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Utilization Of Dyeing Industry Sludge In Developing Green And Sustainable Brick And Paver Blocks

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***Abstract*:**
Tiruppur city is very popular for export of knitting garments. The dyeing industries generate enormous quantity of effluent during their process. As a measure of reducing adverse effect of these effluents on environment, industries are enforced to adopt zero liquid discharge practice. This ZLD process results in the generation of large amount of sludge. In this study an attempt is proposed to utilize dyeing industry sludge in paver blocks and bricks as partial replacement to cement and clay. It is proposed to study the compressive strength, water absorption, efflorescence, abrasion resistance for the 10%, 20%, 35%, 35% with admixture and 75% replacement of cement and clay in paver blocks and in bricks. The properties of the components of sludge, the methodology of processing them, and the suitability of sludge in paver blocks and bricks had been discussed. The strength and other qualities of the paver blocks and bricks met the Bureau of Indian Standards.

1. INTRODUCTION

In India, there are more than 4000 knitting garments. These knitting units need yarn as raw material in their process. The yarn is obtained from spinning mills located in Coimbatore and other parts of India. The knitting industries need to produce the garments in all possible colour to satisfy the buyer's taste, where as the yarn occurs naturally in white colour only. The yarn fabrics are added with different colours by means of process called dyeing. There are more than 800 dyeing industries. These dyeing units are working as job works for knitting industries.

The dyeing industries adopt chemical based process to add colour to the yarn. The yarn has lot of impurities like dirt, husk, cotton waste and proteins. The cloth has to be bleached before dying to remove impurities. These dyeing and bleaching operations require water in large quantities. Moreover in every stage the cloth has to be washed many times to remove the extra chemical and dyestuff. This wash water is not used again in the dyeing process and it is let out into water bodies and natural drainage systems ultimately reaching the Noyyal River.

The effluents are dark brown to red in colour and have high BOD, COD and low levels of DO. Common effluent treatment plants treating these effluents can remove, colour and reduce BOD and COD but cannot address the TDS part. Also the sludge generation is due to chemical treatment and the average sludge generation rate is around 300 tones per day. The salts, dyestuff, and chemicals used in the dyeing process, as well as lime and ferrous sulphate added during the effluent treatment process, are mostly found in the sludge. The density of sludge is also very low. Due to the low density of sludge, it will be easily carried away by winds causing land pollution and health problems.

As of now these sludge dumped around the common effluent treatment plants and are a potential source of threat to environment. Since the sludge is classified as hazardous, conventional disposal methods such as dumping in low lying areas is not safe and suitable. To address the growing menace of sludge problem various alternative methods of disposal like converting into bio manure, partial replacement for cement were tried out.

Asokan Pappu [1] investigated the current state of non-hazardous and hazardous solid waste creation and consumption in India, as well as its recycling potential and environmental implications. To effectively use these wastes as a raw material, filler, binder, and additive in the development of alternative building materials, detailed physical-chemical, engineering, thermal, mineralogical, and morphological properties of these wastes should be evaluated and accurate data made available, according to the following recommendations. Technology-enabling centres must be established to assist entrepreneurs in the effective commercialization of alternative building materials derived from various types of solid wastes and to boost the production capacity of lab scale operations. Durability and performance of newer goods, as well as technology distribution stressing cost-benefit analysis and life cycle assessment reports, will all play a role in the successful commercialization of innovative methods.

2. MATERIALS AND METHODS

In this study, the possibility of using the dyeing industry sludge in paver blocks and bricks as partial replacement to cement and clay was investigated. Paver blocks were cast with 10%, 20%, 35%, 35% with admixture and 75% replacement of cement with the sludge. Bricks were cast with 10%, 20%, 35%, 35% with admixture and 75% substitution to clay with the sludge.

Paver Blocks (IS 2185(PART I):1949)

Hexagon shaped paver blocks of 390cm² with height of 6 cm were made. The materials which will be used in the formation blocks are cement, quarry dust, stone chips of 6mm, stone aggregate of 40mm and sand

53 Grade Ordinary Portland cement of was chosen for the study. Testing for specific gravity was conducted and found a value of 3.15.

As fine aggregate, river sand adhering to IS 383:1970 grading zone-II was used, with a maximum aggregate size of 4.75mm. The fine aggregate specific gravity was 2.61.

Mix Proportions for Paver Blocks

Paver Blocks were made from cement, sand, stone chips of 6mm, quarry dust and water. Apart from the above mentioned, sludge was added in certain proportion as per requirements. Number of paver blocks cast and investigated in this study is 55 numbers. Average weight of paver block was 6 kg.

