REPLACEMENT OF FINE AGGREGATE BY USING LEACHATE SLUDGE IN CONCRETE

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Abstract - *The idea of using sludge gives a platform to use it as an alternative source for the replacement of fine aggregate. In this project concrete was tested with w/c ratio of 0.5. Fine aggregate are partially replaced by using sludge with different percentage such as 5%, 10%, 15% and 20%. Chemical composition of the sludge was found by using SEM and EDX test. The mechanical properties of the sludge 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 partial replacement with sludge in fine aggregate. The strengths were decreased when replacement of fine aggregate reaches above 20%.*

Key Words: *Sludge, fine aggregate, Cement, SEM, EXD, Compressive strength, Split tensile strength, Flexural strength.*

1. INTRODUCTION

Sludge is a by-product that is obtained from the wastewater treatment plant. Disposal of the waste become a serious issue for the society todays. Due to the huge emerging of such waste cause serious problem in designing and operation of the treatment plant resulting pollution in the society. The production of the sludge from the waste treatment plant is increasing day by day around the world. Sludge has a disposal problem in order to reuse and reduce. Hence the test is conducted to reduce the sludge by partially replacing the fine aggregate. The characteristic of the sludge differs for different region and the method of treatment. Sludge is formed after various steps like stabilization, composting, anaerobic decomposition, dewatering and sedimentation. These sludge contain maximum amount of nitrogen, zinc, dry solids, organic material heavy metals etc. hence probably can be used for agricultural purpose (Srinivasan et al., 2016).

At the sewage treatment plant, the sewage sludge was sun dried in the sludge bed (Bharat et al., 2016). In India there are many industries which produce large amount of effluent treatment plant sludge in every year which leads to increasing problem in disposal and environment degradation due to continuous exploitation and depletion of natural resources. Since the land is limited another methods are to be subjected for the treatment of waste sludge (Sreehari et al.,2015).

The sludge pass through 4.75mm IS sieve complexly and retain in 90micron IS sieve similar to that of fine aggregate.The concrete was produced by sludge using M20 grade as per IS 10262:2009 OPC 43 grade cement was used and the water cement ratio is taken as 0.5. The concrete was hand mixed on water-tight, non-absorbent platform with a shovel, trowel and necessary equipment's. The color of the concrete was found uniform. The slump was measured in mm, it was found that the slump is true slump. Further the Compression, Split tensile and Flexural test are carried out to know the strength of different percentage of replacement of fine aggregate by sludge.

2. MATERIALS USED

2.1 CEMENT

Cement is a good bonding material which having both the cohesive and adhesive properties. Cement used in experiment is ordinary Portland cement (OPC) of grade 43 conforming IS 10262:2009. Various lab test were conducted on cement to determine specific gravity, fineness, standard, initial and final setting time. Specific gravity of cement is 3.1.

2.2 WATER

Mostly portable water should be used which is free from the impurities.

2.3 COARSE AGGREGATE

The size of coarse aggregate should be 12.5 – 20 mm. It should pass through 20mm sieve and retained on 12.5mm sieve. Specific gravity of coarse aggregate is 2.6.

2.4 FINE AGGREGATE

River sand was used as a fine aggregate of specific gravity 2.61. It should pass through 4.7mm sieve and retained on 150micron.

2.5 SLUDGE

It was obtained from wastewater treatment plant of having specific gravity 1.4.

3. METHODOLOGY

The concrete was developed by replacing the fine aggregate with 5%, 10%, 15% and 20% of sludge, using M20 grade as per IS 10262:2009. Grade of cement used is OPC 43 grade. Water cement ratio taken is 0.5. The concrete batch was hand mixed water tight, non-absorbent platform with shovel, scoop and other required necessary equipment. Then the mixed concrete was placed

into the steel molds. Molds should be properly filled and compacted with the help of vibrators so the all the edges and corner of the molds get filled uniformly.

