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REUSE OF WATER TREATMENT PLANT SLUDGE IN MODIFICATION OF BRICK

Davinder Kaur[1], Er.Vikram[2]
[1]M.Tech Scholar, JCDMCOE Sirsa, Haryana, India,
[2]Assistant professor, Civil Engineering department, JCDMCOE, Sirsa, Haryana, India

Abstract: A rapid increase in the number of mineral water plants is an indicator of increased public awareness on importance of consuming safe drinking water. Increased environmental awareness among people exerts high pressure on water production industry for safe disposal of residues generated in water treatment plants. The sludge disposed during the various water treatment processes can be a major concern for water treatment plants. Most of the water treatment plants discharges the sludge in to the rivers or as land fill with no treatment. The disposal problems can be drastically reduced if sludge can be recycled into building and construction materials. This paper shows the use of sludge as new and non-conventional construction materials as an alternative way of sludge disposal. Sludge percentage is varied from 0 to 20 percentages by weight and firing on different temperature like 850, 900, 950 and 1000°C. Parameters such as hardness, structure, shape and size, soundness, weight, bulk density, compressive strength and water absorption are studied as per BIS (Bureau of Indian Standards) procedure.

Keyword: Water treatment plant sludge, clay, compressive strength test, water absorption test, hardness, shape and size test, structure test, effloresce test, weight test etc.

I. INTRODUCTION

The brick is one of the common oldest building materials and widely use in present days. The materials conventionally used in manufacturing of brick are clay soil but for more advantage and improve the manufacturing of brick, the conventional materials are modified with some other additive materials. In India, water is purified in water and waste treatment plant. Thus in India, this generate waste sludge disposal to the nearest watercourse, which is a common produce done by all. Other method which is used in India for disposal of the sludge is landfill. Thus the reuse of sludge is most important. The waste sludge can be used in brick making. To make brick project economically as well as technically more strong, I have utilized waste sludge as modifier in current investigation. This reduces the clay soil content in brick which reduces the more demand of clay and also reduce the cost of manufacturing of brick and also improve its properties and reduce the cost and demand of clay.

II. LITERATURE REVIEW

Puspanathan Krishnan et al (2017) has studied on the water treatment Residue (WTR) disposal is a major issue in Malaysia. For this analysis, the following test were conducted on the WTR bricks likewise compressive strength, bulk density, water absorption, efflorescence effects and weight reduction, toxicity and economic analysis. The conclusion for this research indicates 40 % WTR with 60 % clay combinations is best suited as compared to their locally available manufactured bricks.

Vineet Garg et al (2017) has studied and testing which includes the use of dry sludge collected from the waste water treatment plant in the manufacturing of fired clay brick. In this study, the sludge is replace with clay by different ratio of 0%, 5%, 10%, 15%. The results is shown that, the compressive strength and water absorption of the sludge brick is good by use of replacement ratio 5% and 10%.

K. T. Phalak et al (2017) has investigated on dry sludge which available free of cost so it reduces cost of brick by using sludge soil. In this project we have incorporated the use of Dry Sludge in brick up to 50% by replacing Soil (10%, 20%, 30%, 40% and 50%). By this research, the Environmental effects generating from wastes and disposal problems of waste can be reduced.

Anjali G Pillai et al (2017) the compressive strength of the sludge amended bricks is reduced when compared to conventional bricks but they still meet the specified IS standards for 20% sludge addition. The specified conditions of this study indicates that with 20% sludge addition into the bricks, the manufactured bricks meet the relevant technical and environmental standards with the benefit of being light weight as well.

Gopal Bajaj et al (2016) has investigated, the sewage sludge was added ranging from 20, 25, 30 and 40% by dry weight respectively and compared with regular bricks. However, if bricks with more than 30 % sludge addition are not recommended for practical use because it results in the more brittle brick and is not as per the requirement. Also from this investigation can solve disposal problem completely and also construct and economical structure with easy designing.

III. PREPARATION OF SPECIMEN

A. Collection of materials: Waste sludge is collected from the water treatment plant which locates at Jhanda kalan, Sardulgarh. The materials like clay, sand and silt are collected near of the sardulgarh region.

