Effect of WTP Sludge on Properties of Concrete By Partial Replacement of Fine Aggregates

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ABSTRACT: To evaluate the effect of dry sludge on concrete performance, its mechanical properties were studied. The rapid increase in construction activities leads to scarcity of conventional construction materials such as cement, fine aggregate and coarse aggregate. Researches are being conducted for finding cheaper materials. In India, there are many water treatment plant WTP sludge which leads in problems of disposal. The final destination of water treatment treatment plant sludge affects the environment. In this research an attempt is taken by partial replacement of fine aggregate into WTP sludge in various proportions so that the final product property of concrete mixture is same as the conventional mix.Water treatment plant sludge material was replaced with fine aggregates in various percentages such as 0%,5%, 10% & 15%.

Keyword : - *WTP sludge, coarse aggregates, compressive strength, flexural strength, split tensile strength.*

I INTRODUCTION

Concrete is material composed of aggregates bonded together with fluid cement which hardens over time. It is the world's most widely used building material having properties such as fire resistance, durability, strength, maintenance free, easy installation, low installation cost, high compressive strength, custom design flexibility etc. Sludge a hazardous waste produced from purifying water has been identified as a potential alternative ingredient in making concrete. Using sludge in concrete could have an impact on cost, as well as protect the environment from its detrimental effects. The increasing population of India has increased the demand for potable water. This sludge can be used in the concrete by controlling the chemical proportionality of the sludge. Considering the field of construction is one of the biggest consumers of base materials, the recycling of sludge for the concrete could decrease the environmental problems of sludge disposal significantly, while also replacing the necessity for base materials in the process.The concrete industry uses a considerable amount of natural resources to produce cement and concrete. The drawbacks of conventional concrete may also include its high self weight which makes it to some extent an uneconomical structural material. Water treatment sludge is replace with fine aggregate in various percentages such as 0%, 5%, 10% & 15.

II LITERATURE REVIEW

M. Silva and T. R. Nark (2010) Studied on sustainable use of resources, such as use of reclaimed water, especially partially processed Water treatment plant water in concrete. A initial laboratory investigation was conduct samples were collected from the Milwauke Metropolitans various District and analyzed the Characteristics of wastewater.

Prof V. P. Bhargava(2016) Several experiments using alum sludge in brick making had been reported in many countries. Patricia et al.conducted ceramic brick manufacturing from drinking water treatment plants. They carried out experiments to get a sand replacement by 10% of sludge and this percentage is considered appropriate for ceramic brick. It indicated an interesting potential for reuse alum sludge as construction material.

R.A. More and S.K. Dubey (2014) Studied on effect of different types of water on compressive strength of concrete. They made concrete cube with mineral water, WTP water, well water and waste water increased with days & not having much variation in their compressive strength. The concrete mix of M20 grade with water cement ratio of 0.5 was investigated.

III OBJECTIVES OF INVESTIGATION

1 To study strength properties of concrete by replacement of fine aggregate with WTP sludge.

2 To study NDT tests by replacing partially fine aggregates with WTP sludge.

3 To study acid attack on concrete by replacing partially fine aggregates with WTP sludge.

IV MATERIAL.

A.Cement Test Result

Table No. 1: Test value of cement

Cement	Bulk density	1400 kg/m^3
	Specific Gravity	3.15
	Initial Setting Time	120
	Final Setting Time	170
	Le-Chatelier Soundness test	1%
	Fineness of Cement	0.70

B. Aggregate Test Result:

Table No. 2: Test value of Aggregate

Properties	Coarse. Aggregate	Coarse. Aggregate	Fine Aggregate	WTP Sludge
Type	Crushed Angular	Crushed Angular	Natural Sand	--
Max Size	20mm	10	4.75	4.75
Fineness Modulus	2.55	2.51	2.77	2.20
Sp.Gravity	2.70	2.65	2.63	1.08
Water Absorption	1.35%	1.2%	0.7%	0.72%
Impact Value	12.73%	13.16%	--	--
Crushing Value	25%	28.8%	--	--

V. METHODOLOGY

A. SLUDGE

Sludge was collected from Vaijapur for mixing and curing as per IS 456:2000.

