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A STUDY ON BEHAVIOR OF WASTE PAPER SLUDGE ASH AND QUARTZ SAND AS A PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE

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ABSTRACT

Nowadays, the use of cement in the construction industry has been increased day by day which causes damage to the environment as the cement industry emits maximum amount of carbon dioxide. To reduce environmental pollution and save natural resources, it is essential to preserve it for our future generations. In order to solve the above problem, wastepaper sludge ash and Quartz is used as an alternative for cement and sand.

In the proposed work, cement is replaced by 5, 10, 15 and 20% percent by wastepaper sludge ash and the percentage on which optimum strength obtained i.e. 5% replacement is kept constant and natural sand is replaced by Quartz, varying the percentage by 25, 50 and 75%. The compressive strength of concrete is tested by using compressive testing machine and rebound hammer.

Research done showed that Waste Paper Sludge Ash can be used as cement replacement up to 5% by weight. Maximum Compressive strength of cubes with 5% WSA and 50% QS is observed to be 44 MPa.

KEYWORDS: *Waste paper sludge ash, River Sand, Manufactured Sand, Quartz Sand, Cement, Coarse Aggregate, Fine Aggregate.*

1. INTRODUCTION

Development in the construction industry has led to the environmental pollution on larger scale. The waste from paper and pulp industry has become a major problem. This situation leads to high disposal costs and potential environmental problems. [1-3]. Waste Paper mill sludge is composed of mineral fillers, inorganic salts, small cellulose fibers, water, and organic compounds. About 60 kg of ash is produced per ton of paper mill sludge. The composition of mineral fillers depends on the type of paper produced. Paper mill sludge is often incinerated in order to reduce the volume of the waste disposal and to recover heat. This process is achieved first by de-watering (i.e., by mechanical means and/or evaporation) at low temperature (< 200°C), followed by incineration at high temperature (> 800°C). During incineration, organic compounds are burned at temperatures of around 350 to 500 °C, whereas mineral fillers and inorganic salts are transformed into the corresponding oxides at higher temperatures (> 800°C). CaO, Al2O3, MgO, and SiO2 are the most abundant oxides in incinerated paper mill sludge [Liaw et al. 1998] [2]. By the researches, many of artificial pozzolans are found such as fly ash, blast furnace slag, silica fume, rice husk ash, etc. The recent studies show that the waste from paper and pulp industries has pazzolanic property termed as hypo sludge. It contains low calcium and minimum amount of silica and also behaves like cement because of silica and magnesium properties. This property helps in improving the setting of concrete. By utilization of this hypo sludge the strength of the concrete will be increased and also will lead to the reduction in the cost of concrete [4]. The moisture content in waste paper sludge as was found to be 40 % and also contains some fillers such as calcium carbonate and china clay and residual chemicals bound up with water [5]. The Compressive and splitting tensile strength gradually increases when the percentage of WPSA is increased from 0 % up to 15%. As WPSA content is increased beyond 15%, both the strengths decreases. The use of waste paper sludge ash makes the concrete lighter. With 20% replacement of waste paper sludge ash, the weight is reduced by 4.58% [6]. Since waste paper sludge ash has energy content, therefore, it is suitable for an alternative fuel for the manufacture of Portland cement. It is classified as class 2 (liquid alternative fuels) in the Cembureau classification of alternative fuels [7].

River sand is the most widely consumed natural resource on the planet after water. As per the research, the annual world consumption of sand is estimated to be 15 billion tons. In India, some of the states have also banned the use of river sand due to its excessive use which leads to scarcity. This state promotes the use of manufactured sand instead of river sand. Quartz is the second most abundant mineral on the Earth's crust, it also provides good resistance against mechanical and chemical weathering. Therefore, quartz sand can be used as an alternative for river sand. The use of Quartz Sand will not only help in increasing the strength of the concrete but will also help in reducing the cost of construction as quartz sand are cheaper than river sand [8-9].

2. EXPERIMENTAL PROGRAM

1. Description of Test Specimens

A total of 39 cubes were tested under compressive testing machine and rebound hammer. 15 cubes were tested to determine the maximum compressive strength using wastepaper sludge ash. 12 cubes were tested in CTM and 12 were tested by rebound hammer, varying percentage of Quartz. The cubes of size 150 mm x 150 mm x 150 mm were casted. Details of specimens are given in Figure 1

Figure 1 Concrete cubes

2. Materials used

The concrete is obtained by mixing solid constituents consisting of cement, coarse aggregate and fine aggregate as proportions of concrete 1:1.7:2.8 by weight. The percentage of wastepaper sludge ash and Quartz were varied as discussed above.