B. Proportion of materials: To know the best proportion, we make total 120 bricks for different 5 proportions.

Table 1: Proportion of materials

Sr. no.	Clay (%)	Sand (%)	Silt (%)	Sludge (%)
1	30	30	15	0
2	25	30	15	5
3	20	30	15	10

4	15	30	15	15
5	10	30	15	20

D. Mixing of raw materials: The raw material is collected on the earth surface and then mixing of raw materials in dry state for 5 minutes and after that water is added according to raw materials and then mixing for 10 minutes.
E. Placing: Form the test sample by placing material mix in the mould (Size 190 x 90 x 90 mm) in three layers of approximately equal volume.
F. Drying and burning of bricks: We are drying the brick by natural method for 7 days and burnt for 24 hours in a bhatta which located near Sardulgarh.
H. Testing of bricks: The different type of tests are conducted on the modified brick such as hardness, weight, water absorption, soundness, Structure, shape and size, efflorescence, bulk density and compression strength test of brick

IV. EXPERIMENTAL STUDY

(i) Water content test
The mass of water divided by mass of solids is called water content of the soil.

Table 2: Results of water content test

Sr. No.	Test	Specification	Results	Guideline followed
1	Water content	Conventional clay	25%	IS: 2720 - 1973.
		Clay with 5% waste sludge by weight	25.95%	
		Clay with 10% waste sludge by weight	26.89	
		Clay with 15% waste sludge by weight	28.09%	
		Clay with 20% waste sludge by weight	30.65%	

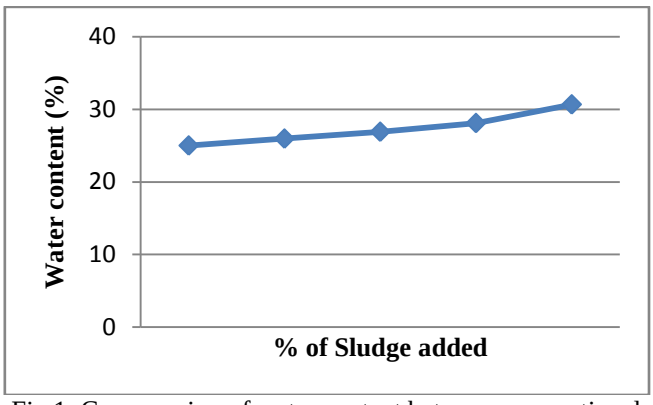

Fig 1: Compression of water content between conventional and modified clay

(ii) Specific gravity test
Specific gravity is the ratio of the weight of a given volume of soil solids to the weight of an equal volume of water at a particular temperature.

Table 3: Result of specific gravity test

Sr. No.	Test	Specification	Results	Guideline followed
1	Specific gravity	Conventional clay	2.69	IS: 2720 – 1980.
		Clay with 5% waste sludge by weight	2.62	
		Clay with 10% waste sludge by weight	2.54	
		Clay with 15% waste sludge by weight	2.35	
		Clay with 20% waste sludge by weight	2.28	

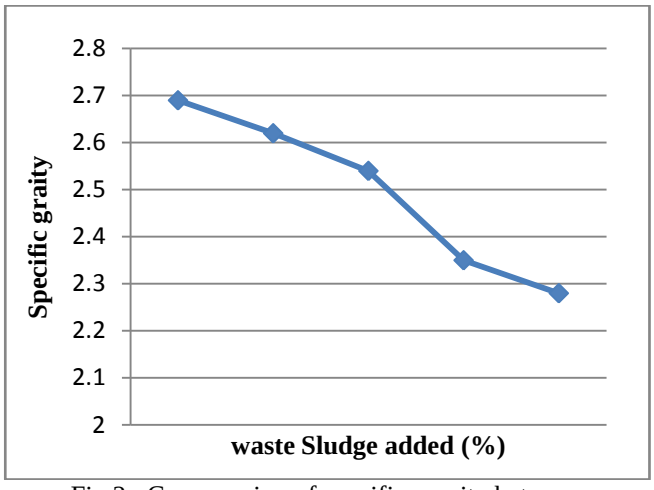

Fig 2 : Compression of specific gravity between conventional and specific gravity

(iii) Particle size analysis of a soil
Determination of quantitative size distribution of particles of dry sludge to fine grained fraction. A set of sieve is used to sieve the soil.

