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An Experimental Investigation on Partial Replacement of Fine Aggregate by Pumice Powder in the Concrete

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Abstract: The use of floating concrete in construction works has been growing rapidly in recent years due to its advantages over ordinary concrete. In this study, pumice powder is recommended as the best aggregate instead of ordinary concrete. The main purpose of structural grade floating concrete is to reduce weight and erect large precast units. It is possible to make floating concrete using pumice with a dry density of 1200 kg/m3 up to 1450 kg/m3. Slump and compression factor test showed that addition of teak sawdust reduced the workability compared to conventional concrete. Fine aggregate dust instead of sawdust gives the properties and advantages of actual production of concrete. The experimental work was conducted in two phases; In the first step, the appropriate input ratio for the binary aggregates was determined through a trial mix and test procedures.

Keywords: Cement, Robotics, Design and production

I. INTRODUCTION

Bricks are one of the most important building materials in the country. In recent year, with increasing urbanization and increasing demands for construction materials, brick clinkers have to grow to meet the demands[1]. Different types of bricks can be used as an alternative to red bricks to reduce environmental pollution and global warming. Light weight blocks can be one of the solutions for brick replacement. Floating concrete is one of the eco-friendly and certified green construction materials[2-4]. Replacing the fine aggregate with some wood powder in the concrete makes the structure much lighter in weight[5-8]. Strength, workability and durability tests are analyzed in this paper. The most important properties of concrete are strength in compressive strength. As the sawdust content increases in the corporation, unit weights and compressive strength values of mortars decrease with a parallel increase in water absorption values for all ages. Wood dust, a fine aggregate of dust, gives the properties and advantages of the actual production of concrete[9].

Substitution of specific Tectona grandis powder in fine aggregate (sand) concrete makes the structure very light in weight. Strength, workability and durability testing are analyzed in this paper. The main objectives of this project are to find alternative material for better aggregate in concrete. To identify the properties of pumice powder. To find the optimum replacement percentage of fine aggregate with pumice powder in concrete. Effect of pumice powder application on workability[10].

II. EXPERIMENTAL PROCEDURE

Effective production of concrete is achieved by careful selection of materials in sorting and proportioning of concrete, taking into consideration the characteristics of cement, aggregate quality, paste proportions, aggregate-paste interaction, type and amount of admixture and composition. The function of cement is firstly to bind the sand and stone together and secondly to fill the voids between the sand and stone particles to form a compact mass. The most important type of cement is referred to as Portland cement (ordinary Portland cement) and is a fine powder made by grinding Portland cement clinker. OPC is classified into three grades i.e. 33 grade, 43 grade, 53 grade depending on 28 days strength. The properties of cement have been improved by using high quality limestones, fine particle size distribution and fine particles.

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Figure 1: Cement powder

But after some time, when the paste begins to lose its plasticity, the needle can only penetrate to a depth of 33-35 mm from the top. The time when water is added and the time when the needle penetrates to a depth of 33-35 mm is called initial setting time.

Table 1: Properties of Cement

Properties	Value
Specific Gravity	3.15
Initial Setting Time	30 min
Final Setting time	600 min
Consistency	26%
Fineness	7.33%

Table 2: Major compounds of Cement

Name of Compound	Formula	Abbreviated Formula
Tricalcium silicate	3 $CaO.SiO_2$	C_3S
Dicalcium silicate	2 $CaO.SiO_2$	C_2S
Tricalcium aluminate	3 $CaO.Al_2O_3$	C_3A
Tetra calcium alumino ferrite	4 $CaO.Al_2O_3.Fe_2O_3$	C_4AF

Table 3: Approximate Oxide Composition Limits of OPC

Oxide	Percent content
CaO	60–67
SiO_2	17–25
Al_2O_3	3.0–8.0
Fe_2O_3	0.5–6.0
MgO	0.1–4.0
Alkalies (K_2O, Na_2O)	0.4–1.3
SO_3	1.3–3.0

The identification of the main compounds of cement is mostly based on Bogue's equations, hence it is called "Bogue's compounds".

