APPLICATION OF CONSTRUCTION AND DEMOLITION WASTE: A SUSTAINABLE MANNER

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Abstract-As we know that the world's two most populated countries, China and India. The current population of India is about 1362 million as Thursday, January 31, 2019, 36% of the world's population. And the population density in India is 460 per km2 (1192 people per m2).Therefore growth rate of population causes the scarcity of land area and environmental degradation. So it required newly constructed house, demolished the old structures, new infrastructure projects by government day by day. Lack of good aggregates is important problem in construction industry. The disposal of sewage wastes comprises as one of the major worldwide environmental problems as these wastes render the environment unfriendly. The growing demand for waste utilization has made solid wastes like sludge and demolition waste an essential composition of this study. The possibility of reduction of the production costs provides a strong logic for use of this waste.

Moreover the bulk density of the sample also decreased. A maximum of 2.61 g/cm3 was achieved for a 30% sludge content and a minimum of 1.983 g/cm3 for a sludge content of 50%. This was attributed due to the organic properties present in the brick. Moreover the water absorption percentage increased with the increased sludge percentage. With a minimum of 0.22 % was achieved for 30% to a maximum of 0.28% for 50%.

Keywords— **brick Kiln; Recycled Aggregates, C&D waste, concrete engineering properties, physical testing of RA', Environmental impacts, sludge Solid waste management,**

Abbreviation: C & D: Construction and Demolition; MT: Million Tones; CPCB: Central Pollution Control Board; TPD: Tones per Day; MSW: Municipal Solid Waste;

INTRODUCTION: Construction and demolition waste are usually found whenever any construction or demolition activity takes place such as construction of bridges, flyovers, roads etc. it comprises mostly of inert and non- biodegradable material such as sand, gravel, concrete, metal, plastic, glass, etc. Demolition wastes are heavy, bulky and have high density and take up loads of land and space. So what if try recycling of these wastes.

These wastes can be used as landfill, base or sub base in road construction, embankment fill, and railway ballast and most importantly in aggregate replacement method for the formation of recycled concrete
Sludge as we know are the waste material from any source, be it Industrial Waste or Municipal Waste. For waste water sludge or any other kind of sludge we know there have been many attempts made to incorporate these wastes with other materials into the production of bricks, for examples, rubber, limestone dust, wood sawdust, processed waste tea, fly ash and polystyrene.

1.1 FACTOR GENERATING LARGE C& D WASTE IN INDIA:

***Growing population and increasing urbanization**:
***Rising income and growing middle class**

* **Expanding industrial and service-related production**

*** Per capita consumption of materials in India**

* **Global material consumption**.

1.2 Importance of Construction & Demolition Waste: Construction and demolition (C&D) waste is generated from construction, renovation, repair, and demolition of houses, large building structures, roads, bridges, piers, and dams. C&D waste is made up of wood, steel, concrete, gypsum, masonry, plaster, metal, and asphalt. C&D waste is notable because it can contain hazardous materials such as asbestos and lead. Utilization of sludge in making of light weight, artificial aggregate and cement like properties is a win strategy as it not only recycles the waste product, but also alleviates the problem of waste disposal **.**Recycling such wastes by incorporating them into building materials is a practical solution for pollution problem.

1.3 Importance of sludge:

On account of its high organic content and good wet ability, sludge makes for an ideal additive to the clay-shale mix of bricks. So the various importance of sludge is-

*In many ways sludge is the ideal additive to the clay-shale mix of bricks. How can that be? Because it is an organic material with the added advantage of being wet. Organic additives improve laying qualities of bricks.

* From the mason's point of view, pure clay makes for a less-than-ideal brick. They accepted mortar more readily, providing a suction that held the brick in place while the mortar began to set.

* Investigation showed that these bricks were lighter and slightly more porous, the result of organic ``contaminants'' in the original clay. When fired, the organic material burned up, leaving tiny voids throughout the brick.

It has become a common practice to include some organic materials in the clay mix.
* For most though not all brick making. Sawdust and coal fines are commonly used, according to Donald Agee, plant manager for the Maryland Clay Products brick company, which has made approximately half a million of the experimental sludge bricks .

* Apart from making better quality bricks, an organic additive has several other important advantages for brick making. Using such material lengthens the life of a brick making plant. Clay is never brought to a brick making plant; the plant is sited where the clay is. When we eventually run out of clay `the place shuts down.

It has proven most effective in restoring vegetative cover to mine tailings and other scars of the Industry.

1.4 Advantages of it over a normal brick:

The main advantages were related to the amount of energy saved and the environmentally friendly way to dispose the sludge waste. They are as follows:
* Increased plasticity due to the fibrous nature of the waste added makes brick molding easier. So basically the workability of the brick mixture increases.

