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Behavioural Study on Lightweight Concrete

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Abstract: ***Abundant availability of natural resources has become a dream for present day engineering society due to large scale consumptions. The utilization of fly-ash in concrete as partial replacement of cement is gaining immense important today, mainly on account of the improvement in long-term durability of concrete combined with ecological benefits. The global consumption of natural sand is too high due to its extensive use in concrete, which results in supply scarcity. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand. On the other hand, the advantages of utilization of by protects or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load. In this context fine aggregate has been replaced by quarry dust. Concrete produced by partial replacing of coconut shell (CS) can be used in plain concrete construction. The use of coconut shell as partial replacement for conventional aggregates should be encouraged as an environmental production & construction cost reduction measures. In this study, the concrete will be made by partially replacing cement with fly-ash, FA with quarry dust, CA with CS. Concrete cylinder and cubes will be casted and test will be conducted for obtaining compression strength, spilt tensile strength, and density result will be compared with conventional concrete.***

Keywords: Light Expanded Aggregate (LEA), Fly ash, Light-weight concrete, spilt tensile Strength, Density

1. Introduction

Lightweight concrete (LWC) generally has a density of less than 2000 kg/m3 and compressive strength of more than 20 N/mm2 , it is known as structural LWC. The challenge in making LWC is in decreasing the density while maintaining strength and without adversely affecting cost. Introducing different types of lighter aggregates into the matrix is a common way to lower a concrete's density. The crushed stone and sand are the components that are usually replaced with lightweight aggregate (LWA) to produce LWC. This research was based on the performance of lightweight concrete. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens in strength. This research report is prepared to show the activities and progress of the lightweight concrete research project. The performance of lightweight concrete such as compressive strength tests, spilt tensile strength test, and density tests and comparisons made with conventional concrete (M_1) were carried out. The use of appropriate dosage of fly ash enhances durability by providing mitigation of alkali silica reaction, resistance to sulfate attack, and reduced ingress of potentially deleterious material such as chloride and water **[1].** Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. In the past,. The variable investigated in this study is variation of dosage of 10%, 20% and 30% of fly ash (M_2) by weight of cement. All along India, we have been using natural sand. The volume of concrete manufactured in India has not been much, when compared to some advanced countries. For the last about 4 to 5 years the old methods of manufacturing ordinary crushed sand have been replaced by modern crushers specially designed for producing, cubical, comparatively smooth textured, well graded sand, good enough to replace natural sand. Concrete containing quarry dust (QD) as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment. 100% replacement of quarry dust in conventional concrete is possible with proper treatment of quarry dust before utilization. The compressive strength of quarry dust concrete can be improved and also super plasticizers can be used to improve the workability of quarry dust replaced concrete. Concrete produced using quarry fines shows improvement in higher flexural strength, abrasion resistance, and unit weight which are very important for reducing corrosion or leaching. Self-compacting concrete can also be produced using quarry dust **[2]**. This paper presents the feasibility of the usage of Quarry Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and cylinders to study the compressive, spilt tensile strengths and densities of concrete made of Quarry Dust. Strength and density Studies were done for concrete with fully replacement of Quarry Dust (M_3) and compared with the Conventional Concrete. Lightweight concrete is typically made by incorporating natural or synthetic lightweight aggregates or by entraining air into a concrete mixture. Coconut shell (CS) exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. Coconut shell can be grouped under lightweight aggregate **[3]**. There is no need to treat the coconut shell before use as an aggregate except for water absorption. Coconut shell is compatible with the cement. The 28-day air-dry densities of coconut shell aggregate concrete are less than 2000 kg/m^3 and these are within the range of structural lightweight concrete. The present studies are partial replacement of coconut shell (M4) (25%) by coarse aggregate.

1.1. Objectives & Scope

- To study the properties of conventional concrete (M_1).
- To study the properties of 10%, 20%, 30% replacement of fly ash by weight of cement(M_2)
- To study the properties of fully replacement of Quarry dust (M_3)
- To study the behavior of coconut shell aggregate concrete (M_4)

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- To investigate the compressive strength, spilt tensile strength in cubes & cylinders

1.2 Application of Lightweight Concrete

Lightweight concrete has been used since the eighteen centuries by the Romans. The application on the 'The Pantheon' where it uses pumice aggregate in the construction of cast in-situ concrete is the proof of its usage. In USA and England in the late nineteenth century, clinker was used in their construction for example the 'British Museum' and other low cost housing. The lightweight concrete was also used in construction during the First World War. The United States used mainly for shipbuilding and concrete blocks. The foamed blast furnace-*slag* and pumice aggregate for block making were introduced in England and Sweden around 1930s.Nowadays with the advancement of technology, lightweight concrete expands its uses.