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Table 4: Properties of Coarse Aggregate

Properties	Value
Specific Gravity	2.65
Size	<20mm
Water absorption ratio	1.65%
Shape Test (Flakiness index)	16.10%
Shape Test (Elongation index)	11.38%
Crushing Strength	21.33%

Most of the aggregates that pass through the 4.75 mm IS sieve are called fine aggregates. According to size, fine aggregate can be described as coarse, medium and fine sand. In this experimental project, fine aggregate was procured locally and conformed to Indian Standard specifications IS: 383- 1970. The sand is sieved through a 4.75 mm sieve to remove particles larger than 4.75 mm and conforms to ZoneII.

Table 5: Sieve analysis of Fine Aggregate

S. No	Sieve size	Weight retained (gm)	Percentage Retained (gm)	Cumulative % of Weight retained	Percentage of Fineness
1	4.75mm	6	1.2	1.2	98.8
2	2.36mm	16	3.2	4.4	95.6
3	1.18mm	68	13.6	18	82
4	600µ	73	14.6	32.6	67.4
5	300µ	203	40.6	73.6	26.8
6	150µ	120	2.2	97.8	2.8
7	Pan	14	2.8	100	0

III. RESULT AND DISCUSSION

Determining the relative proportions of materials like cement, fine aggregate, coarse aggregate and water is called concrete mix design. Concrete proportions should be selected to make the most economical use of available materials to produce concrete of the required quality Many methods of concrete mix proportioning have been recommended throughout the world. Among those methods, Indian Standard method was selected. The design of the mixture used for the present work on IS method is given below.

DESIGNSTIPULATION

Data Required for Concrete MixDesign

(i) Concrete Mix DesignStipulation

(a) Characteristic compressive strength required in the field at28days grade designation =M20

(b) Nominal maximum sizeofaggregate =20mm

(c) Shape ofCA =Angular

(d) Degree of workability requiredatsite = 100mm(slump)

(e) Degree of quality control available at site = As perIS:456

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(f) Type of exposure (as defined inIS:456) =Severe

(ii) Test data of material (to be determined in the laboratory)

(a) Specific gravityofcement =3.15

(b) Specific gravityofFA =2.6

(c) Specific gravityofCA =2.6

(d) Aggregate are assumed to be in saturated surface drycondition.

(e) Fine aggregates confirm to Zone I of IS – 383 Procedurefor Concrete Mix Design ofM20Concrete

Step 1 - Determination of Target Strength

Harmsworth constant for 5% risk factor is 1.65. In this case standard deviation is taken from IS: 456 against M 20 is 5.0.

$$f_{target} = f_{ck} + 1.65 \times S$$

Step 2 - Selection of water / cement ratio:-

From Table 5 of IS 456, (page No. 20)

Maximum water-cement ratio for severe exposure condition = 0.45

Based on experience, adopt water-cement ratio as 0.45. 0.45, hence OK.

Table 6: Mix Proportion for 1m^3

Water	Cement	Fine Aggregate	Coarse Aggregate
197 lit	437 Kg/m^3	692Kg/m^3	1037 Kg/m^3
0.45	1	1 . 6	2 . 4