* The advantages of incorporating the waste are reduction in mass due to the adhesive and sticky nature of the sludge, lower water absorption value and shorter natural drying process due to the presence of organic component.

*The waste also saved the fuel due to the burning of the organic substances inside the waste during the firing process. However, the physical properties have not been proven as the experimental work only emphasized the mechanical properties.

APPLICATIONS

In general, applications without any processing include:

- many types of general bulk fills
- bank protection
- base or fill for drainage structures
- road construction
- noise barriers and embankments

After removal of contaminants through selective demolition, screening, and /or air separation and size reduction in a crusher to aggregate sizes, crushed concrete can be used as: new concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters, and bridge foundations structural grade concrete soil-cement pavement bases lean-concrete or econo-crete bases and bituminous concrete.

2. Case Studies:

This study considers case studies from two different sources, so that the suitability for recycled waste materials can be determined easily. For case study 1, a ten-year-old single storey building (Fig 1(a)) was considered, from which demolished structural elements, such as beams and columns, with known engineering properties of compressive strength, etc., were obtained. For case study 2, randomly chosen demolished structural elements obtained from a municipal dumpsite were considered without any prior knowledge about the engineering properties of concrete.

Fig. 1 (a): Ten-year-old concrete structure of a single story building; (b) Random concrete waste from construction and demolition.

3.Objectives of the Study:

To manufacture brick using sludge along with fly ash as a binding material and mixed with construction & demolition waste in various ratios.

* To compare the compressive strength, water absorption assigned by the Indian Standard Specifications for load bearing bricks.

* Comparison of the designed brick with traditional clay brick.

4.Sample Preparation

The first step of the study was to prepare a mixture or sample and then the properties were checked. The process was as follows.

A particular ratio was of the elements are taken for example a ratio of 3:2:3:2 was taken for fly ash, cement, and sludge & demolition waste. The sludge was then dried at atmospheric temperature for 2 days. Now the

demolition waste was crushed using hammer and then sieved through a sieve size of 1.75 mm. The sand was sdried and also sieved through the same.
The mixture was then added in thoroughly and placed in the mould compactly and was left to dry in atmospheric condition. The sample when dry enough was taken out of the mould by the help of oil and grease. The sample was now cured for 7 days, with continuous supply of water.
This method was repeated with different other ratio of varied sludge content, fly ash, cement, sludge & demolition waste. The weight mentioned is the weight of the brick that was found after it was taken out of mould. The weight of the samples ranged from 2.5-3kg and the samples were casted in a mould of size 23cmx9.5cmx7.5cm.
Individually all the components varied from 400-1200 gm in range in terms of weight. The weight of the mold was also found out to be 1.196 kg.

5. Experimental Program:

5.1 Physical Properties Test:

5.1.1 COMPRESSIVE STRENGTH TEST

The strength test was then carried out on these bricks and the Crushing Strength of the bricks was duly noted as below. It was calculated using the following equation 1.

$$\text{Compressive Strength} = \frac{\rho}{t * w}$$

Where,
P = Load on the material
w = width of the sample
t = thickness/height of the sample

5.1.2BULK DENSITY

Bulk Density (B.D) was calculated for the following samples using the Archimedes' principle.
The weights of the sample were taken (dry weight, D) and then this was followed by soaking the samples in water. Soaking was done by Water Boiling method.
The weight of the samples suspended in water was taken (suspended weight, S) after which the soaked weight (W) of the samples was measured.

$$\text{Bulk Density} = \frac{(D)}{W-S} * \rho w$$

W = Soaked Weight
D = Dry Weight
S = Suspended Weight

5.2 Chemical Properties Test

5.2.1 PH TEST

The chemical alkanity or acidity of the bricks was tested with the help of a pH meter and the results are as follows.

The dried sludge has pH values ranging from 6.10- 6.50 with an average of 6.30. The average pH value for sludge ash is 8.00 with a range of 7.97-9.03. However, the clay samples are on the acidic range; the pH is 4.40 with a range of 4.10-4.60.
A liquid solution of desired sample is prepared and then it was tested by dipping a cleaned pH meter for about 13 second. The value was then recorded.

5.2.2 WATER ABSORPTION:

Water Absorption (W.A) was calculated for the following samples using the Archimedes' principle. The weights of the sintered products were taken (dry weight, D) and then this was followed by soaking the samples in water. Soaking was done by Water Boiling method.

