Experimental Study on Sludge from Common Effluent Treatment Plant as a Partial Replacement of Fine Aggregate in Concrete

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Abstract— Concrete plays a vital role in the development of infrastructure which leading to utilization of large quantity of waste materials and natural resources .There is an urgent need for the identification of new type of concrete materials for construction. With the increase in the industrial activities, the amount of waste generated will increase manifold. Sludge from waste treatment has been collected form the Common Effluent Treatment Plant (CETP), Tirupur and studied its chemical, physical, Biological properties and Engineering properties as well. The chemical sludge was then mixed as a partial replacement with M-sand at an percentage of 30%, 40% and 50% .The proportions are decided based after the preliminary tests conducted on the sludge. The optimum percentage is used for the final proportion mix with required strength. With the optimum proportion the compressive strength can be achieved as same as the strength of normal concrete at the end of 28 days.

Keywords— CETP Sludge,Partial replacement fine aggregates, Construction material,Utilisation of waste materials,

1. INTRODUCTION

The Common Effluent Treatment Plant is well known for treating the waste water from the industries and households. The Tamilnadu state pollution control board (TNPCB), holds the record that there are 850 units engaged in textile industry processes. These units have established 5 common effluent treatment plants . The liquid effluents are treated with addition of lime , magnesium, and iron. During the process as result of chemical coagulation, flocculation, and solid/liquid separation the sludge was generated.

In the Common Effluent Treatment Plant sludges are disposed by so many ways, without being utilized. The waste from the plants turning the surrounding unaesthetic. It is socially responsible to turn the waste as a useful resource.

Clearing the waste sludges is a major work for the plants that might lack the continuous process of treating the waste water.The sludges other than chemical sludges contains so many pollutants that are hard to use as a construction material, which could be further treated for the proper use.

The sludges are also a source of Environment pollution,the pollutants over a period of time forms fine dust after the evaporation of water creating air pollution and reduces the visibility.The components of the sludges are bio hazards in nature having potential to endanger health of workers dealing with the waste, civilians and any living organism.It forms silt deposition when dumped on lands and water bodies which affects its actual ecosystem.The presence of high calcium indicates the potential use of partial replacement of the sludge.About 200 tonnes/day of textile sludge are generated in the place and disposed in an engineered landfill.The Common Effluent Treatment Plant has three types of sludges they are as follows,

Chemical sludge
Biological sludge
Salt sludge

After various experiments on the properties of the sludges chemical sludge has the similar properties of the fine aggregates. Initially the sludge was mixed in three different proportions and the optimum could be found out and used. It is been used varingly in concrete at different proportions in the mix of M40.Materials used are given below

Cement- OPC 53 grade
M-sand
Coarse aggregate 20 mm
Chemical sludge as a partial replacement
Water
Super plasticizer-Cornplast 530.

Ordinary Portland cement (53-grade) confirming to BIS,IS: 12269 was used. The M-sand passing through 2.36 mm sieve was used about 60% and the sludge was used about 40%.

All building materials were manufactured according to Bureau of Indian Standards (BIS).

The M40 mix proportion is adopted and designed with water cement ratio as 0.38. This concrete is placedinthenominalconcrete cube steel mould of size 150 x

150 x 150 mm size. In the same way it is placed in cylindricaland prism moulds. The materials used in the concrete and their proportions are given in the Table 1

TABLE 1
Mix proportion sludge in concrete – M40

Sl.no	Material	Quantity
1	Cement	391.57 kg/m³
2	Fine aggregate (M-sand)	529.53 kg/m³
3	Fine aggregate (Sludge)	353.05 kg/m³
4	Coarse aggregate 20mm	1130 kg/m³
5	Chemical admixture	708 kg/m³
6	Water	148.8 l/m³

2.PROPERTIES

2.1 Chemical Properties

The chemical sludge is mainly composed of Calcium with small amount of Zinc, Hydrochloric acid. Its chemical composition is controlled by adding Lime Soda and Magnesium during the sedimentation process. Table 2 shows the quantity of chemicals in the sludge.