The Sludge were dried in Oven at 100 degree C for 3 hours and then used as replacement with fine aggregate

B. FINE AGGREGATE:

Locally available natural river sand is used confirming to IS 383-1970. Properties of aggregate are as shown in table no 2.

C. COARSE AGGREGATE

The aggregate of size 20mm were used confirming to IS 383-1970.Properties of aggregate are as shown in table no 2

Table No. 3: Summary of Concrete Mix Design

Material used for Concrete	
Grade Designation	M 30
Type of Cement	OPC 53
Maximum Size of aggregates	20 mm
Cement content	400.00 Kg/m^2
Maximum Water Cement Ratio	0.45
Exposure Condition	Severe
Method of Concrete Placing	Manual
Degree of Supervision	Good
Type of Aggregate	Crushed Angular

A. Concrete Mix Design

Mix design is a process of selecting suitable ingredients for concrete mixes and to determining their proportions which would finding out , as economically as possible, a concrete that satisfies the requirements. The proportion of the ingredients of concrete is an important phase of concrete technology as it ensures quality and economy of construction work.

In pursuit of the goal of obtaining concrete with desired performance characteristics, the selection of component materials is the first step, the next step is a process called mix design by which one arrives at the right combination of the ingredients. There are many methods of designing concrete mixes. In this research concrete mix design was done for both group of concrete separately.

B.Mix Design For Grade M 30:

Design Steps

Step 1:Target Mean Strength For the degree of quality control specified namely "Good" the value of standard deviation is, σ = 4.0 N/mm2 (I.S: 10262-2009). Hence the targeted mean strength for the desired compressive strength *f*ck =*f*ck + *1.65* x *s s - IS 10262 Table1* = 30 + (1.65 x 5.0) *f*ck = 38.25 N/mm2.

Step2: Selection of Water Cement Ratio from Table 5 of IS 456 – 2000 Maximum water-cement ratio is 0.5.

Step 3: Selection of Water content Size of maximum aggregate =20 mm Maximum volume of water = 197 liters considering (trial): 180 liters

Step4: Selection of Cement content Water cement ratio: 0.5 Cement content = 180/0.4 = 400.00 kg/m3, 400.00 kg/m3> 320 kg/m3 minimum cement content for mild exposure. Therefore OK

Step5:Proportion of the Volume of fine Aggregate and coarse Aggregate Content From Table no 3 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate for water cement ratio of 0.45 =0.60 As per our experience we considered water cement ratio as 0.45 and for that we made no change in value and no effect of pump able concrete to be provided. Therefore volume of coarse aggregate required = 0.60 Volume of fine aggregate: 1 – 0.60 = 0.40

Step6: Mix Calculations

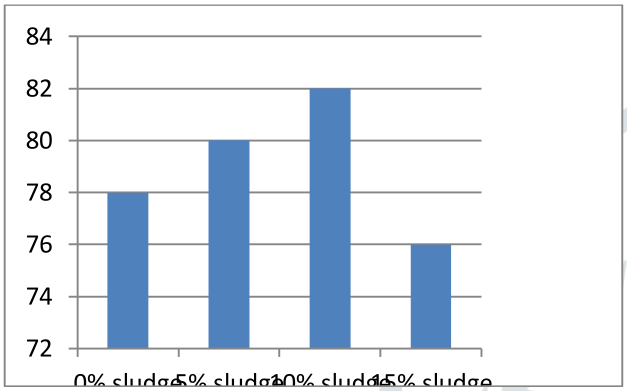
VI. RESULTS

A.Slump Cone Test-

Slump Cone test was conducted for investigation of workability of fresh concrete. Fine aggregate replaced with 0%, 5%, 10% ,15%.