The weight of the samples suspended in water was taken (suspended weight, S) after which the soaked weight (W) of the samples was measured. Using the equation no. 3 the water absorption percentage can be calculated.

$$\text{Water Absorption} = \frac{(W-D)}{D} * \rho w * 100$$

W = Soaked Weight
D = Dry Weight
S = Suspended Weight

5.2.3 PRESENCE OF HEAVY METALS

The chemical composition of the of the various sludge was done by *Atomic Absorption Spectrometer* for a few elements which are harmful and present in it

RESULTS AND DISCUSSION:

6. Physical Properties Test

6.1 COMPRESSIVE STRENGTH TEST

The strength test was then carried out on these bricks and the Crushing Strength of the bricks was duly noted as below.
This test is the most important test for assuring the engineering quality of a building material.
The study showed that with the increase in %age of sludge content the strength decreased. This is because the strength of a material greatly depends on the sludge content and the temperature it's being applied to. It was also seen that with the increase in amount of cement the strength increases. This is mainly due to the properties of the cement.
The compressive strength varied from 10 MPa to 16MPa. So from the various ratios experimented we see that the best possible ratio for building a brick came out to be 2:3:4:1 and 2:3:3:2

Sludge (%)	**Sample I**	**Strength (MPa) of Sample I**	**Sample II**	**Strength (MPa) Of Sample 1I**	**Sample III**	**Strength (MPa)** of Sample **1II**	**Sample IV**	**Strength (MPa) of Sample 1V**
30%	3:2:3:2	13.23	2:3:3:2	15.88	2:2:3:3	14.48	3:2:3:2	13.7
40%	1:3:4:2	12.45	2:3:4:1	15.57	3:2:4:1	14.01	3:1:4:2	14.79
50%	2:1:5:2	11.67	2:2:5:1	14.07	1.5:1.5:5 :2	13.23	1:2:5:2	13.54

6.2 BULK DENSITY

The bricks made with clay normally have a bulk density of 1.5–2.0 g/cm3. As shown, the particle density of the bricks is inversely proportional to the quantity of sludge added in the mixture. This finding is closely related to the quantity of water absorbed as demonstrated.

From the figure 2 it shows that the average bulk density is declining slope. However the figure 3, figure 4, figure 5 shows that in a particular amount of sludge content, with the increase in amount of cement it attains a maximum limit at some point and then starts decreasing from the peak.

However the bulk density increased with the increasing amount of cement as its binding material. When the mixture absorbs more water, the brick exhibits a larger pore size, resulting in a light density. The firing temperature can also affect the particle density of the bricks. The results show that increasing the Sludge content results in a decrease in particle density.

30% Sludge					
	Dry weight (g)	**Soaked Weight (g)**	**Suspended Weight (g)**	**Bulk Density (g/cm3)**	**Avg**
A1	19.78	23.28	15.83	2.65	
A2	20.86	25.83	17.87	2.62	2.62
A3	21.94	27.55	18.96	2.55	
A4	23.03	28.64	19.93	2.64	

Table 2: Table for Bulk Density for 30% Sludge.

40% Sludge					
	Dry weight (g)	**Soaked Weight(g)**	**Suspended Weight (g)**	**Bulk Density (g/cm3)**	**Avg**
B1	24.11	30.77	20.15	2.27	
B2	25.19	31.75	20.99	2.34	2.26
B3	26.27	34.48	21.97	2.10	
B4	27.36	34.43	22.80	2.36	

Table 4: Table for Bulk Density for 40% Sludge

50% Sludge					
	Dry weight(g)	**Soaked Weight (g)**	**Suspended Weight (g)**	**Bulk Density (g/cm3)**	**Avg**
C1	28.44	36.91	22.55	1.98	
C2	29.52	39.48	23.98	1.91	1.98
C3	30.60	38.76	23.09	1.95	
C4	31.69	39.05	23.95	2.10	

Table 5: Table for Bulk Density for 50% Sludge.

7. CHEMICAL PROPERTY TEST

7.1 PH TEST

The chemical alkanity or acidity of the bricks was tested with the help of a pH meter and the results are as follows.

The dried sludge has pH values ranging from 6.10-6.50 with an average of 6.30. The average pH value for sludge ash is 8.00 with a range of 7.97-9.03. However, the clay samples are on the acidic range; the pH is 4.40 with a range of 4.10-4.60.

Also from the table we can see that with the increase in percentage of sludge the alkalify of the sample too increase. This is mainly due to the presence of various metallic and nonmetallic elements.