Table 4 Result of sieve analysis test

Sieve size (mm)	Soil retained	Percent retained	Cumulative percent retained	Percent finer (%)
4.75 mm	223.4	44.7	44.7	55
2.0 mm	97.1	19.4	64.1	35.9
1.0 mm	90.2	18	82.1	17.9
600 µm	23.4	4.7	86.8	13.2
425 µm	17.2	3.4	90.2	9.8

300 µm	10.8	2.2	92.4	7.6
212 µm	9.1	1.8	94.2	5.8
150 µm	8.5	1.7	95.9	4.1
75 µm	10.2	2.0	97.9	2.1
Pan	10.1	2.1	100	0

(iv) Liquid limit test
The water content at which the soil change in liquid form is called the liquid limit of the soil. When the soil in the form of liquid than the shear strength of the soil is less.

Table 5: Result of liquid limit test

Sr. No.	Tests	Specification	Results	Guideline followed
1	Liquid limit	Conventional clay	42.54%	IS: 2720 – 1973.
		Clay with 5% waste sludge by weight	40.65%	
		Clay with 10% waste sludge by weight	41.23%	
		Clay with 15% waste sludge by weight	43.87%	
		Clay with 20% waste sludge by weight	44.89%	

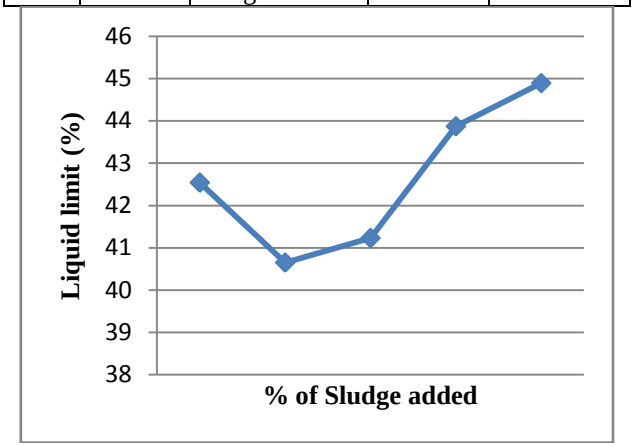

Fig 3: Compression of liquid limit test between conventional and modified clay

(v) Plastic limit of a soil: The plastic limit of soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm dia. If the threads can be reduced to less than 3mm in diameter, without any cracks, it means that the water content is more than its plastic limit. Knead the soil to reduce the water content and roll it into a thread again.

Table 6: Results of plastic limit test

Sr. No.	Tests	Specification	Results	Guideline followed
2	Plastic limit	Conventional clay	21.12%	IS: 2720 – 1980.
		Clay with 5% waste sludge by weight	21.98	
		Clay with 10% waste sludge by weight	23.78	
		Clay with 15% waste sludge by weight	25.72%	
		Clay with 20% waste sludge by weight	27.98%	

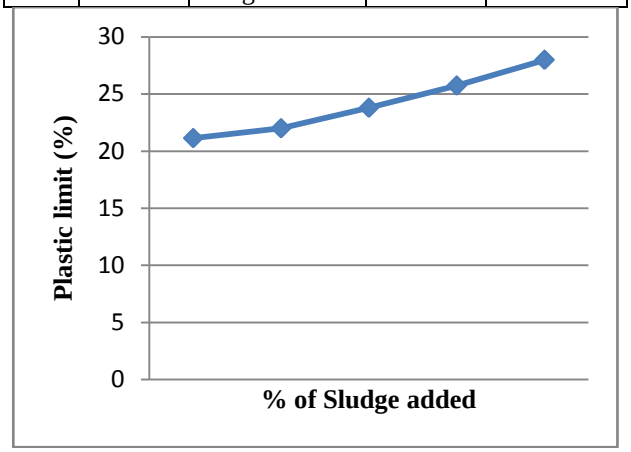

Fig 4: Compression of plastic limit between conventional and modified clay

(vi) Shrinkage limit test
The shrinkage limit is the limit in which the water presents in the soil is just sufficient to fill all the pores of the soil, and the soil in the form of saturated soil.