Table No-4 Slump Cone Test

Mix design	Slump values in mm
0% sludge	78
5% sludge	80
10% sludge	82
15% sludge	76



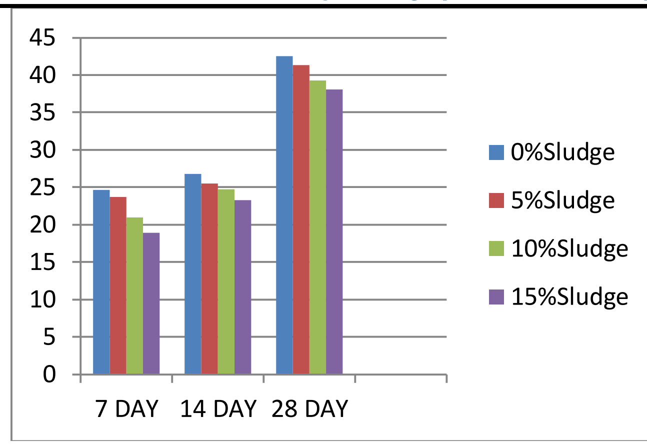
Graph No1- Slump Cone Test

B.Compressive Strength:

A cube compression test was performed on standard cubes of GPC of size 150mm x 150mm x 150 mm after 7 days, 14 days and 28 days after ambient curing.

Table No.5: Compressive Strength of Concrete

Sr No	1	2	3	4
% OF Sludge	0%Sludge Avg Mpa	5%Sludge Avg Mpa	10%Sludge Avg Mpa	15%Sludge Avg Mpa
7 DAYS	24.6	23.7	21	18.9
14DAYS	26.8	25.5	24.7	23.3
28DAYS	42.50	41.30	39.30	38.10



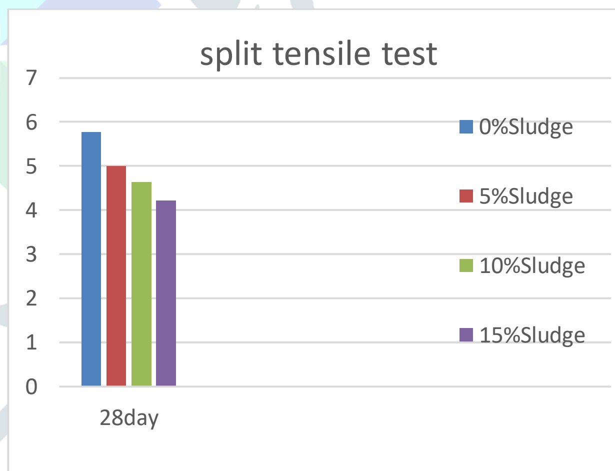
Graph no2- Compressive Strength Of Concrete

C.Split Tensile Test.

The split tensile test conducted on cylinders of 150mm dia.x300mm height. Split tensile strength of cylinder specimens is determined by placing between the two plates of Compression Testing Machine.

Table No. 6: Split Tensile Test Of Concrete

Sr No	28day Avg(Mpa)
0%Sludge	5.76
5%Sludge	5.00
10%Sludge	4.63
15%Sludge	4.21



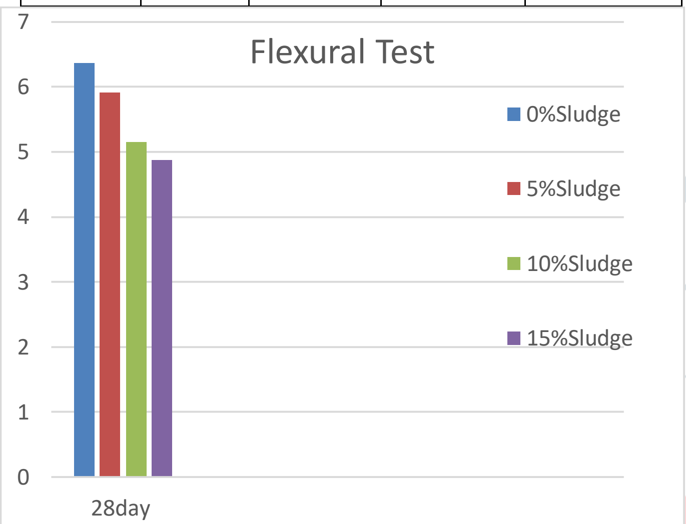
Graph no3- Split Tensile Test Of Concrete

D.Flexural Test

In flexural test, the Standard beam specimen of size 100mm x 100mm x 500mmwere supported symmetrically over a span of 400mm in the machine in such a manner at the load is applied uppermost surface as cast in the mould.