Table.1 shows the mix proportions of Different proportions of replacement for cement by sludge such as 10%, 20%, 35% and 75% are adopted. The weight of each proportion is summarized.

Table.1 Mix Proportions and constituents composition for Paver Blocks

% Replacement	Sludge kg	Cement kg	Stone Chips kg	Quarry Dust kg	Sand kg
10	0.1	0.9	3	1.5	0.5
20	0.2	0.8	3	1.5	0.5
35	0.35	0.65	3	1.5	0.5
35 + admixture	0.35	0.65	3	1.5	0.5
75	0.75	0.25	3	1.5	0.5

Burnt Clay Building Bricks

Bricks are made up of size 19X9X9 cm, the materials, which are used in this bricks, are composite soil of clay, red earth sand

The sludge obtained has the moisture content of about 30%. As a result, it is dried in a hot air oven at 100 degrees Celsius for 24 hours. After drying, the sample was sieved with a 75 micron sieve.

Replacement Proportion for Bricks

Bricks are construction materials that are made from Clay (Red soil). Apart from the above mentioned, sludge is used in certain proportion as per requirements. Number of bricks used in this study was 45 numbers. Average weight of bricks was 3.25kg

Table.2 shows the mix proportion of different proportions of replacement for clay by sludge such as 10%, 20%, 35% and 75% are adopted. The weight of each proportion is summarized.

Table.2 Mix Proportions and constituents composition for Bricks

% Replacement	Sludge kg	Clay kg
10	0.325	2.925
20	0.65	2.6
35	1.137	2.112
75	2.437	0.812

3. RESULTS AND DISCUSSIONS

3.1 Leaching of Trace Elements from paver and bricks

The sludge added in casting of paver is containing chemicals used in the manufacturing process. It is possible to expect their leaching from the paver blocks which are going to be exposed open atmosphere. Hence extent of leaching of chemicals was analysed by chemical analysis carried out on the leachate for pH and elements including chloride, fluoride, sulphate, calcium and magnesium. Results observed in the chemical analysis in shown in Table 3

Table.3 Observed concentrations for pH and trace elements in the leachate collected from paver blocks and bricks choking study

Trace Elements	Sludge	Paver Blocks			Bricks	
		0%	35%	35% + Ad	0%	35%
Chlorides	813.57	71.78	114	153.1	86.43	100.5
$Sulphate^{-}$	966.57	25.6	641.75	127.52	49.36	86.39
Fluorides	15.5	2.5	6	8.5	5	15
Calcium	412	30	50	27.5	30	47.5
Magnesium	713	25	55	52.5	40	47.5
pH	9.2	7.1	8.1	8.34	7	8.16

3.2 Compressive Strength of paver blocks

Compressive strength test on Paver blocks after the 7th day, 14th day and 28th day curing was conducted. Table 4 shows the compressive strength values observed for mixes used. It has been noted that increasing of sludge content resulted a decrease in strength but the mix with sludge replacement and addition of admixture resulted improvement in strength. It is evident, 28 days compressive strength for 0 %, 35 % and 35 % plus admixture mixes obtained as 19.239, 15.504 and 19.460 N/mm^2 respectively.

Table.4 Compressive Strength of paver blocks

% replaced	Average Compressive Strength, N/mm^2		
	7 days	14 days	28 days
0	7.582	13.128	19.239
10	5.885	19.013	14.259
20	5.206	16.297	16.070
35	5.066	14.261	15.504
35 + ad	7.016	17.202	19.460
75	4.979	11.317	11.765

The 28 days Compressive strength increases by 1.14% for 35 + admixture replacement respectively. Fig.1 compares the compressive strength of paver blocks of different proportions.

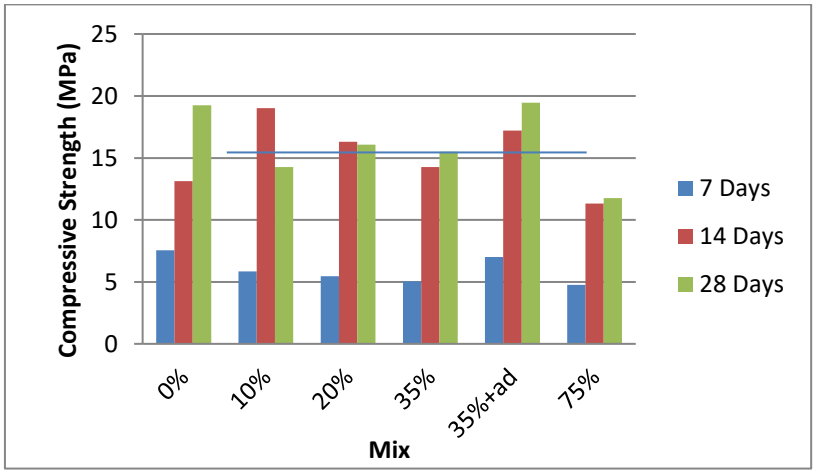

Fig.1 Comparison of Compressive Strength of Different Mixes

3.2 Water Absorption for paver blocks

Water Absorption is ratio of difference of mass of saturated surface dry specimen and oven dried specimen to the mass of oven dried specimen which is given in percentage. It is an indication of porosity in paver blocks.