TABLE 2

Characterization of Sludge from CETP

Sl.no	Chemicals	Quantity
1	Calcium	108.22 mg/l
2	Zinc	91.60 mg/l
3	Magnesium	92.5 mg/l
4	Cadmium	3.96 mg/l
5	Copper	57.48 mg/l
6	Chromium	2.98 mg/l
7	Lead	12.1 mg/l
8	Total volatile solids	31.85%

2.2Physical Properties

The particles of coal bottom ash are irregular, porous and rough porous texture. The particle size ranges from fine gravel to fine sand. Sludge is lighter and more brittle when compared to M-sand. Sludge is obtained at semi solid state and converted to solid state by evaporating water in it for that it has to kept in sunlight for one day or in oven at temperature 115°c. The specific gravity of sludge varies from 2.78 to 2.80 depends upon the acid used during the treatment process. Table 3 shows the specific gravity of different sludges from various water treatment plants and industrial treatmentplants. Sludge is usually a well graded material and provides proper particle size distribution.

The specific gravity of the sludge can be found out by the same way what we do for M-sand, Pycnometer method and water absorption test.

TABLE 3

Specific gravity of sludge from various treatment plants

Sl.no	Material	Specific Gravity
1	Chemical sludge	2.78
2	Fine aggregate (M-sand)	2.80

Water absorption test is done , 100g of sludge was taken (W1) and it was kept in water for one day then weighted as 109.4g (W2). Weight of water absorbed is calculated by W2-W1. The percentage of water absorption was 9.4% where less than 10% is acceptable.

3. METHODOLOGY

3.1 Casting of cubes

Concrete cubes were made using sludge as a partial replacement of fine aggregates with various percentages(30%, 40%, 50%)

Fig.3.1. Casting of concrete cubes(M40)

3.1.1 Curing of Concrete Cubes and Beams

After casting all the test specimens were kept at room temperature for curing. The specimens were de-moulded after 24 hours, and then keep into the water for curing for 28 days.

3.2 Properties of Sludge concrete

3.2.1 Workability

Water demand is necessary to achieve desired workability that depends on the number of fines and their properties in it. Sludge particles are dense and its surface becomes smooth during weathering effects.

3.2.2 Bleeding

The water loss through bleeding in concrete is mainly depends on water cement ratio. Since the sludge was obtained in a semi solid state it having high capacity to absorb water than M-sand which may results in bleeding. Thus, super plasticizer was added to maintain the water content in concrete, its percentage was taken with respect to IS 10262: 2009.

3.2.3 Setting time

The initial setting time of concrete is the moment at which the mix shows certain level of stiffness in it. The addition of sludge as a partial replacement of fine aggregate increases the setting time. The water absorption capacity of sludge delays the initial and final setting time

3.2.4 Plastic shrinkage

Usually the volumetric contractions or plastic shrinkage of the concrete is mainly caused by the loss of water by evaporation. If the evaporation is greater than the plastic shrinkage too increases. The sludge provides greater dimensional stability than the M-sand. The denser particles of acts as a reservoir in the concrete mix. With respect to the time of passage the water absorbed by the sludge particles are send to concrete, thus helps in reducing plastic shrinkage in concrete.

4. TESTS ON FRESH CONCRETE

4.1 Slump cone test results.

TABLE 4.1
Workability of the mixtures

sludge	Sludge 30%	Sludge 40%	Sludge 50%
Chemical sludge	40	45	90
Biological sludge	80	108	145
Salt sludge	87	112	157

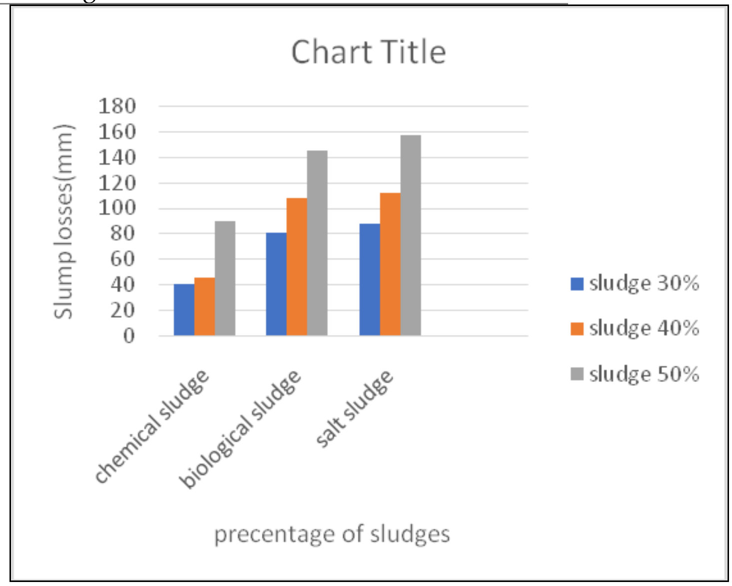


Fig.2. slump losses of different sludge mixes.

