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Utilisation of Sewage Sludge as a Partial Replacement of Cement to Increase the Strength of Concrete

V. K. Shankar[1], Akshay S. Kumar[2], K. Bharath Krishna[3*], M. Mohanraj[4]
[1,2,3,4]*Department of Civil Engineering, Dr. N. G. P Institute of Technology, Coimbatore, India*

***Abstract*: The sewage sludge from waste water treatment plant is increasing all over the world. Disposal of this sewage sludge is becoming a severe environmental issue to our society. Due to this fast urbanization, the demand of cement has increased. It will lead to increased cement production and emission of carbon dioxide because the cement industry one of the major contributor of carbon dioxide emission. Therefore, the research for replacement of cement using sewage sludge ash is very important to reduce both the emissions of carbon dioxide and the disposal problem of sewage sludge ash. Five different percentages of sludge used to partial replace the cement in the concrete. The partial replacement of cement in concrete with sludge has shown lower water absorption and increase compressive strength of concrete. The replacement of cement in concrete with 5% SSA have lower water absorption, and then increase in compressive strength of concrete up to 10% as compared with the control samples.**

***Keywords*: Compression test, Concrete, Sludge, Split tensile test, Waste water treatment.**

1. Introduction

The Sewage sludge ash ⟨SSA⟩ is a byproduct of wastewater treatment plant. Nowadays, the amount of sewage sludge has increased highly because of the urbanization and growth of the population and is expected to increase in future. The high amounts of sewage sludge will lead to affect the environment and surroundings. The best alternative solutions for the disposal of sewage sludge are incineration. The main component of sewage sludge after the high temperature incineration such as SiO2, CaO, Al2O3, which are all the components of ordinary cements ⟨Tenza-abril et al., 2011⟩. Basically the residue is inert and odourless in diverse solutions. With the current rate of urbanization, it is expected that the demand of cement will increase further. This demand for cement shows that concrete structures are expected to increase nowadays ⟨Jamshidi et al., 2012⟩. The main source for carbon dioxide emission is the cement industry. Almost 5-7% of global CO2 emissions are caused by cement plants; 900 kg of CO2 is emitted to the atmosphere for producing one ton of cement ⟨Benhelal et al., 2013⟩. This research should be conducted for us to study about potential of using Sewage Sludge Ash as cement replacement in concrete for structural use in future.

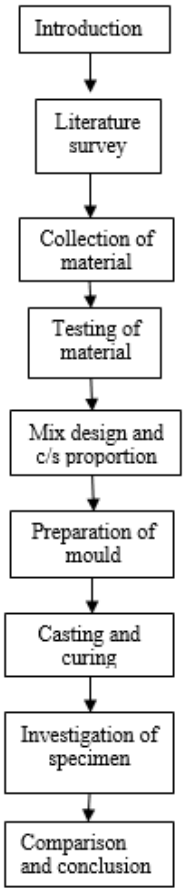

Fig. 1. Methodology

2. Material Collection

A. *Cement (OPC)*

The Ordinary Portland Cement of 53 grades conforming to IS: 8112 is used. The cement used is fresh and without any lumps.

B. *Aggregate*

Aggregate give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates.

*Corresponding author: bharathybk007@gmail.com

Least glue implies less amount of concrete and less water, which are further mean expanded economy, higher quality, bring down shrinkage and more noteworthy solidness.

C. Sewage Sludge

It had conducted on waste sludge powder. Which is collected from waste water treatment plant in Tirupur district, Tamilnadu and are drilled and sieved in 90micron.

D. Mix Design

There is no unified approach towards mix design, rather there are a number of approaches, and each has some merits are demerits. Design mix of M20 Grade {I.S: 10262-2009} some of the important mix design approaches are as given below and the same was used to prepare the various test sample replacement of cement with the sludge.

Table 1

Cement	Fine Aggregate	Coarse Aggregate	Water
404	672	1326	202
1	1.67	3.28	W/C Ratio=0.5

E. Testing of the specimen

1) Compression test.
2) Tensile strength test

1) Compression test

Compression tests are used to determine a material's behavior under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen (usually of either a cuboid or cylindrical geometry) using platens or specialized fixtures on a universal testing machine.

The compression strength of the specimen is tested on the compression testing machine. The values are observed and tabulated. This result is based on the Indian standard IS 516:1959.