2. Material Properties

The raw materials used in this investigation were locally available and these included ordinary Portland cement (OPC) as binder, quarry dust sand as fine aggregate, crushed granite and CS as coarse aggregate. Potable tap water was used for mixing and curing throughout the entire investigation. Detailed descriptions of each material are provided in the following sections.

2.1 Cement

Ordinary Portland cement of 43 grade conforming to Indian Standard IS 12269-1987 was used throughout the experimental program. The standard consistency was 34%, whereas the initial and final setting times were 32 min. and 210 min. respectively. The specific gravity of cement was 3.13 and its compressive strength after 28 days was 27 MPa.

2.2 Coarse Aggregate

In this investigation, two types of coarse aggregates were used for preparation of concrete, Natural Coarse Aggregate (NCA) and coconut shell Coarse Aggregate (CSA).

2.2.1 NCA

Crushed hard granite chips of maximum size 20 mm were used in the concrete mixes. The bulk density of aggregate was 1460 kg/m^3 and specific gravity was found to be 2.65.

2.2.2 CSA

Available coconut were hammered and crushed to smaller pieces and sieved. The sieved materials were taken required quantity for casting. Physical properties are tabulated in 1.

Table 1: Physical Property of NCA and CSA

Properties	*NCA*	*Sand*	*CSA*	*QD*
Bulk Density(Kg/m3)	1460	1450	1440	1666
specific gravity	2.65	2.62	1.50	2.65
Fineness Modulus	7.1	7.11	7.12	7.01
Water Absorption (%)	1.0	1.80	2	0.84

2.3 Sand

Fine aggregate (sand) used for this investigation for concrete was river sand conforming to Zone-II. And quarry dust as fine aggregate was used in this project. specific gravity of sand is 2.62 and Water Absorption value is 1.80%.

2.3.1 Quarry dust

Quarry dust as a fine aggregate used for this project. The physical Properties of quarry dust is specific gravity was found to be 2.65 and water absorption was 0.84%.

2.4 Specimen details

Concrete mould were such as cubes (150 mm x 150 mm x 150 mm), cylinders (150 mm x 300 mm) cleaned first and oiled for easy stripping.

3. Methodology

Table 2: Mix proportions:

W/c ratio	Series	Cement (Kg/ m^3)	Fly ash (Kg/ m^3)	Sand (Kg/ m^3)	Q.D (Kg/ m^3)	C.A (Kg/ m^3)	C.S (Kg/ m^3)	S.P (% by weight of cement)
0.5	M1	383	0	575	0	1253	0	0
	M2	344	38	575	0	1253	0	0.1
		306	76	575	0	1253	0	0.2
		268	114	575	0	1253	0	0.4
	M3	306	76	0	575	1253	0	0.15
	M4	306	76	0	575	940	313	0.2

4. Results and Discussion

4.1 Tests on hardened concrete

Table 3: Compressive Strength of partial replacement of fly ash

Age (days)	M_1	M_2 Replacement (%)		
		10	20	30
7	19.56	18.72	19.53	19.17
28	27.65	25.78	27.55	26.48

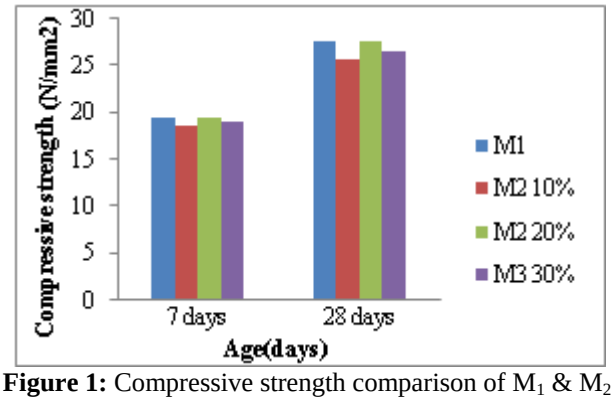

Figure 1: Compressive strength comparison of M_1 & M_2

The above graph, represent the 20% replacement of fly ash by weight of cement is optimized.

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Table 4: Spilt tensile strength of partial replacement of fly ash

Age (days)	M_1	M_2 Replacement (%)		
		10	20	30
7	1.27	0.5	1.22	1.19
28	2.45	1.57	2.41	2.35

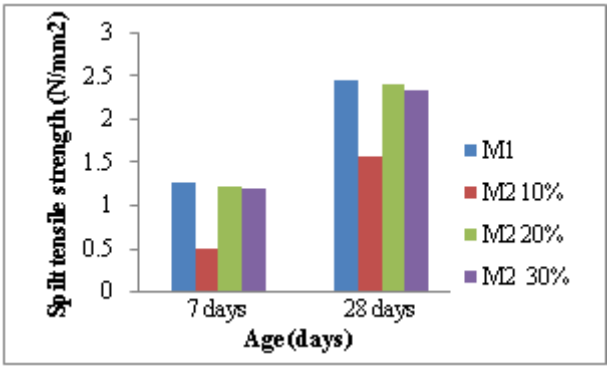

Figure 2: Spilt tensile strength of M_1 & M_2

The above graph, represent the 20% replacement of fly ash by weight of cement is optimized