Table No.7: Flexural Test Results

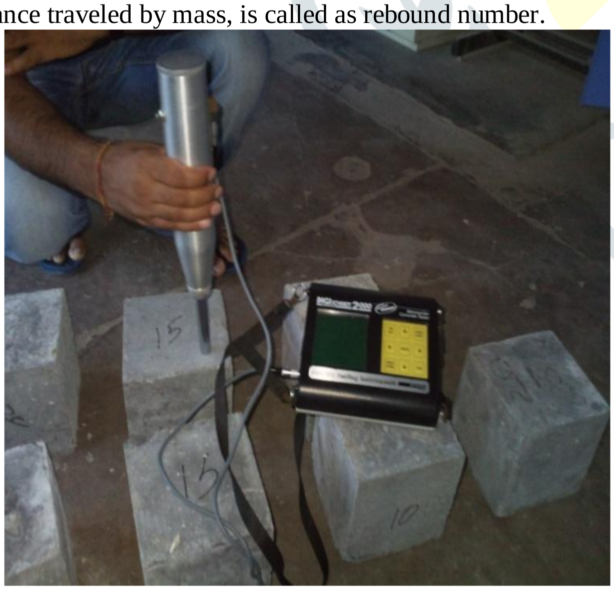
Sr No	Flexural Strength (at 28 days in MPa)			
	0% Sludge	5% Sludge	10% Sludge	15% Sludge
1	11.65	10.95	9.75	8.4
2	11.8	11.00	9.8	8.25
3	12.20	10.95	9.85	8.45
Avg value (MPA)	11.80	10.96	9.80	8.36



Graph No. 4- Split Tensile Test Of Concrete

E .Rebound Hammer Test (IS: 13311 (Part 2) – 1992).

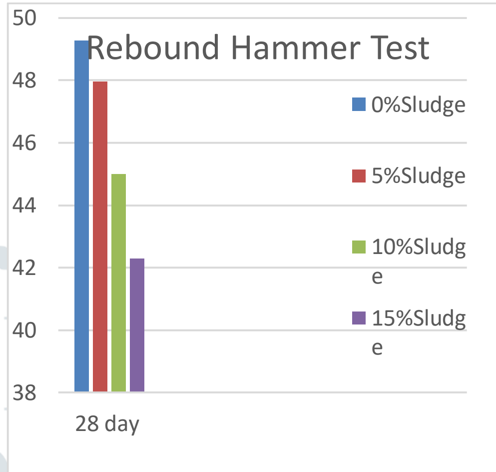
Rebound hammer test is used to be finding the compressive strength of concrete members. It is consists of every rebound spring control hammer that slides on a plunger within the tubular housing. After impact the hammer rebounds. The distance traveled by mass, is called as rebound number.



Rebound Hammer Test

Table No. 8: Rebound Hammer Test

% of sludge replacing	Compressive strength (at 28 days in MPa)			AVG
0%Sludge	49.4	49.5	48.9	49.26
5%Sludge	47.9	47.85	48.1	47.95
10%Sludge	45	44.9	45.2	45
15%Sludge	42.6	42.4	41.9	42.3



Graph no5- Rebound Hammer Test

F . Ultrasonic Pulse Velocity Method: - IS 13311-1 (1992):

A pulse of the longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test.

v = L/T

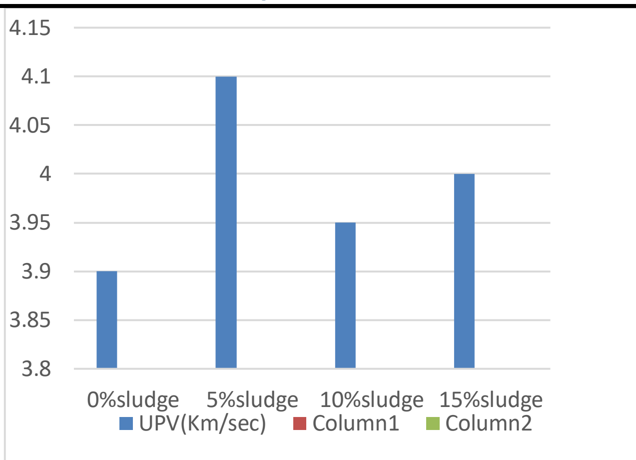
v = Longitudinal pulse velocity, Km/sec.