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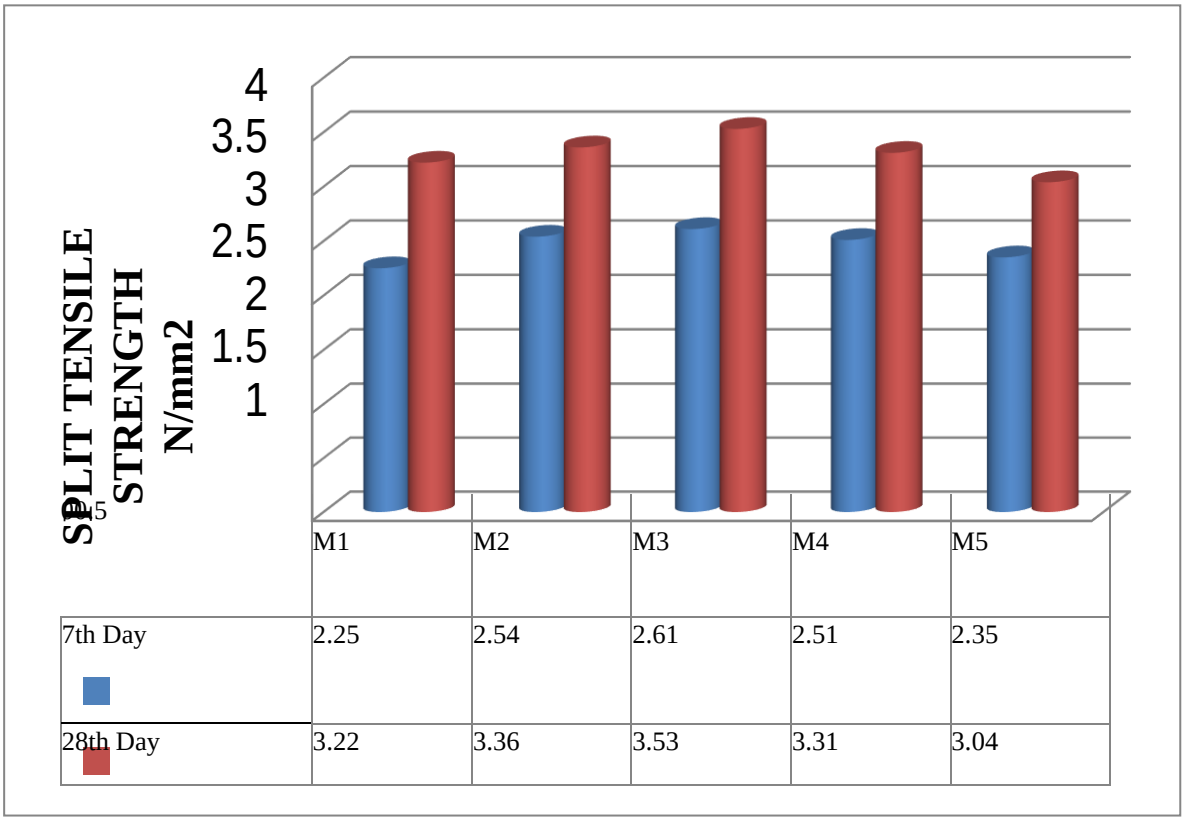
Table 7: Materials Quantity for Mix

Mix	Cement Kg/m^3	Fine aggregate Kg/m^3	Pumice powder Kg/m^3	Coarse aggregate Kg/m^3	Water Lit/m^3
M1	437	692	0	1037	197
M2	437	664.32	27.68	1037	197
M3	437	650.48	41.52	1037	197
M4	437	636.64	55.36	1037	197
M5	437	622.8	69.2	1037	197

Compressive strength or compressive strength is the ability of a material or structure to withstand loads that reduce its volume, as opposed to tensile strength, which can withstand loads that tend to stretch. In other words, compressive strength resists compression (being pushed together), where as tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. The compressive strength of concrete is measured by crushing cylindrical concretespecimens in compression testing machine. According to the practical work the maximum strength is attained at the Mix M4 which was the 8 percentage of the replacement that is greater than the nominal mix strength and the minimum strength is at the Mix M5 which was 10 percentage replacement.



Graph 7.1 Compressive Strength of various Mix

	M1	M2	M3	M4	M5
7thDay	**18.22**	**18.44**	**18.6**	**18.22**	**17.77**
28thDay	**32.7**	**33**	**33.4**	**33.7**	**32.4**

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The maximum strength achieved in the split tensile test in M3 mix is 6% alternate and there is an oscillation in strength where the strength increases up to M3 mix and falls in M4 mix and the strength falls.

IV. CONCLUSION

The objective of the design of pine needle collection robot with on board storage mechanism on a mobile robotic platform is successfully achieved.

1. From the project we have identified the properties of pumice powder and other materials and the results show that better strength can be achieved by using pumice powder.
2. The results of the compressive strength test showed that the highest strength was achieved in the M4 mixture, which was 8% of the replacement fine aggregate. The compressive strength increases up to 8% and starts decreasing.
3. M3 mix has high strength which is 6% of change of fine aggregate in split tensile strength test. Increasing up to 6% the strength starts to decrease further.
4. Water absorption capacity increases with increasing percentage of pumice powder. High amount of water absorption reduces the strength.
5. The optimum percentage for replacement of fine aggregate with pumice powder is 8%.
6. As pumice powder is cost effective, the cost of concrete can be reduced by replacing fine aggregate with pumice powder concrete.

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