



Utilization of Sludge from Majis Waste Water Treatment for the Partial Replacement of Nature Fine Aggregate in Concrete

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This experimental investigation is to utilize the sludge waste as a replacement of natural fine aggregate. We can introduce a sustainable construction material which is proved to be an alternative for waste disposal, helping out to free from environmental pollution. By replacing the natural fine aggregate of sludge waste it helps us to save our nature. Per day for construction site, we are using a large quantity of natural fine aggregate. This study reviews various attempts that have been made to use sludge waste as the partial replacement of fine aggregate. The fine aggregate is partially replaced by a trial mix of 5%, 10%, 15%, 20%, 25% and 30% with sludge waste. Then fresh concrete and hardened concrete is prepared by the partial replacement of fine aggregate. This process is to be done by dry condition. The mechanical and physical properties of the concrete after replacement is to be tested in the laboratory and the results are compared with the ordinary concrete. The comparison of results shows that the replace of 20% sand by sludge waste shows more compressive strength than that of the ordinary concrete with sand as fine aggregate. From the result we can understand that if the sludge contains finer particles the strength of the concrete will further increase.

Introduction

The increasing of waste water in the industrial and domestic with respect to increase in the population. This increase in the population is the more responsible for the pollution in the environment. The waste produced from the human beings and the atmosphere must be treated before disposing to the atmosphere. One of the waste aspects in our society is the wastewater sludge. Wastewater sludge is the residual material removed from wastewater treatment plant. To sustain the pollution human health and environment, suitable treatment and disposal methods are required.

Waste water treatment produce considerable quantities of sludge waste, which increases the environmental pollution and wastage of land. But on the other hand, we are producing large quantities of concrete for construction purposes. For manufacturing large quantities we have to use more natural available materials like rocks, sand, etc... Now a days, concrete is the most used manmade material in the world. The Oman construction industry alone consumes approximately 30 million tons of concrete every year and relative amount of mortar too. Therefore the demand of concrete and the required raw materials is very high. This causes hike in the cost of cement, fine and coarse aggregate. To avoid the problems like cost hike and cuts in supply of concrete and mortar, the alternate material or the partial replacement for the cement and aggregate should be developed by the recycling of waste material. This provides us economical, environment-friendly and light-weight construction products. Use of the waste materials also reduces the problems of



land filling, environmental resource consumption and health concern.

The wastewater in sewage plants is a collection of households, industries and storm water. These components treated together, not separated. This means that there are large amounts of pollutants in the influent wastewater which will also be in sludge. The sludge has two main components, liquid and solid. Liquid part, include water and dissolved substances.

The dissolved substances contain organic and inorganic substances.

The organic dissolved substance such as carbohydrates and fatty acid and the inorganic dissolved salts such as ammonium. The solid part of sludge contains organic and inorganic solid matter. The organic matter involves living organisms and their decomposition product. The inorganic solid matter is founded in the form of metals and nutrients.

Literature Review

“Experimental Study on Effects of Sludge Waste in Concrete” To evaluate the effect of dry sludge on concrete performance, physical and mechanical properties were studied. The waste sludge material was replace with fine and coarse aggregate in various percentages such as 50%, 45%, 40% ,35%,30%, 25%,20%,15%, 10%, 5%, 4% and 3%.Also reference concrete mix is made for comparative reasons.

“An Experimental Study on Mechanical Properties of Concrete using Sludge Ash” The aim of this project is to give a simple method of using the sludge ash in partial replacement with cement. The sludge ash retained is partly replaced with cement in concrete at different proportions. Mechanical properties such as compressive strength, tensile strength and flexural strength of the sludge concrete are determined.

“Experimental Study On Replacement Of Concrete Material By Water Treatment Plant Waste Sewage” The outcomes demonstrated that the dry sludge hindered the quality advancement and has more un favorable impact on compressive quality when it has higher natural substance and its particles got to be distinctly better. The review reasoned that the dry sludge can be utilized as a part of as an added substance to solid blends and to interlock block glue as one of the accessible transfer alternatives for Gaza Strip ooze.

“Replacement of Fine Aggregate Using Sludge in Concrete” The purpose of this study is to find an alternate source for fine aggregate. In this project concrete was tested with w/c ratio of 0.45.The mechanical properties such as compressive strength, split tensile strength and flexural strength were tested for 7, 14 and 28 days. This experimentation holds good strength till 20% of replacement with sludge in fine aggregate. The strengths decreased when the replacement of sludge is above 20%.

Methodology

Mixing of sludge with fine aggregate is to be done by the following processes. In dry method, the sludge is placed in the oven for 24 hours by maintaining the temperature of about 200 degrees Celsius. After that the material is finely grinded and mixed with the fine aggregate.

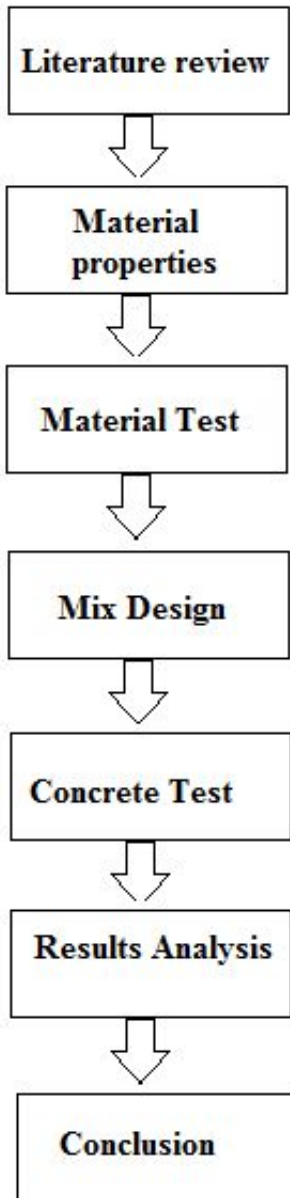


Figure 1. Methodology

Materials

Cement

A cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. Portland cement is the most common type of cement in general use around the world. SRC - 42.5 grade is used.