4. MIX DESIGN

The mix design was done as per IS 10262:2009 for M20 grade of OPC 43 grade cement of water cement ratio 0.5. The values are shown below;

Grade of desigination	M20
Type of cement	OPC 43 grade
Maximun nominal size of aggregate	12.5-20mm
Maximum cement content	250kg/m^3
Maximum water cement ratio	0.5
Workability	50-75mm
Exposure condition	Moderate
Degree of supervision	Good
Type of aggregate	Crushed angular
Maximum fine aggregate content	656kg/m^3
Maximum coarse aggregate content	1315kg/m^3
Chemical admixtures	Not used

Table 1: Mix Design

4.1 CURING

After the proper mixing, and placing into the molds, the molds were kept for proper drying for 24 hours. After that the mold should be demold and kept in water for 7, 14 and 28 days for curing purpose to obtain desire strength and durability.

5. TESTS AND RESULTS

5.1 Compressive strength Test

Figure1: Compression testing Machine

Compression test is the resistance of material against loading. Compression testing machine is operated at the loading rate of 2.5KN/s. Cube sample of size 100x100x100mm are used .

Compressive strength = F/A

Where, F= Load applied [N]

A=Area [mm^2]

COMPRESSIVE STRENGTH of 5% SLUDGE (N/mm^2)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	26.4	30.2	34.8

Table 2: Compressive strength of 5% of sludge

COMPRESSIVE STRENGTH of 10% SLUDGE (N/mm^2)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	28.2	31.5	35.6

Table 3: Compressive strength of 10% of sludge

COMPRESSIVE STRENGTH of 15% SLUDGE (N/mm^2)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	27.1	33.2	34.7

Table 4: Compressive strength of 15% of sludge

COMPRESSIVE STRENGTH of 20% SLUDGE (N/mm^2)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	24.9	34.6	36.8

Table 5: Compressive strength of 20% of sludge

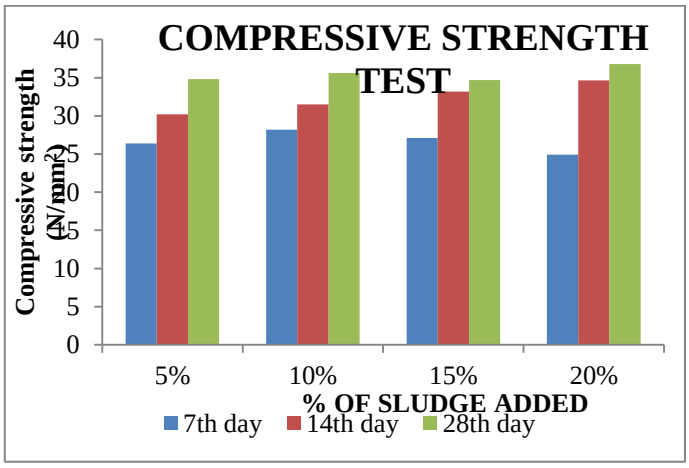

Chart 1: Compressive strength of concrete in which sludge is partially replaced in fine aggregate

5.2 SPLIT-TENSILE STRENGTH

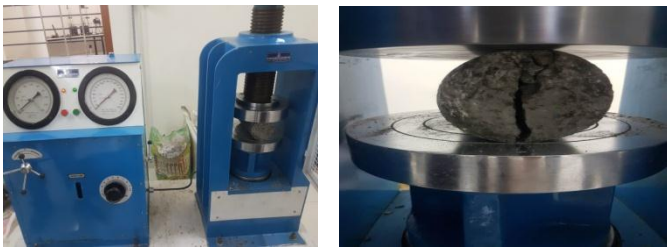

Figure 2: Split Tensile testing Machine

Tensile test is defined as the resistance of material under tension. The concrete cylinder is very weak in tension due to its brittle in nature and do not resist much tensile loading. The concrete is subjected to failure under tensile loading. The strength of the cylindrical molds is tested in compression testing machine (CTM) until its break down and reading should be noted down during failure. Cylinder sample of size150x150x300mm are used.

As per IS456, split tensile strength of concrete =0.7Fck.

