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Performance of Treated Sludge as a Replacement of Fine Aggregate in Construction Application

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Abstract: ***Large quantities of sludge are produced during the conventional processes of coagulation, flocculation and sedimentation in water treatment plants. The volume of sludge generated during water treatment process can be as high as 2% of the total volume of water treated. The cost of treatment and the disposal of the sludge plays a significant part of a water treatment plant. As the disposal of sludge produced from water treatment plants is highly expensive and difficult, valuable reuse options have been proposed to remove the sludge. In India, there are numerous emanating treatment plants bringing about mounting of sludge. It is very difficult and expensive to transfer the sludge from treatment plant. The more waste generated by the plants creates environmental problems of toxic threat. The treated waste sludge materials can be used as a replacement of fine aggregate to minimize the landfills is one of a cost-effective solution to this problem. There is a lack of conventional construction materials such as cement, fine aggregate and coarse aggregate due to the rapid increase in construction activities. To find replacement materials in construction many research have been conducted. The usage of treated sludge as a fine aggregate in construction material is an environmentally friendly option for the disposal sludge generated by water treatment industry.***

Key Words: Concrete, Sludge Waste, Environment

I. INTRODUCTION

In the developing countries such as India, Srilanka and Pakistan concrete is the widely used construction material. Aggregates, water and cement are used to produce concrete and its production is expensive due to the cost of materials and high energy required. In such situation to minimize the cost and use of the raw materials, a fine aggregate can be replaced by the sludge from water treatment plant. Sludge produced during water treatment has the disposal problem. In order to reduce that reuse the sludge as a replacement material in construction with different percentage as a fine aggregate. This leads to the reduction of sludge waste and the construction cost to certain level. During the treatment of water sludge is produced as a waste product [1]. The region and the technique of water treatment determine the characteristic of sludge. Sludge are formed after the various processes of chemical treatments. The treated sludge which has been used for other purpose is known as bio solids.

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This bio solid is normally used for agricultural purpose because it contains maximum amount of nitrogen content. But it has the disadvantage that the sludge contains pathogens in high numbers and it affects the agricultural land. Still now, there is no proper study on sludge to use as a replacement material. Carbon, nitrogen, phosphorus are the important elements for the development of plant can be back to the soil by the use of composted sludge as a soil amendments in farming and agriculture. The ability of the soil for aeration, percolation of water and development of root can be improved by the use of organic carbon. Compared to the chemical fertilizers the amount of nitrogen and phosphorus needed for plant growth are also released by the sludge gradually for plant uptake. The potential of leaching of the nutrients to ground by rainfall run-off is much reduced. The reuse of sludge can be limited by the presence of pathogens and dense metals. The presence of pathogens must be reduced because it cause health issues to workers handling the sludge. Treated sludge, which has been attain low content of moisture. It is very difficult to remove heavy metals and toxic chemicals in the sludge. The goal of wastewater management is to avoid these chemicals and metals to entering the wastewater or sludge since the sludge intended for reuse in agriculture. The sludge can be reused for the purposes such as filling of lands used for highways and rehabilitation purposes. The disposal of heavy metals or toxic chemicals sludge for land filling generally, lining of the landfill with clay or plastic liner may be essential to avoid contamination of groundwater. The usage of treated sludge in a proper way by replacing with fine aggregate as an amount of 10%, 15% and 20%. By using this sludge, the sludge is treated properly and use as a replacing material gives a disposal to a certain level.

II. MATERIALS USED

The sludge was collected in a water treatment plant ant it was treated by a required treatment and remove the harmful Pathogens and other toxins. The treated sludge was dried and it was sieved in IS 4.56 mm sieve. The sludge image is shown Fig 1.

Fig. 1. Sludge sample (water treatment plant)

The experimental investigation includes materials are as follows

Cement: Chettinad 53 grade Ordinary Portland cement (OPC) (IS 1489 PART I 1991).

Fine aggregate: Clean river sand ZONE II of IS 383 – 1970

Coarse aggregate: Crushed granite coarse aggregate of normal size greater than 4.7mm and less than 20 mm size is used.

Water: Locally available portable water obtained from source of college campus pore well is used for mixing and curing of concrete for normal conditions conforming to the requirements of water for concreting and curing as per IS: 456 – 2000.

III. MIX DESIGN

In this experiment work, concrete specimens were cast with and sludge. The specimens considered in this study consisted of 27 numbers. The nominal mix proportion used for casting the specimens was 1:1.14:2.31 (Cement: fine aggregate: coarse aggregate: water cement ratio). Fresh concrete was cast in steel moulds and hand compaction. The M_{20} mix design is done by the concept of code IS 10262 (2009) with w/c ratio of 0.48.The sludge was taken as 10%, 15% and 20% as a replacement of fine aggregate. The size of specimen was 150x150x150 mm. In the laboratory the mixing procedure is done with hand mixing as per standard procedure. After proper hand mixing is done, the fresh concrete is placed a in the moulds. Vibrating table is used for compaction. After compaction, the concrete specimens along with the moulds were kept for drying for 24 hours. After 24 hours the concrete cubes are taken out from the moulds and kept in water for 28 days.