RATIOS	pH values
Dried Sludge	6.43
Normal Brick	8.6

Table 6: Table for pH results

Sludge (%)	Sample 1	pH	Sample 2	pH	Sample 3	pH	Sample 4	pH
30%	3:2:3:2	8.18	2:3:3:2	7.6	2:2:3:3	7.23	3:2:3:2	7.78
40%	1:3:4:2	12.45	2:3:4:1	15.57	3:2:4:1	14.01	3:1:4:2	14.79
50%	2:1:5:2	10.18	2:2:5:1	7.89	1.5:1.5:5:2	8.3	1:2:5:2	8.74

7.2 Water Absorption:

The figure shows that with the increase in %age of sludge the water absorption increases. From figure 7 it can be clearly seen that with the increase in sludge content in the sample the water absorption too increased. At the point when the blend contains a somewhat higher measure of sludge, the adhesiveness of the blend diminishes, however the inner pore size of the block increments.

As a result, the amount of consumed water increments. This indicates that the workability of the brick decreases with the increase in amount of sludge. The bricks made with clay have lower water absorption value than those made from sludge .This can be one of the demerits of the designed bricks. As workability is an important factor in concrete mixing and is equally responsible for determine the strength and other characteristics of the brick.

30% Sludge					
	Dry weight (g)	Soaked Weight (g)	Suspended Weight (g)	Water Absorption	Avg
A1	19.78	23.28	15.83	0.18	
A2	20.86	25.83	17.87	0.24	0.23
A3	21.94	27.55	18.96	0.26	
A4	23.03	28.64	19.93	0.24	

Table 8: Table For water absorption %age for 30% sludge content

40% Sludge					
	Dry weight (g)	Soaked Weight (g)	Suspended Weight (g)	Water Absorption	Avg
B1	24.11	30.77	20.15	0.28	
B2	25.19	31.75	20.99	0.26	0.28
B3	26.27	34.48	21.97	0.31	
B4	27.36	34.43	22.80	0.26	

50% Sludge					
	Dry weight (g)	**Soaked Weight (g)**	**Suspended Weight (g)**	**Water Absorption**	**Avg**
C1	28.44	36.91	22.53	0.30	
C2	29.52	39.48	23.98	0.34	0.28
C3	30.60	38.76	23.09	0.27	
C4	31.69	39.05	23.95	0.23	

7.3 Presence of Heavy metals:

The chemical composition of the various sludge samples was done by *Atomic Absorption Spectrometer for*a various elements which are harmful and present in it.

Sludge Sample	**Zn (mg/l)**	**Pb(mg/l)**	**Cu (mg/l)**	**Fe (mg/l)**
Sample 1	2.89	2.5	2.28	20.7
Sample II	3.62	3	2.54	25.8

Table 11: chemical composition of sludge

A clay sample was also tested in AAS and the chemical composition was found out as such.

Clay Sample	**Zn (mg/l)**	**Pb (mg/l)**	**Cu (mg/l)**	**Fe (mg/l)**
Sample 1	1.5	0.5	0.14	34.6

Table 12: chemical composition of clay

From the AAS we also found out that the amount of various harmful elements is very high in the case of bricks than in the case of a normal brick.

7.4 Comparison of our designed brick with traditional clay brick

Normal Brick	Designed Brick
□ The compressive strength of a normal 7 day cured brick is around 7.5-10 MPa.	□ The Brick with sludge was easily surpassing this, and is in the range from 12-16 MPa.
□ The pH of a normal brick range from 7-9	□ While the pH value of our designed Brick was found out to lie in range from 6-8
□ The Bulk Density of a normal Clay is in the range from 1.5-2 g/cm3	□ While the Bulk density of our designed brick was found out to be between 1.8-2.6 g/cm3
□ The water absorption of a normal brick ranges from 15-20%	□ While the absorption % for designed sludge brick was found to be from 22-28%

8.CONCLUSION:

The experimental results carried out during the present work would lead to the following conclusions.
The samples with Sludge content of 30-40% was found to be vitrified.

A ratio of 2:3:3:2 containing fly ash, cement, and sludge and demolition waste, respectively was found to be the better suitable ration manufacturing brick made of sludge and demolition waste along with fly ash and also has a potential to be used as instead of normal bricks.

While some of the properties of the designed brick with the ratio of 2:3:3:2 was found to be absolutely fine, some weren't. Such as compressive strength of the brick was 15.88 MPa, whereas the normal brick strength lies in the range of 7.5-10 MPa.
The bulk density of it was found to be 2.62 g/cm3, whereas a normal brick ha a density of 1.8-2 g/cm3.
The properties like pH was found to be 6.7 which wasn't appropriate enough as normal bricks have pH a of 8.5-10.5**.**

The samples and their properties were also checked according to the IS: 1077 –1992 and IS: 2212 –1991, the Code of practice for brick work to be used.

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