4.2 Compaction factor test

TABLE 4.2

Compaction Factor Tests (40% sludge)

Sludge concrete mix	Partially compacted (kg)	Fully compacted	Compaction factor
Chemical sludge			
30%	11.46	15.67	0.731
40%	11.48	15.89	0.722
50%	11.43	12.45	0.918

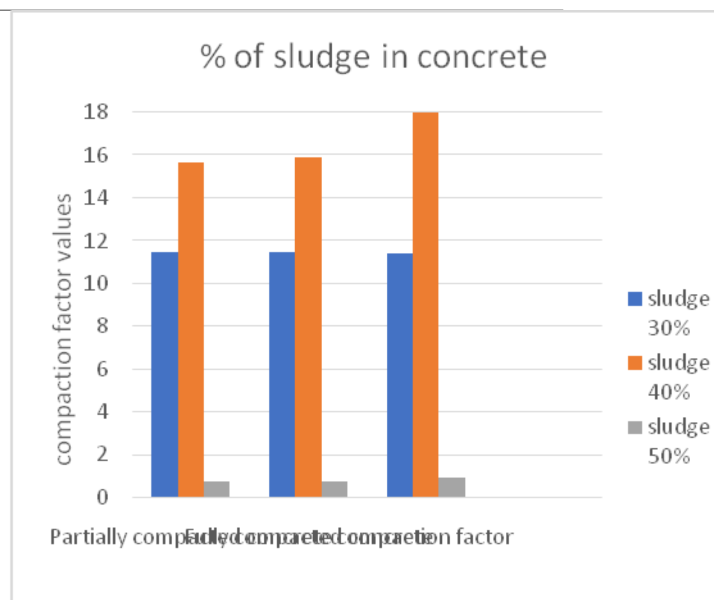


Fig.3. Compaction factor for concrete

4.3Flow table test

TABLE 4.3

Characterization of sludge concrete in Flow table

Sludge	Sludge 30%	Sludge 40%	Sludge 50%
Chemical sludge	28	32	18
Biological sludge	19	19	20
Salt sludge	17	18	18

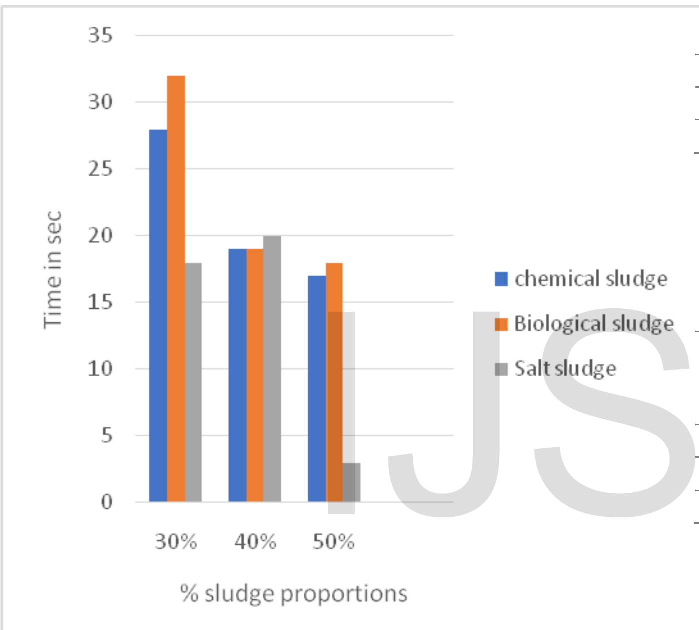


Fig.4 Flow table test

5. Tests on Hardened concrete

5.1 compressive strength tests

The strength development of any concrete is influenced by porosity which is influenced by water/cement ratio and the presence of bond cracks at the interface of aggregates. This concrete provides the same amount of strength which normal concrete produce neither increase nor decrease but it is cost efficient. The partial replacement of fine aggregate by sludge causes internal microstructure college which results in slight loss in compressive strength. Different sludges at different proportions are taken and the mean value is used for the final proportion. The casted cubes are to be tested for 3, 7, 28 days strength test.