Sulphate Resisting Portland Cement is a type of Portland cement in which the amount of Tricalcium aluminate (C3A) is restricted to lower than 5 % and (2 C3A + C4AF) is lower than 25%. SRC can be used for structural concrete wherever OPC or PPC or Slag Cement is usable under normal conditions.



Figure 2. Cement

Grade	Specific gravity	Initial setting time	Final setting time
SRC 42.5	3.10	30 min	580 min

Table 1. Properties of cement

Natural fine aggregate

Fine aggregates play a very important role in concrete. The aggregate whose size is lesser than 5 mm. It manages to fill the voids between the coarse aggregates .The fineness helps in increasing cohesion there by resisting segregation.

Grade	Specific gravity	Initial setting time	Final setting time
SRC 42.5	3.10	30 min	580 min

Table 2. Properties of sand

Figure 3. Sand

Sludge

All water treatment plants (WTPs) produce waste/residue known as water treatment sludge (WTS) during the purification of raw water.Silica, alumina, ferric oxide and lime constitute the major percentage of chemical components present in the sludge. Some heavy metals are also found in the sludge. The following shows the chemical properties of the sludge

Cd	Cr	Cu	Pb	Mo	Ni	Se	Zn	Hg
<0.5	115	134	18.4	5.8	281	19.6	382	2.42



Table 3. *Properties of sludge*

Figure 4. *Sludge*

Coarse aggregate

The coarse aggregate constitutes the bulk of concrete mixture and gives the dimensional stability to concrete. Size of aggregates greater than 4.75 mm is considered as coarse aggregate. Generally aggregates of size between 4.75 mm to 20 mm are used in concrete. The size, shape and texture of aggregates control the workability; cement content and drying shrinkage parameters. Generally smooth and rounded aggregates are preferred for concrete.

Specific gravity	Bulk density	Fineness modulus
2.88	3.83gm/cc	5.68

Table 4. *Properties of coarse aggregate*

Figure 5. *Coarse aggregate*

Mix Design

The Mix Design is followed by DOE method and the mix proportion is shown below

Cement	Fine aggregate	Coarse aggregate	Water
360 kg	529.2 kg	1360.8 kg	180 liters
1	1.47	3.78	0.5

Table 5. *Proportions of materials*

Experiment procedure

Several experimental investigation are carried out to check the performance of concrete by using sludge waste as the replacement of natural fine aggregate

Mix		S1	S2	S3	S4	S5	S6	S7
FA	Sand	100	95	90	85	80	75	70
	Sludge	0	5	10	15	20	25	30

Table 6. *Trial Mix proportions of replacement of fine aggregate with sludge*

Compression strength test

The compressive strength of the specimen of standard size 150 mm x 150 mm x 150 mm cubes are tested for 7, 14 and 28 days of curing. The strength of the concrete is obtained from 7 trial mixes of



cubes. The coarse aggregate and fine aggregate are first mixed and then cement is added with sludge in the proportions of 0, 5%, 10%,15%,20%,25% and 30% respectively. The water is added to the mixture and mixed well. The concrete is then poured into the cubes in three layers and tamped with tamping rod of size 12 mm and compacted well. The cubes are demolded and are subjected for curing. The cubes are taken out after curing period and is tested for compressive strength. Load is applied until the failure point has been reached.

Compressive strength of the specimen is calculated by,

$$f_{ck} = P/A$$

Replacement Mix	7 days N / mm ²	14 days N / mm ²	28 days N / mm ²
S1	14.5	18.7	24.8
S2	13.6	18	23
S3	14	17.5	23.5
S4	14.7	18	25
S5	15.5	19.5	25.5
S6	14.3	18.5	24
S7	13	17	23.2

Table 7. Compressive strength test

Results and Investigation

After the detailed investigation on different strength parameters has been done, the following result has been achieved.

1. The specimens added with the sludge have a significant result over the Compressive strength. The compressive strength for the specimens S5 were found to be 15.5,19.5 and 25.5 for 7 days, 14 days and 28 days respectively. The compressive strength of the materials after 20 % replacement of the natural fine aggregate shows more strength, as shown in fig.6.

Figure 6. Comparison of compressive strength

Conclusion

The following conclusions have been made based on the results obtained from the experimental investigation.

1. The specimen with sludge as waste material was found to be good in compression which had the compressive strength of 25.5 after 20% replacement of natural fine aggregate by sludge.
2. Better strength was achieved with the replacement of the sludge waste in concrete. The strength has increased up to 5% when compared to that of the conventional concrete specimen.
3. Sludge can be used as an effective replacement of fine aggregate in concrete. This can reduce the usage of natural fine aggregate. By this method we can utilize more quantities of sludge waste. This is one of the way to dispose sludge waste by eco friendly means.

Benefits



Replacement of natural sand by sludge in concrete protect the environment of Oman from land filling and contaminating the sea water by heavy metals and toxic chemicals. Save the natural aggregates for the future generations of Oman. Improve the performance of concrete.

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