3. Mixing, Casting and Curing

Pan mixture was used for dry and wet mixing of ingredients, like conventional method used for making normal concrete. Fresh concrete was subjected to twenty five manual strokes per layer in three equal layers followed on vibration table for ten seconds. The side forms of moulds were stripped after 24 hours after casting and then left for curing I water for 28 days.

4. Instrumentation

The Loading arrangement for cube used is shown in Figure 2. The specimens were then tested in compression testing machine of 2000kN capacity. The load was applied using a hydraulic testing machine and the specimens were tested under pure axial compression.

Figure 2 Compression Testing Machine

3. RESULTS AND DISCUSSIONS

Results obtained from the proportion fixed and varying percentage of Quartz and wastepaper sludge ash are follows-

Sr No.	Percentage of WSA	Cement (in Kg)	Waste Paper Sludge Ash (in Kg)	Fine Aggregate (in Kg)
1	0%	4.85	0	8.5
2	5%	4.6	0.25	8.5
3	10%	4.37	0.48	8.5
4	15%	4.12	0.73	8.5
5	20%	3.88	0.97	8.5

Table 1 Mixture proportion of mortar

Sr No.	Percentage	Cement (in Kg)	Waste Paper Sludge Ash (in Kg)	Fine Aggregate (in Kg)	Quartz Sand (in Kg)	Coarse Aggregate (in Kg)
1	0%	4.6	0.25	8.5	0	14
2	25%	4.6	0.25	6.3	2.2	14
3	50%	4.6	0.25	4.25	4.25	14
4	75%	4.6	0.25	2.2	6.3	14

Table 2 Mixture proportion of concrete

Sr. No.	Designation	Percentage Replacement	Compressive Strength (MPa)		
			A	B	C
1	CWSA0	0	19	21	22.3
2	CWSA5	5	37.2	30.1	33.3
3	CWSA10	10	27.8	20.4	21.1
4	CWSA15	15	21.2	25.2	22.4
5	CWSA20	20	19.2	20.1	22

Table 3 Compressive strength of cement-wastepaper sludge ash mortar

Sr. No.	Designation	Percentage Replacement	Compressive Strength (MPa)		
			A	B	C
1	CWSA5QS0	0%	39.7	39.4	39.6
2	CWSA5QS25	25%	39.9	39.3	39.5
3	CWSA5QS50	50%	42.5	44.4	45.1
4	CWSA5QS75	75%	35.1	33.4	33.6

Table 4 Compressive strength of concrete block tested in CTM Table

Sr. No.	**Percentage Replacement**	**Rebound Number**			**Compressive Strength**		
		A	B	C	A	B	C
1	0%	35.86	35	36.1	29	28.1	29.2
2	25%	34.2	37	37.8	30.1	31.5	32.1
3	50%	41.4	40.66	41.7	36	35.4	36.4
4	75%	36.93	36.6	36.43	30	29.8	29.5