TABLE 5.1 (a)

Compressive strength of chemical sludge concrete

proportions	3days Strength (N/mm²)	7 days Strength (N/mm²)	28 days Strength (N/mm²)
30%	16	25	33
40%	19	33	39
50%	14	20	26

TABLE 5.1 (b)

Compressive strength of biological sludge concrete

proportions	3days Strength (N/mm²)	7 days Strength (N/mm²)	28 days Strength (N/mm²)
30%	11	16	28
40%	12	15	20
50%	10	14	18

TABLE 5.3(c)

Compressive Strength of Salt sludge concrete

proportions	3days Strength (N/mm²)	7 days Strength (N/mm²)	28 days Strength (N/mm²)
30%	8	10	13
40%	10	18	18
50%	8	10	11

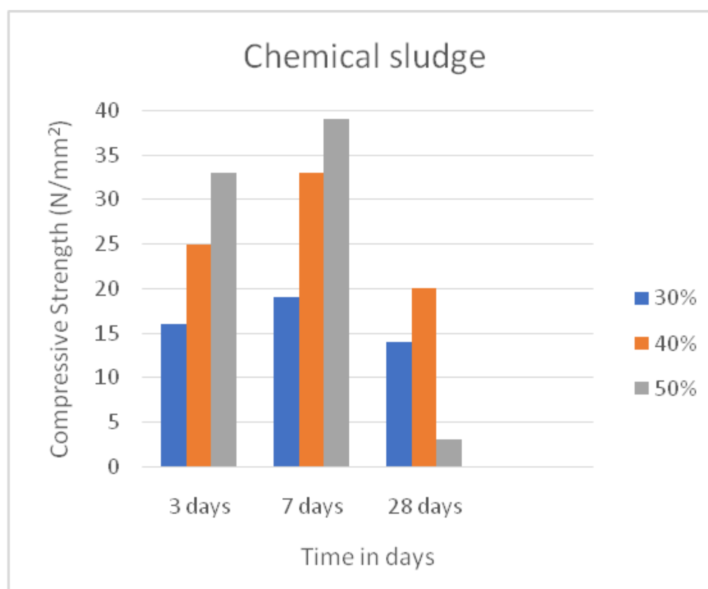


Fig. 5 chemical sludge concrete strength

5.2 Flexural strength of chemical sludge beams

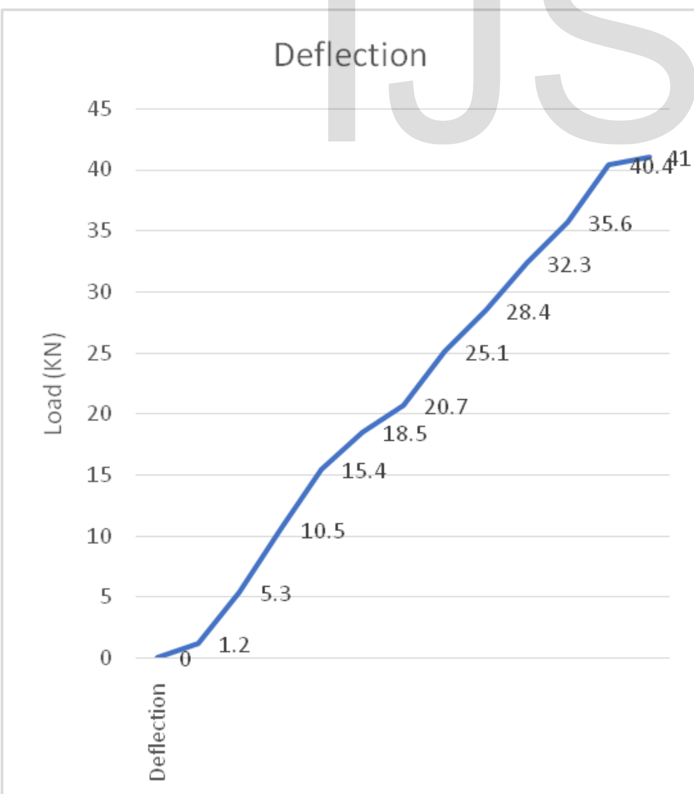
TABLE 6

Flexural strength of chemical sludge beam

Sl.no	Load (KN)	Deflection at mid span (mm)	Observation
1	0	0	-
2	1.2	0.1	-
3	5.3	0.51	-
4	10.5	1.53	-
5	15.4	2.36	-
6	18.5	2.73	Initial crack
7	20.7	3.38	-
8	25.1	4.74	-
9	28.4	5.27	-
10	32.3	5.95	-
11	35.6	6.78	-
12	40.4	7.30	Ultimate load
13	41	8.11	-

