Experimental Investigation on Concrete by Partial Replacement of Cement with Sewage Sludge Powder & Fly Ash

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Abstract— Sludge is an inevitable by-product of wastewater treatment. The disposal of sludge is a complex problem that can affect air, land & environment. Thus the large scaled disposal of sludge is one of the major concerns of any municipality. Currently the most common methods of sludge disposal are ocean dumping, land filling & agricultural use. All these disposal alternatives have varying degrees of environmental impact. Therefore there is a need of alternative solutions to the problem of sludge disposal. One possible solution lies in using incinerated sludge for economical uses in construction as substitute materials. Digested and dewatered sludge, after incineration at a high temperature, yields a hard, cellular, porous mass with low unit weight. This hardened mass of sludge ash can be crushed to smaller-sized aggregates, which, when graded in suitable proportions, manifest the basic attributes required of lightweight aggregates.

Key words: Compressive Strength, Density, Water Absorption, Slump Test, Concrete Mix, Paper Waste

I. Introduction

Sewage sludge refers to the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater. The term septage is also referring to sludge from simple wastewater treatment but is connected to simple on-site sanitation systems, such as septic tanks.

When fresh sewage or wastewater enters a primary settling tank, approximately 50% of the suspended solid matter will settle out in an hour and a half. This collection of solids is known as raw sludge or primary solids and is said to be "fresh" before anaerobic processes become active. The sludge will become putrescent in a short time once anaerobic bacteria take over, and must be removed from the sedimentation tank before this happens.

This is accomplished in one of two ways. In an imhoff tank, fresh sludge is passed through a slot to the lower story or digestion chamber where it is decomposed by anaerobic bacteria, resulting in liquefaction and reduced volume of the sludge. After digesting for an extended period, the result is called "digested" sludge and may be disposed of by drying and then landfilling. More commonly with domestic sewage, the fresh sludge is continuously extracted from the tank mechanically and passed to separate sludge digestion tanks that operate at higher temperatures than the lower story of the Imhoff tank and, as a result, digest much more rapidly and efficiently.

Bio solids is a term often used in conjunction with reuse of sewage solids after sewage sludge treatment. Bio solids can be defined as organic wastewater solids that can be reused after stabilization processes such as anaerobic digestion and composting. Opponents of sewage sludge reuse reject this term as a public relations term.

II. Literature review

Donatello and Cheeseman estimate that approximately 1,700,000 tons of ash are generated annually on the global level during thermal treatment of sludge from WWTPs (mostly in the US, EU, and Japan). This number is expected to rise steadily due to construction of new and renovation of existing WWTPs. Research conducted so far has shown that, due to its characteristics and chemical composition, the ash created in this way can be used in some branches of economy, especially in construction industry where it can be used in the production of cement, concrete, bricks, ceramics, asphalt mixes in road construction, soil improvement mixes, and for extraction of phosphorus, which is a limited resource on the Earth.

Lopes and al. Chen and al. have determined that the composition and properties of ash are greatly influenced by the origin of wastewater, by the type and quantity of additives during their treatment, and by the sludge treatment method. This points to the great significance of the ash quality and composition testing under various circumstances, as related to the quality of wastewater and technological processes used at the WWTP. That is why the results of some research conducted with the sludge whose composition differs from that of the sludge generated in the territory of Croatia should be taken with some caution. For instance, industrial production decreased considerably over the last two decades in Croatia, which resulted in a considerable change in the quantity and composition of wastewater treated at WWTPs, and hence also in the composition of sludge. Similarly, the composition of sludge and ash generated at the WWTP depends to a great extent on the technological process used in water purification and in subsequent treatment of sludge.

III. Experimental procedure

Four controls mixes with partial replacement of waste paper sludge and fixed proportion of fly ash with cement were prepared. In all twenty four cube samples, 24 cylinders & 24 beams were casted for the study with four different weight percentages of paper sludge (0%, 10%, 20%, 30%) to study the effect on compressive strength, split tensile and flexural strength at 14, 28 days

IV. Results

A. Mix Proportion

Mix no.	Cement (kg)	W/c ratio	C.A (Kg)	F.A (Kg)	Sewage Sludge(Kg)	% Fly ash	Water (liters)	Extra water
1	384	0.5	1087	800	-	10	178	18.93

2	346	0.5	1087	800	38	10	190.3	18.52
3	308	0.5	1087	800	76	10	178	18.93
4	269	0.5	1087	800	115	10	178	18.93

The following are the results obtained in various laboratory tests carried out in this study:

Mix no.	% Sewage Sludge by wt. of Cement	Slump
1	0	4.5
2	10	5.5
3	20	4.5
4	30	4

Table 1: Slump Flow Test Results

Mix no.	% Sewage Sludge by wt. of Cement	Compressive Strength (MPa)	
		14 Days	28 Days.
1	0	23.90	34.72
2	10	22.10	32.15
3	20	18.50	29.42
4	30	14.77	26.72

Table 2: Compressive Strength Test Results

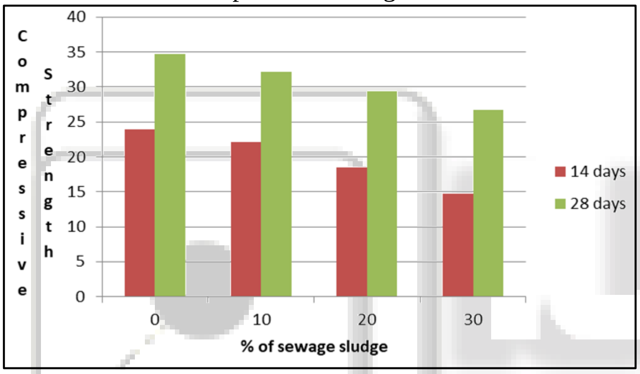

Fig. 1: Graphs Representing Compressive Strength

Mix no.	% Sewage Sludge by wt. of Cement	Split Tensile Strength	
		14 Days	28 Days.
1	0	23.90	34.72
2	10	22.10	32.15
3	20	18.50	29.42
4	30	14.77	26.72

Table 3: Split Tensile Results at 28 days

Mix no.	% Sewage Sludge by wt. of Cement	Flexural Strength	
		14 Days	28 Days.
1	0	5.74	5.61
2	10	5.56	7.87
3	20	4.5	6.02
4	30	5.74	5.61

Table 4: Flexural Strength Results at 28 days for Cylinders

V. CONCLUSION & FUTURE SCOPE

A. Conclusion

On the basis of available information, general conclusions derived from experimentation for studying the effects of paper sludge in concrete from the present study are stated. The new IS: 10262:2009 code preamble was used for mix proportioning of paper sludge induced concrete with constant variant of fly ash. The following conclusions are arrived at on the basis of present investigation.

1) Slight bleeding was observed in all the trial mixes.
2) The effect of partially replacing cement with varying percentage of sewage sludge enhances the cohesiveness of mixes. Further it can be concluded that for a given flowability, however smaller quantity of water is required in case of agro wastes with high fineness and low carbon content.
3) Compressive strength showed improved results when replaced with 10 % of sludge.
4) When sludge replacement with cement was 10 percent the compressive strength increase by about 7% as compared to 20% replacement.
5) Split tensile strength also showed good results when replaced with 10% of cement.

B. Future Scope

The cementing co-efficient factor for the sewage sludge may be used for adjustment in water/cement ratio. A further study should be carried out at different cementing co-efficient of sewage sludge.

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