Split tensile strength =2P/pi DL

P= applied load

D= diameter of the specimen

L= length of the specimen

Therefore, P= Tsp x pi DL/2

Expected load = p x f.s

Therefore, split tensile strength is T = 2P/pi DL

SPLIT TENSILE STRENGTH of 5% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	1.35	2.36	3.39

Table 6: Split Tensile strength of 5% of sludge

SPLIT TENSILE STRENGTH of 10% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	1.2	2.12	3.3

Table 7: Split Tensile strength of 10% of sludge

SPLIT TENSILE STRENGTH of 15% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	1.3	2.1	3.2

Table 8: Split Tensile strength of 15% of sludge

SPLIT TENSILE STRENGTH of 20% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	1.4	2.41	3.4

Table 9: Split Tensile strength of 20% of sludge

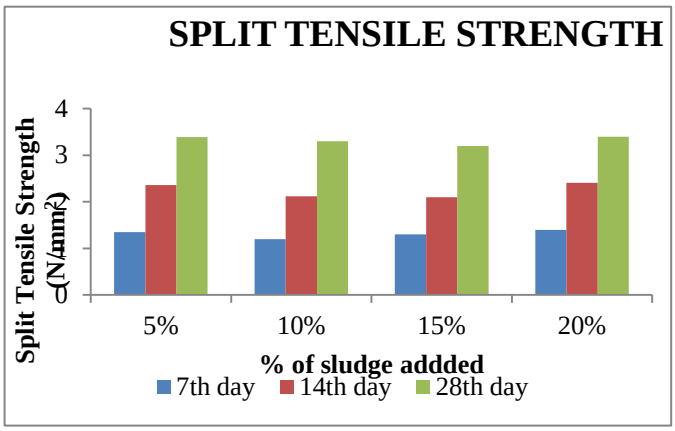

Chart 2: Split Tensile strength of concrete in which sludge is partially replaced in fine aggregate

5.3 FLEXURAL STRENGTH

Figure 3: Flexural testing Machine

Flexural strength is one of the part or measures of the tensile strength. It is a measure of an unreinforced concrete of beam or slab to resist the failure of bending and expressed as modulus of rupture which denotes as MPa or psi. Beam of size of the specimen is 100x100x5000mm is used. Test of flexural strength is conducted immediately after the curing is done.

Formula:

MR = $3PL/2bd^2$ (1/3 break) and PL/bd^2 (Half break)

1. MR= modulus of rupture in MPa or psi.

P= ultimate applied load indicated by testing machine

L= span length

b= average width of the specimen at the fracture

d= average depth of the specimen at the fracture

FLEXURAL STRENGTH of 5% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	4.1	4.65	5.0

Table 10: Flexural strength of 5% of sludge

FLEXURAL STRENGTH of 10% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	4.22	4.64	5.22

Table 11: Flexural strength of 10% of sludge

FLEXURAL STRENGTH of 15% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	4.34	4.63	5.30

Table 12: Flexural strength of 15% of sludge

FLEXURAL STRENGTH of 20% SLUDGE (N/mm²)			
Sl. NO	**7 Days**	**14 Days**	**28 Days**
1	4.40	4.85	5.42

Table 13: Flexural strength of 20% of sludge

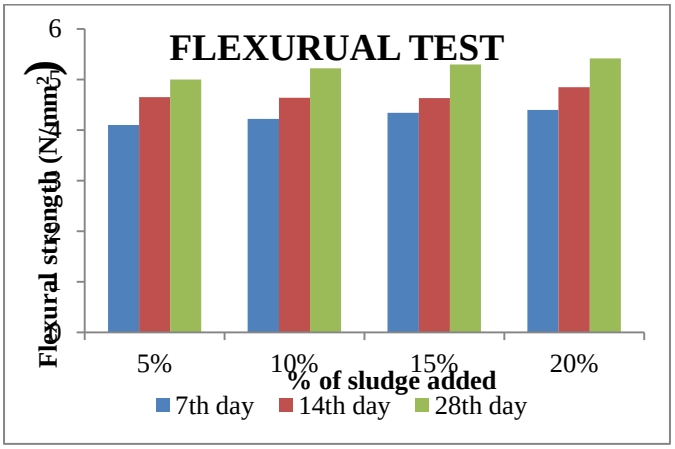

Chart 3: Flexural strength of concrete in which sludge is partially replaced in fine aggregate

6. CONCLUSION

- The result after the replacement of fine aggregate using sludge in concrete with 5%, 10%, 15% and 20% shows the increase in compressive strength, split tensile strength and flexural strength.
- The replacement of fine aggregate using sludge above 20% results that there is decrease in the compressive strength, split tensile strength and flexural strength.
- It process helps in reducing the pollution from the environment.

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