Table 5 Compressive Strength using Rebound Hammer

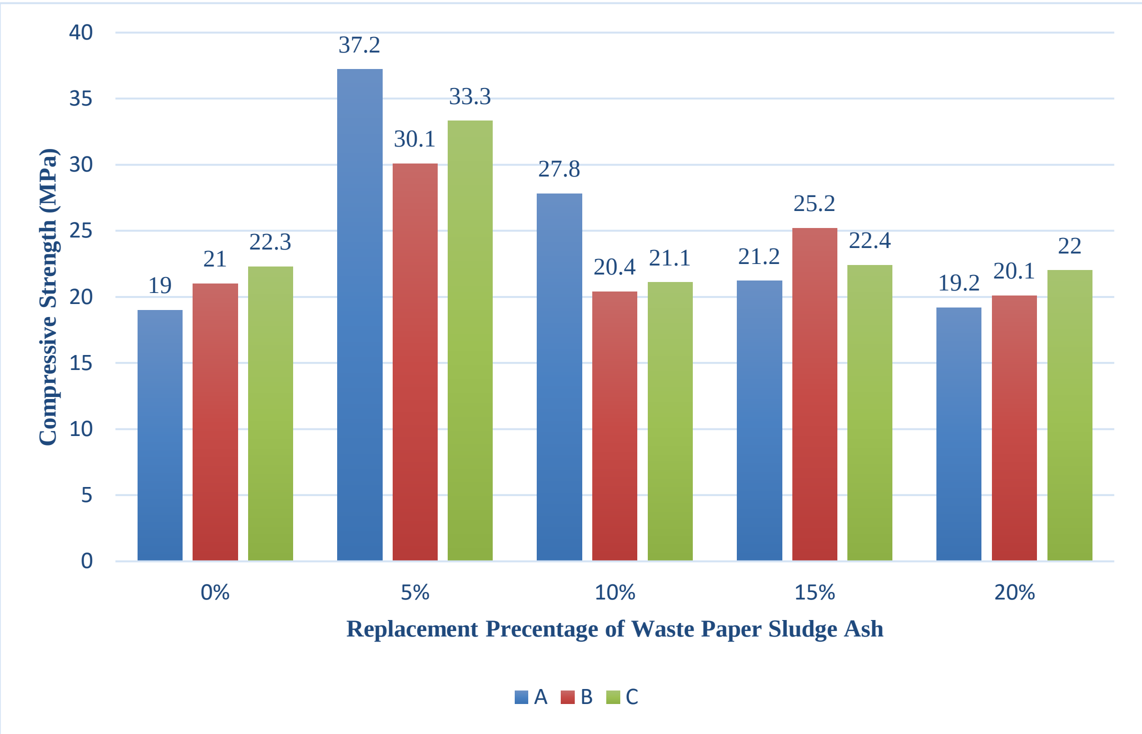

Fig. 1 Compressive strength of mortars

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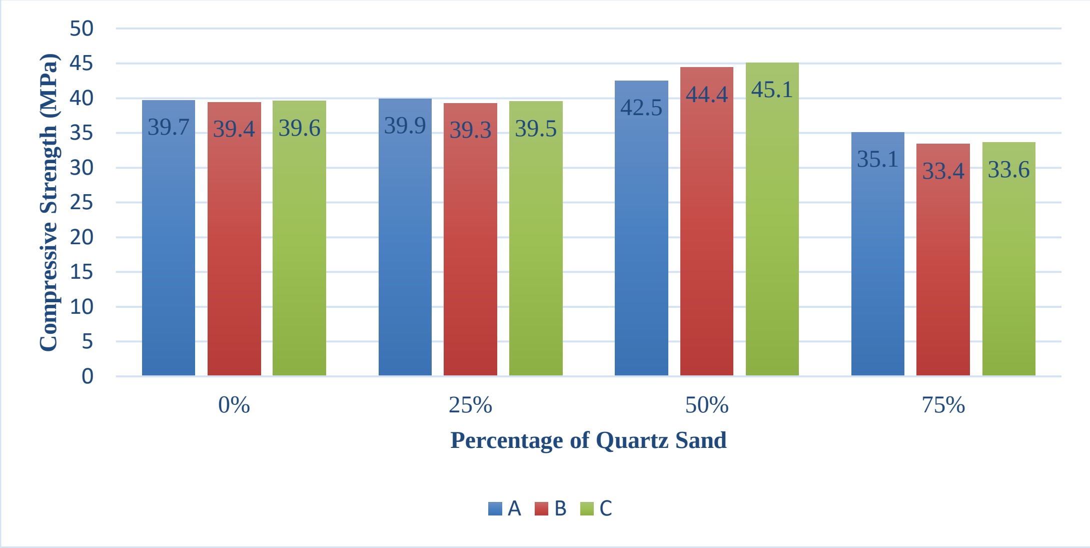