Table 7: Result of shrinkage limit

Shrinkage limit	Conventional clay	25%	IS: 2720-1972
	Clay with 5% waste sludge by weight	26.87%	
	Clay with 10% waste sludge by weight	28.45%	
	Clay with 15% waste sludge by weight	30%	
	Clay with 20% waste sludge by weight	31.98%	

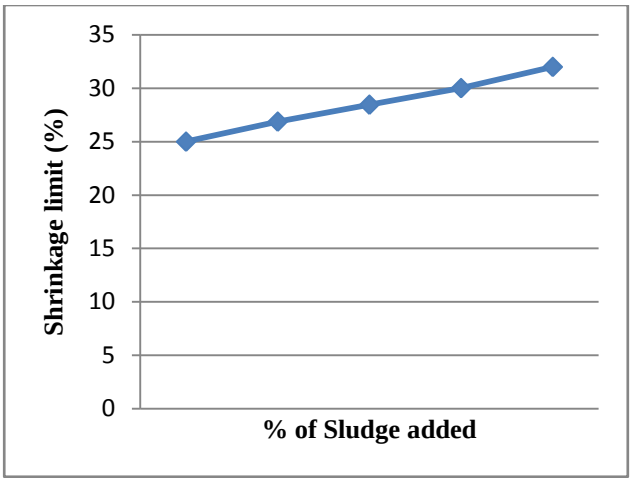

Fig 5: Compression of shrinkage limit between conventional and modified clay

(vii) Hardness test: This test is carried out on the brick to check the hardness of the brick.

Table 8: Result of Hardness Test

Sr. No.	% of sludge added	Burning temperature (℃)	Average result of hardness test for brick
1	0%	850	No mark on the surface of brick
		900	
		950	
		1000	
2	5%	850	No mark on the surface of brick
		900	
		950	
		1000	
3	10%	850	No mark on the surface of brick
		900	
		950	
		1000	
4	15%	850	No mark on the surface of brick
		900	
		950	
		1000	
5	20%	850	No mark on the surface of brick
		900	
		950	
		1000	

(ix) Weight test of brick: This test is conducted on the brick to check the weight of the brick. We can weigh the bricks in the dry state with weight machine. A dry brick put on the weigh machine and note down the weight of the all modified brick.

Table 9: Result of weight test of brick

Sr. No.	% of sludge added	Burning temperature (℃)	Average value of weight test (kg)
1	0%	850	3.4
		900	3.3
		950	3.27
		1000	3.2
2	5%	850	3.32
		900	3.1
		950	2.9
		1000	2.4
3	10%	850	3.1
		900	2.8
		950	2.69
		1000	2.6
4	15%	850	2.8
		900	2.79
		950	2.5
		1000	2.45
5	20%	850	2.5
		900	2.3
		950	2.1
		1000	1.8

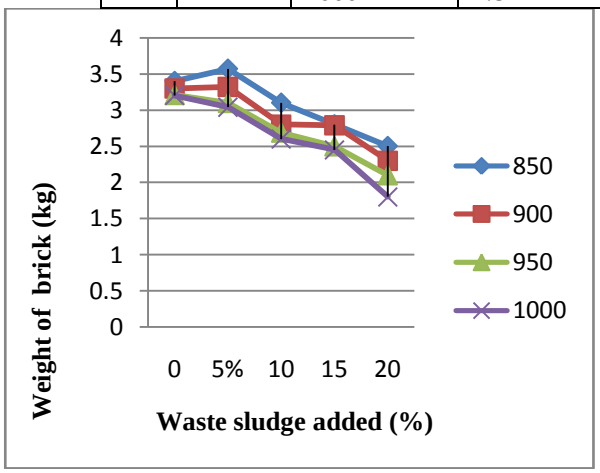

Fig 6: Compression of weight test of brick between conventional and modified clay

(x) Water absorption test: This test is performed to determine the quantity of water which a brick can absorb in it.

