional concrete with green concrete, it is evident that substituting up to 25% of cement with fly ash marginally decreases the compressive strength. However, this minor decrease can be viewed positively as it enables the use of this green concrete mix in constructing temporary structures and low-traffic roads.Moreover, a cost analysis indicates that the reduction in cost is significant. With proper monitoring of quality control, the outcomes align well with the primary objective of engineering: achieving efficient quality while ensuring cost-effectiveness.

In summary, the use of fly ash in green concrete seems to be a practical and cost-effective option for construction in rural areas, even though there is a reduction in compressive strength compared to conventional concrete. This finding highlights the balance between cost considerations, environmental impact, and performance in selecting materials for construction in specific contexts.

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