IV. TESTS AND RESULTS

A. Compressive strength of concrete

The compressive strength test was carried out for 7 days, 14 days and 28 days on cube specimens using standard test methods. A digital compression testing machine of 1000 KN capacity operated at a loading rate of 2.5kN/s is used to determine the compressive strength of the testing specimens. The compressive strength of the specimens are tested and recorded. The table I shows the values of tested results for 10% ,15% and 20 % replacement of fine aggregate with the sludge.

Fig. 2. Compression test on cube specimen

Table I: Characteristic Compressive Strength in N/mm2

Days	Compressive Strength		
	10%	15%	20%
7	18.1	19.5	18
14	19.2	21	18.5
28	24	26.4	23.8

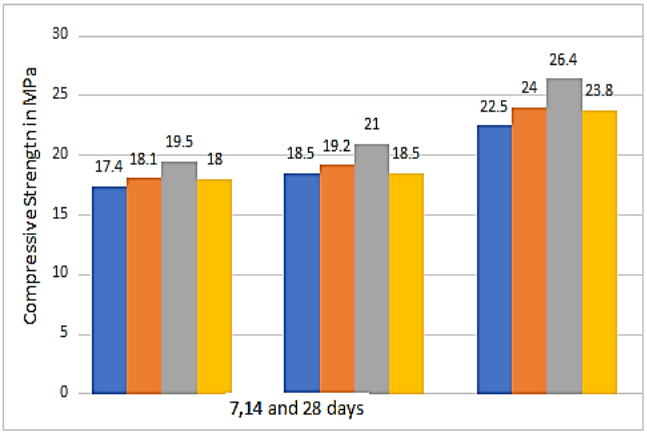

Fig 3. Comparative Compressive strength of Different replacement percentage of sludge

The test result shows that replacement of sludge as 15% gives the increase in strength. The strength get degrees addition more than 15% sludge.Fir3.Shows the test results of different percentage of Sludge compare with the conventional Concrete.

B. Split tensile strength of concrete specimen

In this experiment, cylinders of size 150 mm in diameter and 300 mm height were tested. The tensile strength of concrete is determined by the splitting tensile strength test on concrete cylinder.

The table II shows the values of tested results for 10%, 15% and 20 % replacement of fine aggregate with the sludge.

Table II: Split tensile strength of concrete

Days	Split tensile Strength			
	CC	10%	15%	20%
7	1.4	1.45	1.52	1.5
14	2.5	2.52	2.54	2.5
28	3.2	3.42	3.45	3.4

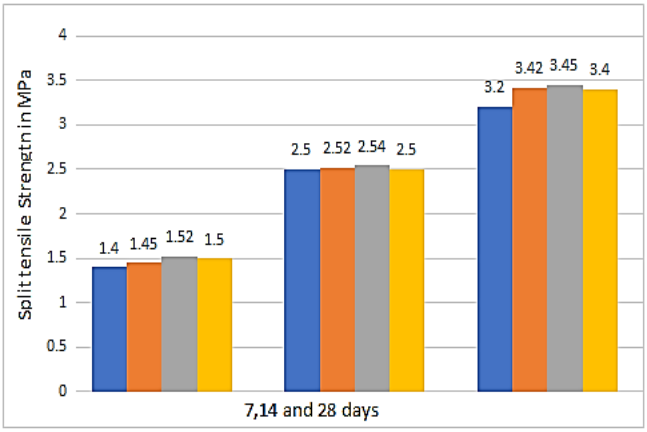

Fig 4. Comparative Split tensile strength of different replacement percentage of sludge

The test result shows that replacement of sludge as 15% gives the increase in strength slightly. The strength gets slightly degrees addition more than 15% sludge. Fig4. Shows the test results of different percentage of Sludge compare with the conventional Concrete.

V. CONCLUSION

The fine aggregate may be replaced by treated sludge in a certain level and it can be replaced with 10% to 20 % in concrete to the weight of fine aggregate. The addition of 15% of fine treated sludge can improve the compressive strength. By compared with the control specimen the split tensile strength is slightly increased. The maximum compressive strength and split tensile strength were found to be 26.4 N/mm2 and 3.45 4 N/mm2 for OPC 53 grade cement. Among all these mixes tested the addition of 15 % of sludge aggregate shows the better results in compressive and split tensile test compare to the normal concrete. Thus, replacement of sludge as a fine aggregate is suitable up to 15% replacement. Further increases in percentage reduce the strength. So the sludge waste is only used up to certain extent.

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