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Experimental Investigation on the Effects of Coffee Husk Ash as Partial Replacement of Cement on Concrete Properties

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Abstract **–Only 125 years' worth of lime stone is anticipated. The main issue is how the construction will go in the future. The partial preservation of the concrete material is crucial. In this initiative, coffee husk ash (CHA) is being used to partially replace cement. 60% of the silica in coffee husk, which is useful for binding, is present. Small amounts of SiO_2, Al_2O_3, and Fe_2O_3 make up CHA, whereas Cao makes up a larger portion. Due to the silica (SiO_2) and aluminate content, coffee husk ash functions as a pozzolanic material when added to cement. This reaction between the free lime produced during the hydration of the cement and the reaction material results in the formation of extra calcium silicate hydrate as a new hydration product. From environment point of view, when Coffee Husk is dumped in factories it produces green house gases such as methane, carbon dioxide etc. which threatens the environment and imparts Global warming. The main objective of this project is to conserve cement and provide better settlement of agriculture waste. Based on the primary objective of this research, the laboratory tests were designed to obtain the strength of concrete specimens with partially replacement different percent of coffee husk ash under different types of loading. Three types of tests were performed- the compressive strength test, compression factor test, and slumps test.**

Keywords- CHA(coffee husk ash), SiO_2(silica oxide), Al_2O_3(Aluminum Oxide, Fe_2O_3(Iron oxide),Pozzolana

1. INTRODUCTION

In this project, cement in the concrete material is only partially replaced. For any country, protecting the environment is crucial. There is a rising need for low-cost environmentally acceptable building materials as well as locally available resources as social, economic, and environmental issues take on greater significance in contemporary society. The demand for resources increased throughout time as a result of increased raw material utilization. As a result, the construction industry needs a large amount of raw materials. There is an urgent need for building suitable and accessible housing because over a billion people worldwide, the most of whom live in developing countries, are either homeless or have extremely substandard housing. due to environmental harm and the release of carbon dioxide.[5]

2. STUDY AREA

During processing, coffee produces a lot of by-products and leftovers. Different residues are produced depending on how coffee cherries are processed. Since 1 kg of coffee husks are produced for every 2 kg of coffee beans, coffee husks are the main solid leftover from handling and processing coffee. Ethiopia annually discards 192000metric tonne of coffee as a byproduct.[1]

Availability of coffee in Ethiopia:

With around 15 million people relying on coffee for a living either directly or indirectly, coffee production is significant to the Ethiopian economy. Additionally, coffee is a significant export from Ethiopia, accounting for around 25% of its GDP. Ethiopian produces the most coffee in sub- Saharan Africa and ranks fifth globally behind Brazil, Colombia, and Indonesia.[2]

3.OBEJECTIVE

The following are the project's primary goals:

- Using industrial waste as a substitute for traditional raw materials, which reduces environmental pollution and helps to properly manage our natural resources.
- To provide alternative, cost-effective, and environmentally friendly building materials.
- Developing guidelines to promote the use of industrial waste management.
- To compare the red mud and CHA concrete to standard concrete in terms of compressive strength, tensile strength, and flexural strength.
- To address the current and rapidly rising demand for cement

4.MATERIALS

Cement: pozzolana Portland cement Portland Through the examination, cement of Grade 43 according to IS:269-1976 was employed. The cement used is brand-new and lump-free. To make sure the cement met the requirements of the IS guidelines, various tests were run on it. For all test mixtures.
It is discovered that fine aggregate has a specific gravity of 2.62. A 1% water absorption rate was discovered. same kind of cement was used in the same reduced quantity.

Fine aggregate: In accordance with the IS, local river sand that passes through a 4.75mm sieve was used for the trial program.

Coarse aggregate: Up to 70%–80% of the material used to make concrete is made up of coarse aggregate. The physical characteristics of the coarse aggregate, such as its gradation, specific gravity and absorption capacity, moisture content, and unit weight, were determined through laboratory tests. The coarse aggregates must be made of crushed rock and must be free of dust, friable material, organic material, and other harmful things. They must also be clean, hard, and durable. In addition to having strong compressive and shear strengths, aggregates also have adequate permeability and a good interlocking capability. 26.5mm to 2.36mm coarse aggregate.

Coffee Husk Ash: Research was done on burning coffee husks, and the ideal temperature was found. The silica content increases with increasing temperature. Since the resultant CHA is crystallized, the moisture content must be removed by exposing it to sunlight. It is sieved with a 75mm sieve to get rid of the impurities. Coffee husk ash's chemical makeup primarily depends on the ash processing factors including burning technique and grading. The ASTM C618 limit chemical requirement is the total of SiO2+ Al2O3+ Fe2O3 to 70%. According to the chemical analysis of CHA shown in the above table, SiO2, Fe2O3, and Al2O3 are the main oxides of CHA and are present in the proper amounts.[7]

Fig. Coffee Husk

The chemical composition of CHA and OPC Cement is as fallow:

Chemical Constituent	Composition (in %)	OPC cement
SiO_2	60.00	17 - 25%
Fe_2O_3	3.00	0.5-6%
CaO	9.52	60-65%
MgO	4.08	0.1-4%
SO_3	1.07	1-2.75%
$CaCO_3$	7.92	1%
Total SiO_2+Al_2O_3+ Fe_2O_3	73.07	

Water: A water-to-cement ratio of 0.5 is maintained for the amount of water. The concrete was mixed with portable water that has a Ph range of 6.5 to 8.5. Additionally, the water is devoid of radicals such as arsenic, lead, and others that could react with cement components and weaken them.[3] The primary chemicals in cement undergo hydration, a chemical reaction in which they create chemical bonds with water molecules to produce hydrates, also known as hydration products. In the following section, the specifics of the hydration process are examined. Purity of the water is necessary to avoid side reactions that could weaken the concrete or otherwise obstruct the hydration process. Water plays a crucial role in the creation of "perfect" concrete since the water to cement ratio is the most vital component. Concrete loses strength when it has too much or too little water, and it becomes unworkable.

5. METHODLOGY

Firstly, the coffee husk is laid in sun light to remove moisture, after some time this coffee husk is allowed to burned in oven at a temperature of 300° C for 24 hrs. Grater the temperature of the oven grater will be the silica content. After burning it is allowed to cool. Taking the help of crusher, it is crushed in fine powder to the size of cement. Now this powder is passed through IS sieve 75mm. In lab firstly we have made the controlled specimen of M25 grade in second phase we have made several cubes in the set of three cubes replacing cement by CHA 5%, 10% and 15% by weight respectively.[6] After casting the cubes in 15cm x15cm x 15cm cube. These cubes are allowed for curing next 7 days, 14 and 28 days.
Various test were performed on the cubes to determined different chemical and mechanical properties of concrete.

5.TESTS AND RESULTS

Preliminary test:

S.No	Properties of Materials	Standard Value	Experimental Value
1	Fineness of cement	0 -10%	8%
2	Standard consistency value	32%	32%
3	Soundness Test	Less than 10%	8.55mm = 9mm
4	Initial and Final setting time	30 min & 10 hrs.	35 min and 10 hrs.

Fig. Sieve Analysis of Coffee Husk Ash

Result of Compressive strength test after 7 days is given in table below:

S.No	Mix	Different percentage of Replacement	Sample No.	Compressive Strength(N/mm^2)	Average Compressive Strength(N/mm^2)
1	M25	5	1	16.92	16.57
			2	17.28	
			3	15.50	
2	M25	10	1	17.75	17.42
			2	17.50	
			3	17.00	
3	M25	15	1	18.82	19.44
			2	20.10	
			3	19.40	
4	M25	20	1	16.50	16.29
			2	17.02	
			3	15.35	

Result of Compressive strength test after 14 days is given in table below:

S.No	Mix	Different percentage of Replacement	Sample No.	Compressive Strength(N/mm^2)	Average Compressive Strength(N/mm^2)
1	M25	5	1	20.92	20.53
			2	20.18	
			3	20.50	
2	M25	10	1	21.50	20.72
			2	20.50	
			3	20.15	
3	M25	15	1	21.52	22.09
			2	22.10	
			3	22.67	
4	M25	20	1	20.18	19.62
			2	19.67	
			3	19.01	

Result of Compressive strength test after 28 days is given in table below:

S.No	Mix	Different percentage of Replacement	Sample No.	Compressive Strength(N/mm^2)	Average Compressive Strength(N/mm^2)
1	M25	5	1	27.85	20.53
			2	20.05	
			3	20.45	
2	M25	10	1	21.65	20.72
			2	20.20	
			3	21.05	
3	M25	15	1	21.70	22.09
			2	22.10	
			3	22.60	
4	M25	20	1	26.85	22.01
			2	19.05	
			3	20.14	

6. CONCLUSION

The primary conclusion of this project is as fallow:

1. Based on the Experimental Investigation we have found that our best result is on replacing cement with coffee husk ash on 15%. The strength of concrete is increased by 11 to 12 percent.

2. The compressive strength increased as the curing time increased, but reduced as CHA concentration increased. The compressive test revealed that for specimens of the same age, larger percentage replacement resulted in a lower degree of strength. Aged specimens produced stronger strength in the reveries for the same replacement percentages.
3. As the cement is replaced in concrete by 15% percentage with coffee husk ash which is an agricultural waste

product. The cost of construction with concrete is reduced by 8%.

4. Increased cement replacements with CHA had a longer setting time and advanced normal consistency (i.e., required more water for workability). When CHA was added to concrete, both elements of workability and slump were significantly reduced.
5. As the CHA 20 percentages were raised in all of the specimens, it was noticed that the slump diminished. The density of the CHA concrete was reduced due to the CHA's lower specific gravity as compared to cement.
6. This study has shown that concrete made from CHA has a great deal of potential as a source of environmentally acceptable cementitious material that decreases pollution and offers a sensible choice for managing coffee waste.
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