Table.5 Water absorption % observed for the mixes

Mix	Water Absorption, %		
	7days	14days	28days
0%	3.765	4.74	4.020
10%	5.391	4.925	4.287
20%	5.719	7.206	4.280
35%	3.753	4.634	4.787
35%+ad	5.663	6.181	6.032
75%	6.079	5.959	5.992

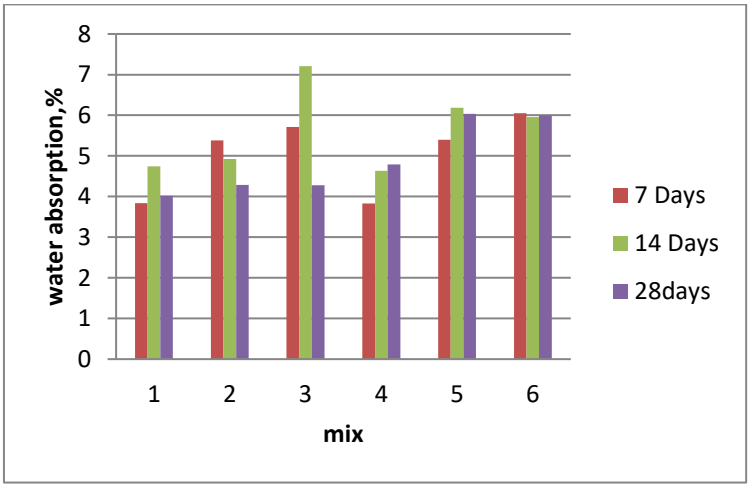

Fig.2 Comparison of the water absorption of paver blocks of different proportions

3.3 Abrasion resistance

Abrasion resistance is expressed as loss in paver thickness (mm) which is caused by the impact and rolling action. Table 6 shows the loss in thickness obtained for different replacement.

Table.6 abrasion resistance

Mix	Average loss in thickness, mm
0%	1.75
10%	1.83
20%	2.145
35%	2.692
35% + ad	1.78
75%	3.15

Abrasion resistance also decreases at 35%+admixture replacement respectively**.**

Fig.3 compares the abrasion resistance of paver blocks of different proportions.

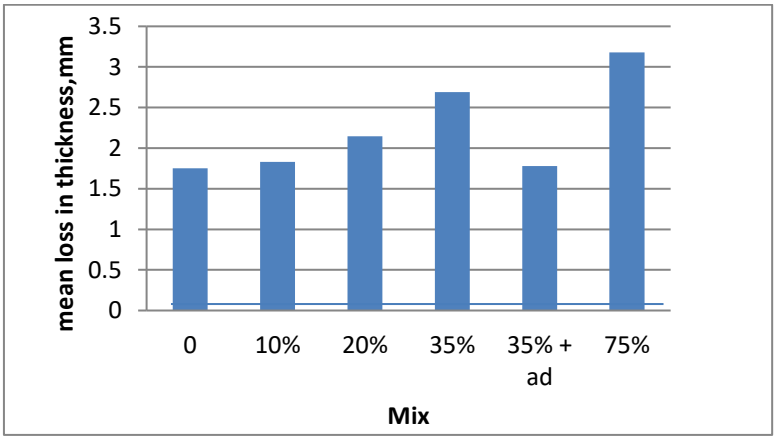

Fig.3 Comparison of abrasion resistance of Different Mixes

3.4 Visual tests for bricks

In this test, bricks were closely inspected for its shape. The bricks of good quality should be uniform in shape and should have truly rectangular shape with sharp edges. Observations recorded on all mixes of bricks is as shown in Table 7. It is observed that all test observations are fulfilled by the mixes of 0, 10 and 20 %. These mixes found to be passing all categories of requirement.