Table 10: Result of water absorption test

Sr. No.	% of sludge added	Burning temperature (℃)	Average value of water absorption test (%)
1	0%	850	17.25
		900	15.45
		950	10.88
		1000	5.95

2	5%	850	19.78
		900	17.35
		950	15.75
		1000	6.15
3	10%	850	21.93
		900	20.15
		950	16.85
		1000	6.95
4	15%	850	23.45
		900	21.15
		950	19.75
		1000	8.65
	20%	850	25.32
		900	21.95
		950	20.15
		1000	10.45

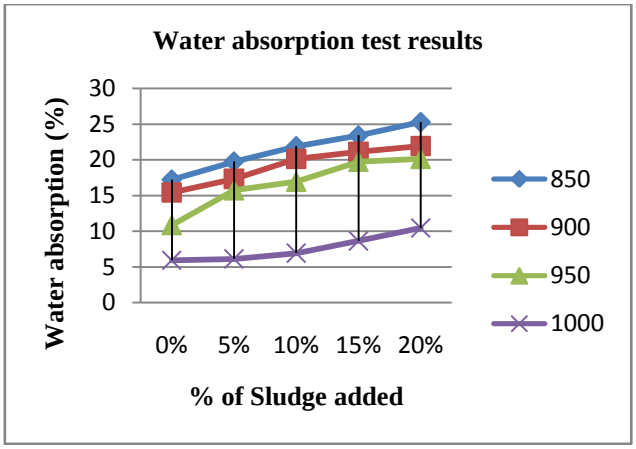

Fig 7: Compression of water absorption value between conventional and modified clay

(xi) Soundness test:

Table 11: Result Soundness Test

Conventional bricks	Modified clay bricks
A clear ringing sound produce	Good sound

(xii) Structure test: This test is carried out on brick to see the structure of the brick when the brick is broken.

Table 12: Structure Test

Conventional bricks	Modified clay bricks
When the brick are broken no any lumps and holes are there in it.	No lumps and holes are given in it.

(xiii) Shape and size test: This test is performed to know the standard size and shape of the brick.

Table 13 shape and size test

Size of brick	Length mm	Width mm	Height mm	Plane area mm sq
1	190	90	90	17100

(xiv) Efflorescence test:

Table 14: Efflorescence Test

Sr. No.	% of sludge added	Burning temperature (℃)	Average result of efflorescence test
1	0%	850	No perceptible deposit of salt is there in it.
		900	
		950	
		1000	
2	5%	850	No perceptible deposit of salt is there in it.
		900	
		950	
		1000	
3	10%	850	No perceptible deposit of salt is there in it.
		900	
		950	
		1000	
4	15%	850	No perceptible deposit of salt is there in it.
		900	
		950	
		1000	
5	20%	850	No perceptible deposit of salt is there in it.
		900	
		950	
		1000	

(xv) Bulk density: The weight of fired brick samples and volume of the samples was also measured..

Table 15: Result of bulk density of brick

Sr. No.	% of sludge added	Burning temperature (℃)	Average value of bulk density test (g/cm^3)
1	0%	850	2.2
		900	2.1
		950	2.12
		1000	2.07
2	5%	850	2.1
		900	2.01
		950	1.88
		1000	1.55
3	10%	850	2.01
		900	1.81
		950	1.7
		1000	1.68
4		850	1.8

	15%	900	1.81
		950	1.62
		1000	1.59
5	20%	850	1.62
		900	1.49
		950	1.36
		1000	1.16

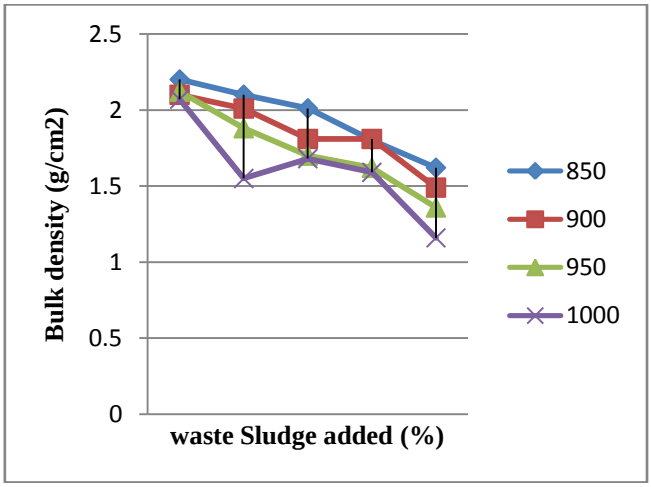

Fig 8: Compression of bulk density between conventional and modified clay

(xvi) Compressive strength test: The compressive strength of the brick can be found out by placing it in a compression testing machine.