5.2.1. Load deflection behaviour of beam

The first crack occurred in the sludge concrete at the load of 18.5 kN. The ultimate strength of beam was 40.4 KN. The deflection was experienced at 7.3 mm.



6. Conclusion

The present study investigated the physical, chemical and engineering properties of sludge as a partial replacement of fine aggregate in concrete. The specific gravity, water absorption, compressive strength, flexural strength were found. The sludge was experimented with amount of 30%, 40%, 50% and the optimum of 40% was used in concrete .

Based on the results of the tests conducted on sludge at different proportions the following conclusions have been made:

The initial and final setting time of the concrete has increased due to high water absorbing capacity of the sludge.

The chemical sludge particles from the common effluent treatment plant provides great particle size distribution and less plastic shrinkage.

The concrete with 40% of sludge exhibits good workability as compared to normal concrete. With 50% of sludge it fails in all aspects.

This concrete produces the compressive strength of $39 N/mm^2$ and the flexural strength of 40.4 KN which is similar to the strengths of nominal M40 grade of mix.

From the results obtained it is suggested sludge can be partially replaced for fine aggregate in concrete upto 40% which does not affects the standards of the concrete.

7. References.

Anon., 2002. Effective utilisation of wastes. Civil Engineering and Construction review 15(2), 22.

Palanivelu, K., Rajkumar, R., 2002. Characterization and leachability studies on Textile effluent treatment plant. Environmental Pollution Control Journal 5 (1), 38-40.

Sharma, K.M., Lakshmi.S., 2002. Utilization of building materials from industrial wastes. Civil Engineering and Construction Review 15(2), 46-50.

R.Srinivas Prabhu, Dr.R.Anuradha, Experimental Research on Triple Blended Self Compacting Geo Polymer Concrete, Asian Journal of Engineering and Applied Technology, ISSN: 2249-068X. Vol. 5 No. 2, 2016, 15-21.

AldeinSuil, Kuantan., The use of sewage sludge ash(SSA) as a partial replacement of cement.

K Chandrasekaran, ISSN:2278-0181 Vol.4., 2015, Management of waste water from hosiery knitwear dyeing.

Naik, M.A., 2001. Effluent treatment for textile industry. Environmental Pollution Control Journal 4 (6), 56.

Shetty, M.S. Concrete Technology, Theory and Practice, S. Chand & Company, New Delhi,2013.

Neville, A.M. Properties of concrete, Fifth Edition, Pearson Education Limited, England 2011.

Kumar Mehta Paulo, P and Monterio, J.M. Concrete Microstructure, Properties and Materials. McGrew-Hill Education, 2006.

Ravishankar. K and Krishnamoorthy T.S. Structural Health Monitoring, Repair and Rehabilitation of concrete Structures, Allied Publishers, 2004.

R.Srinivas Prabhu, Dr.R.Anuradha, Durability Studies on Concrete by using Plastic waste, International Journal of ChemTech Research, ISSN: 0974-4290 Vol.10 No.8, 634-644.

Gambhir. M.L. Concrete Technology, Tata McGraw Hill,2013.

Gunasekaran. K, Annadurai. R and Sudarsan. J.S. Concrete Technology. AR Publications, Chennai, June 2015.

IS 456: 2000, Indian Standard Specification for plain and reinforced concrete.

IS 516: 1959, Indian Standard Specification for method of test for strength of concrete.

IS 1489 (Part I):1991, Indian Standard Specification for Portland Pozzolana Cement Part I Fly ash based, 2000.

IS 4926: 1976, Indian Standard Specification for ready mixed concrete, 1999.

Bureau of Indian Standard, 2000. Code Practice for plain Cement Concrete , New Delhi.