Fig. 2 Compressive strength of concrete using CTM

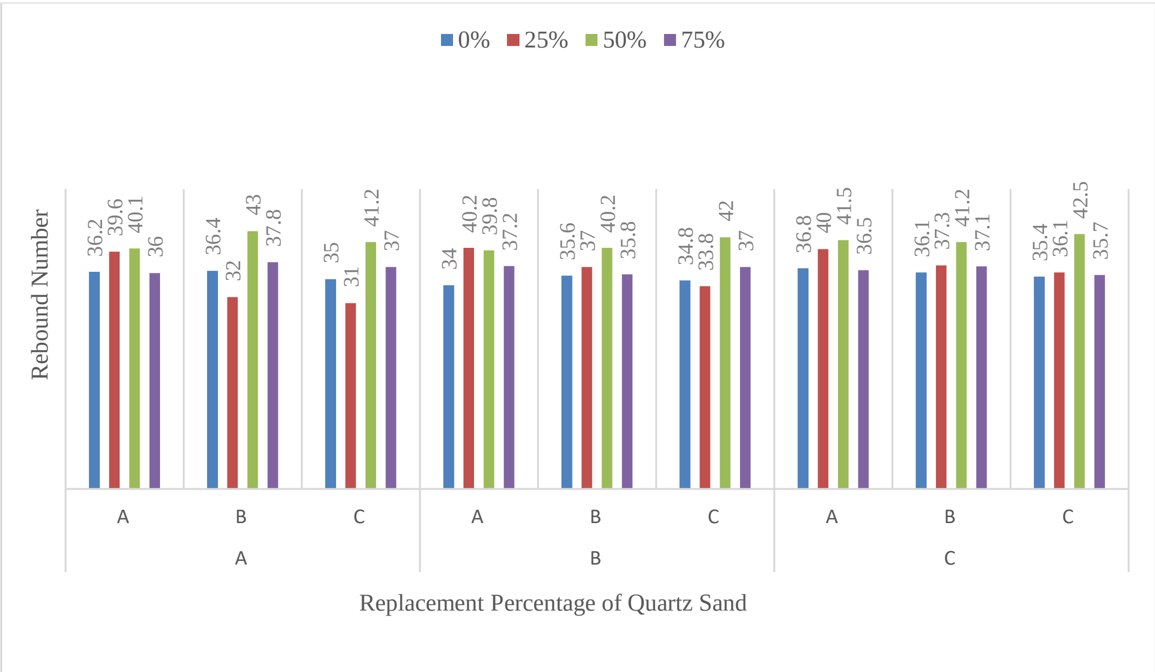

Fig. 3 Compressive strength of concrete using Rebound Hammer

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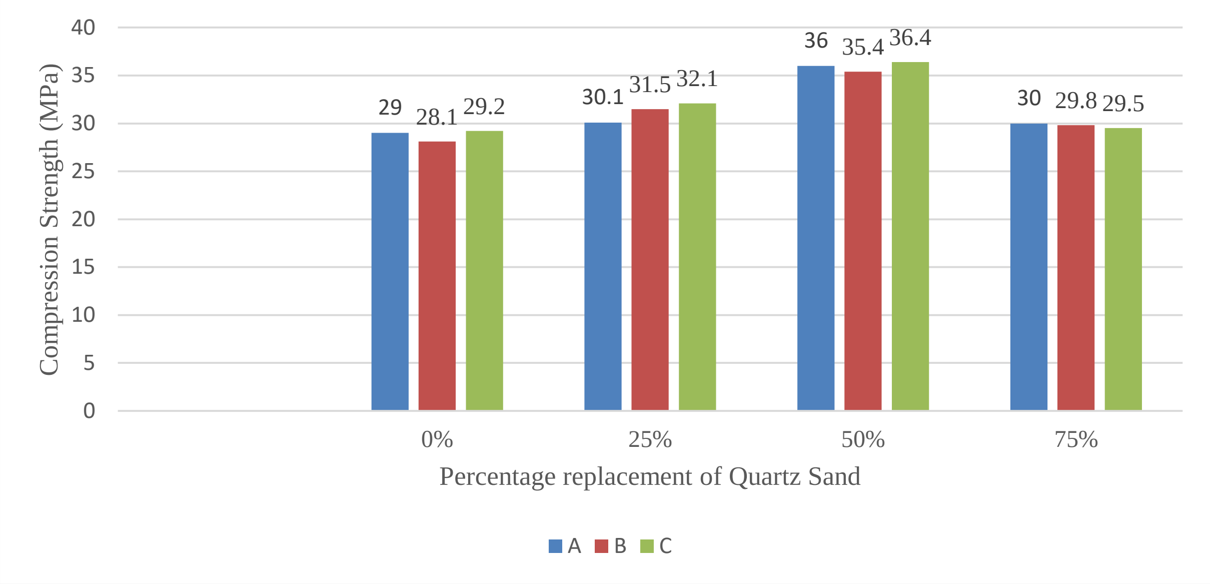

Fig. 4 Compressive strength of concrete using Rebound Hammer

1. Maximum Compressive strength of cubes using 5% WSA is found to be 33.53 MPa.
2. Increasing percentage of WSA decreases compressive strength.
3. Maximum Compressive strength of cubes with 5% WSA and 50% QS using CTM is observed to be 44 MPa.
4. Increasing the percentage of quartz sand leads to decrease in compressive strength even less than conventional concrete.
5. Compressive strength observed by rebound hammer is comparatively less than the results obtained for cubes tested in CTM.
6. Even though the compressive strength observed by rebound hammer was less, but it was observed that the compressive strength is maximum at 50% replacement of fine aggregate by Quartz Sand.
7. Max. compressive strength of cubes with 5% WSA and 50% QS using Rebound Hammer is observed to be 35.93 MPa.

5. CONCLUSIONS

1. Cost of Wastepaper Sludge ash is negligible and quartz sand is less as compared to the normal sand, hence decreases the construction cost.
2. Natural resources can be saved by the use of Waste Paper Sludge Ash and Quartz Sand as partial replacement of cement and fine aggregate respectively, it was observed that the.
3. By the use of wastepaper sludge ash as partial replacement of cement it not only increases the strength of concrete cube but it also reduces the huge problems of dumping the waste product of paper and pulp industry.

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