Table 16: Compression Strength Test

Sr. No.	% of sludge added	Burning temperature (℃)	Average value of compressive strength test (kg/cm^2)
1	0%	850	132
		900	153.5
		950	200.8
		1000	225.11
2	5%	850	128.05
		900	145.05
		950	195.11
		1000	227.12
3	10%	850	120.34
		900	135.78
		950	150.89
		1000	215
4	15%	850	100
		900	125.09
		950	135.78
		1000	200.87
5	20%	850	95.23
		900	115.09
		950	122.08
		1000	195.63

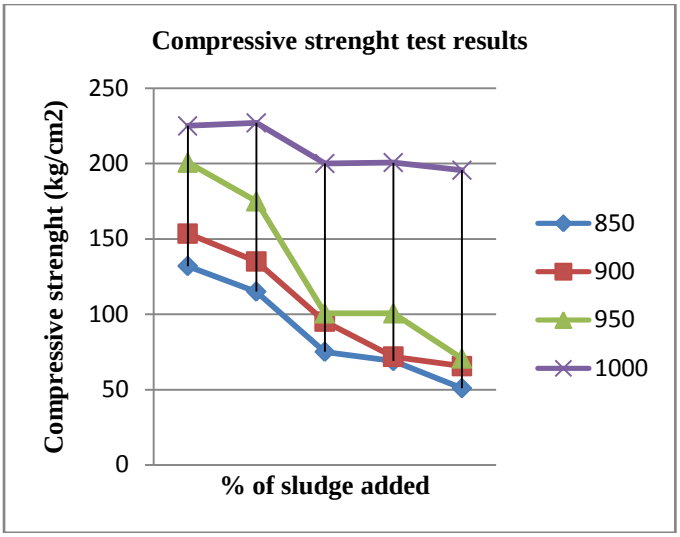

Fig 9: Compression of compressive strength test between conventional and modified clay

V. CONCLUSION

The bricks were manufactured by waste sludge to replace clay with the ratio of 0%, 5%, 10%, 15%, and 20% (by dry weight) and fired at 850°C, 900°C, 950 ℃ and 1000°C and determine the different properties of the fired clay bricks. Based on the experimental work in this research, the following conclusions have been reached;

- Liquid limit, plastic limit and shrinkage limit test results will be also show that the value of these test increase with increase.
- The weight of the brick according to Indian standard is 3.2 kg. When the sludge is addition in the clay with 0%, 5%, 10%, 15% and 20% then the weight of the brick is reduced according to percentage addition.
- 15% and 20% sludge bricks burnt at 1000℃ can be regarded as first class brick category and when the bricks burnt at 950 ℃ then only 0%, 5%, 10% and 15% sludge bricks can be regarded as first class brick. On the other hand 900 ℃ fired bricks with 20% sludge can be regarded as second class brick category and 850 ℃ fired bricks with 15% and 20% sludge can be regarded as third class brick category.
- The soundness, structure and shape and size of the modified clay bricks was good like as a conventional brick and no perceptible deposit of salt is produced on modified brick.
- The compressive strength of the sludge brick reduce considerably from 225.11 kg/cm^2 to 195.63 kg/cm^2 at temperature 1000 ℃ and percentage ratio 0% to 20%. On the other hand compressive strength increase with an increase of firing temperature for all brick samples. The addition of 5%, 10%, 15% and 20% sludge brick at temperature 900 ℃ produce a first class brick type and on the other side at temperature 850 ℃ with ratio 20% produce a second class brick type.

Based on the results obtained from laboratory and field

condition, bricks with sludge content of 10% and 15% by dry weight and fired between 950°C to 1000°C can produce good quality bricks which can satisfy all the desirable mechanical and physical properties as per Indian standard 1077-1970. Also, there will be minimal cause for concern for leaching of toxic metals in the environment. Incorporating sludge in clay bricks therefore can be a promising venture for successfully recycling waste materials into building materials.

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