Table 5: Compressive strength of M_1 + M_3

Age (days)	M_1	M_3
7	19.56	24.85
28	27.65	32.57

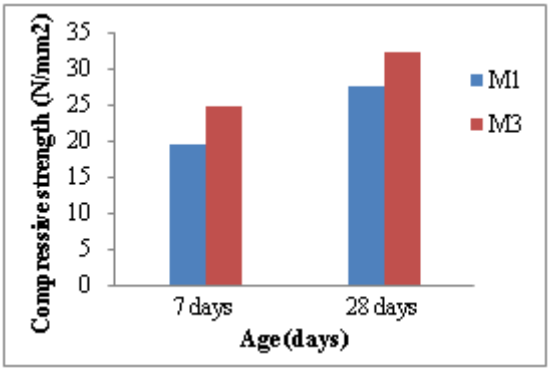

Figure 3: Compressive strength of M_1 + M_3

Table 5: Spilt tensile strength of M_1 + M_3

Age (days)	M_1	M_3
7	1.27	3.19
28	2.45	4.5

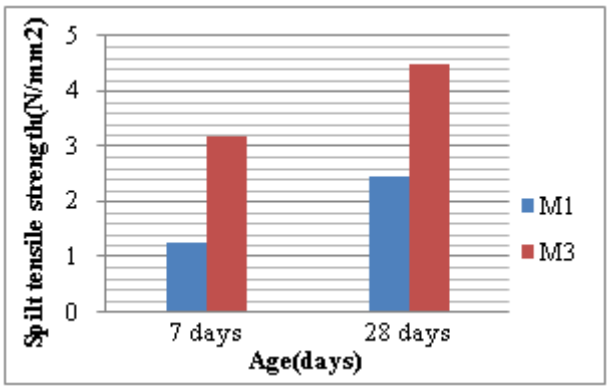

Figure 4: Spilt tensile strength of M_1+ M_3

Table 6: Compressive strength of M_1 + M_4

Age (days)	M_1	M_4
7	19.56	15.92
28	27.65	22.49

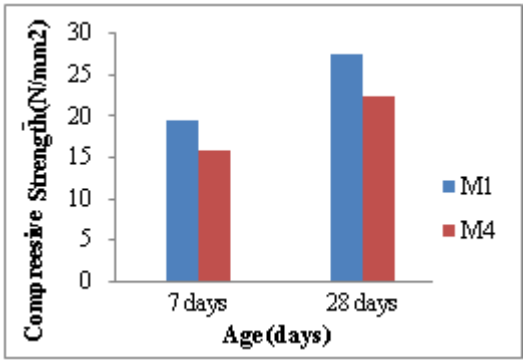

Figure 5: Compressive strength of M_1 + M_4

Table 7: Spilt tensile strength of M_1+ M_4

Age (days)	M_1	M_4
7	1.27	1.09
28	2.45	1.94

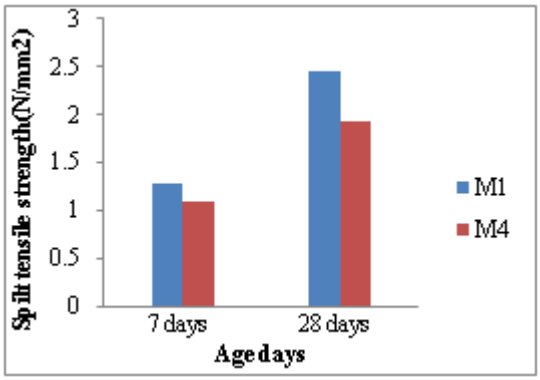

Figure 6: Spilt tensile strength of M_1+ M_4

Table 8: Densities of concrete

Density	M_1 (kg/m^3)	Replacement of M_2 (%) (kg/m^3)			M_3 (kg/m^3)	M_4 (kg/m^3)
		10	20	30		
Cube	2962	3022	3111	3170	3117	2518
Cylinder	2735	2697	2700	2740	2546	2170

5. Conclusion

In this study, the density and strength characteristics of concrete by volume replacement of cement by 10%, 20%, 30% fly ash, fully replacement of sand by quarry dust and 25% replacement of coarse aggregate with coconut shells were investigated. It was concluded that,

- Compared the density of concrete was decreases with M_4 than M_1, increases with M_2,M_3 than M_1
- Compared the compressive strength of concrete was decreases with M_4 than M_1, increases with M_2,M_3 than M_1
- Compared the Spilt tensile strength of concrete was decreases with M_4 than M_1, increases with M_2, M_3 than M_1.

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