Table 2

SR	SLUDGE	COMPRESSIVE STRENGTH AT 7 DAYS(N/mm2)	COMPRESSIVE STRENGTH AT 28 DAYS(N/mm2)
N/	0%	17.2	24.33
2.	5%	16.9	23.9
3.	10%	16.2	22.7
4.	15%	17.9	24.96
5.	20%	10.36	13.91

2) Tensile strength test

A tensile test, also known as a tension test, is one of the most fundamental and common types of mechanical testing. A tensile test applies tensile (pulling) force to a material and measures the specimen's response to the stress. By doing this, tensile tests determine how strong a material is and how much it can elongate. Tensile tests are typically conducted on electromechanical or universal testing instruments, are simple to perform, and are fully standardized.

The tensile strength of the specimen is tested on the compression testing machine. The values are observed and tabulated. This result is based on the Indian standard IS 516:1959.

Table 3

Sr. no	Sludge%	Split tensile strength at 28 days(N/mm2)
1.	0	2.93
2.	5	2.8
3.	10	2.72
4.	15	2.65
5.	20	3.15

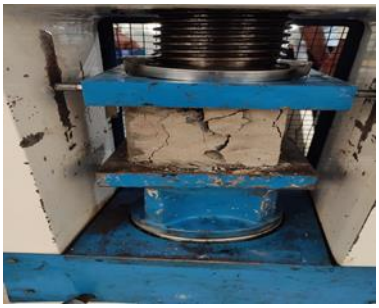

Fig. 2.

Fig. 3.

F. Comparison to Conventional Cube

The following test where taken in the sludge substituted concrete block and the result are compared with the conventional concrete block.

1) Compression strength test
2) Tensile strength test

1) Compression strength test

The compressive strength is performed on compression testing machine and the value is observed for the curing period of the 7 days and 28 days of curing.

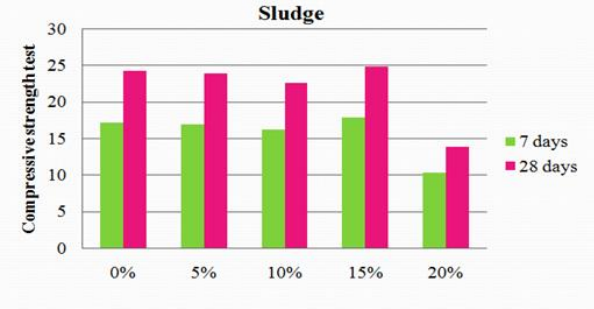

Fig. 4.

2) Tensile strength test

The tensile strength is performed on universal testing

machine and the value is observed for the curing period of the 28 days of curing.

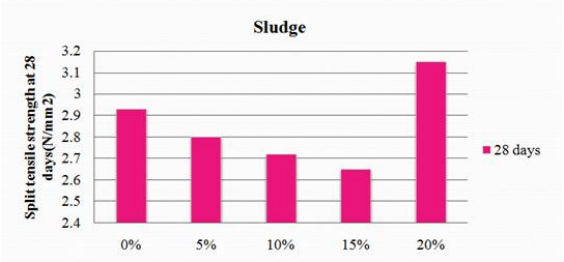

Fig. 5.

3. Conclusion

- The sewage sludge is finally replaced partially in place of cement in concrete block. The land fill problems due to the improper disposal of Sludge is minimized. As we increasing percentage of sludge by the weight of cement it shows a increase in the compressive strength and tensile strength of the concrete block.
- From the analysis of the results of this research, the following conclusion can be established:
- Incineration of sewage sludge at 600 °C reduces its volume to less than 50 %, which is a feasible solution to the land disposal problems. Besides that, incineration removed the organic compound and increases composition of oxide element SiO2, P2O5, CaO and Al2O3.
- Incinerated sewage sludge ash is a potential cement replacement as the major oxide of SSA (SiO2, CaO and Al2O3) similar to the Portland cement based composites where it is the primary component found in the cement clinker.
- The cement replacement of 5% SSA has shown improvement of compressive strength up to 10% as compared with the control. However, cement replacement with SSA more than 5% shows adverse result to the compressive strength.
- The replacement of sewage sludge ash in concrete of 5% SSA has the lowest water absorption value. Thus, 5% sewage sludge ash concrete has the lowest porosity and highest durability. The concrete with 5 % of sewage sludge ash is the optimum mixture.

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