L = Path length, Km

T = Time taken by the pulse to traverse that length, Sec

Table No.9: Ultrasonic Pulse Velocity Method

% of Replacing	Time in Microsecond	Avg.Time In Microsecond	UPV (Km/Sec)	Remark
0% Sludge	38	38.5	3.9	As per IS 13311-1992 Part I,
	38.5			
	39			
5% Sludge	38	37	4.1	
	36			
	37			
10% Sludge	37	37.8	3.95	
	37.5			
	38			
15% Sludge	38	37.1	4	
	36.2			
	37.1			



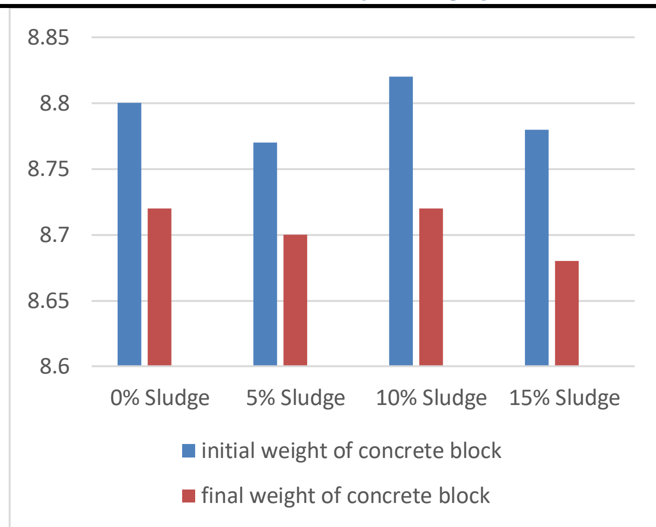
Graph No. 6. Ultrasonic Pulse Velocity Method

G.Acid Attack Test –

Concrete is susceptible to acid attack because of its alkaline in nature. The components of the Concrete break down during contact with acid. The specimens were subjected to acid attack test in order to ensure its durability. If the concrete is exposed to adverse effects of chemically in its life time

Table No.10: Acid Attack Test

Sr. No.	Speci-men & % Of Repla-cement	Initial weight of concrete block before the immersing in acid in kg	final weight of concrete block after the removing in acid in Kg	% of loss in weight
1	0% Sludge	8.800	8.720	0.909
2	5% Sludge	8.770	8.700	0.79
3	10% Sludge	8.820	8.720	0.909
4	15% Sludge	8.780	8.680	1.13



Graph No. 7. Acid Attack Test

VII.CONCLUSION

This chapter presents the conclusions drawn from the detailed experimental investigations carried out on tests of concrete specimens.

The experimental study conducted on partially replacement of sludge waste as a fine aggregate in concrete. The following conclusions can be drawn:

1. Strength of 5 % replaced sludge concrete is increased compared with 10, 15 % of concrete. The compressive strength of concrete is showing better results up to 10 % sludge replacement with fine aggregate.
2. With partially replacement of sludge waste workability of concrete is also good.
3. According to results it is not suitable for structural element so used for the paving blocks and for footpath as a non-structural element.
4. Application of Dry Sludge replace as Fine Aggregate in Concrete With 5%, 10% & 15%. Producing concrete specimen at w/c ratio of 0.45, with 30% of dry sludge was impossible due to very low workability.
5. Compressive strength of concretes containing dry sludge (w/c ratio of 0.55)Compressive strength of concretes containing dry sludge (w/c ratio of 0.45) It was observed that the dry sludge of waste water treatment plant in Vaijapur city has a satisfying the dry sludge due to low pozzolanic activity, acts as filler or fine aggregate in concrete.
6. Utilization of 10% of dry sludge in concrete caused 8% decrease in compressive strength which was much lower than the decrease amounts reported in previous researches (about 42%). On the basis of results, it is proposed to use concretes containing more than 10% of dry sludge as non-constructional concretes such as paving and flooring concretes.

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