Table .7 Consolidated Visual Test observations on bricks of all mixes

Observations	Mixes satisfying
The bricks should be smooth, well-finished, and free of cracks.	All proportions
They should have straight and sharp edges.	0, 10, 20, 35%
They are homogeneous in colour, shape, and size as per standards.	0, 10, 20%
When the bricks are struck together, a clear ringing sound should be produced.	0, 10, 20%
The fracture of good bricks had shown the compact structure with no voids that was uniform and bright.	0, 10, 20%
When dropped from a height of 1m, bricks should not break down.	All proportions

The ringing sound gets quieter as the sludge content rises. Original base material bricks with 0% sludge provide a great ringing sound. In the case of bricks containing 20% sludge, the ringing sound is the least noticeable. This could be due to the bricks' greater porosity. A good ringing sound is heard from bricks having 10% sludge.

3.5 Dimensional Tolerance for bricks

Twenty bricks were chosen at random to ensure that the length, breadth, and height measurements were accurate. These dimensions should be measured in tens of thousands. Height measurements, unlike length and breadth, must be obtained from two points and averaged for each brick. The difference between the specified job size and the average real size is the tolerance. The range tolerance is used to account for the total difference between the largest and smallest bricks in a sample and can be used to solve problems with size variation. Only a little amount of variation in dimensions is allowed, ±3% for class one and ±8% for the other classes. Table 8 shows the dimensions of the bricks that were seen.

Table.8 Dimensional Tolerance dimensions observed

% Replacement	L (cm)	B(cm)	H(cm)
0%	530.6	250.2	181.1
10%	539	253.2	184.2
20%	542.3	265.2	177.8
35%	543.8	255.5	168.4
75%	536.2	256.3	183.3
Standard	548.6	264.0	180.3

3.6 Compressive strength of bricks

The brick specimens were measured for their weight and dimensions. Fill the frog and all cavities in the bed with cement mortar made from a 1:1 mix of cement and clean coarse sand (grade 3 mm and below). They were then treated for 24 hours with damp jute bags and 3 days by immersion in clean water. Any traces of moisture should be removed and wiped away. The load is then applied uniformly axially. It was reported that there was a crushing load. The compressive strength is calculated by dividing the compressive load by the area of the brick loaded. The compressive strength values of bricks obtained for various replacements are shown in Table 9. The 10 percent mix replacement resulted in a slight increase in compressive strength. The compressive strength of bricks of various mixes is shown in Fig.4.

Table.9 compressive strength

Mix	Average Compressive Strength, N/mm^2
0%	5.000
10%	5.330
20%	2.833
35%	1.416
75%	1.000

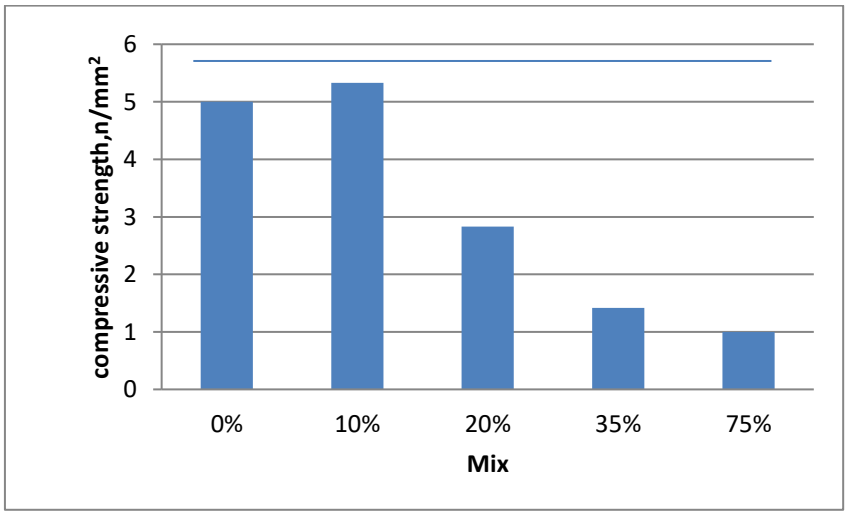

Fig.4 Comparison of compressive strength of Different Mixes

3.7 Water Absorption for bricks

Water absorption is the ratio of the mass difference between a saturated surface dry specimen and an oven dried specimen to the mass of the oven dried specimen, expressed as a percentage. Water absorption in bricks is a sign of porosity.

Table.8 Water absorption values observed

Mix	Water absorption, %
0 %	7.863
10 %	5.577
20 %	5.780
35 %	6.03
75 %	6.840

The various mixes show better results of water absorption than control paver blocks. The value decreases by 29, 26.4, 23.5, 2.7and 14.9 % for Mix 10, 20, 35, and 75 respectively. Fig.5 compares the water absorption of bricks of different proportions

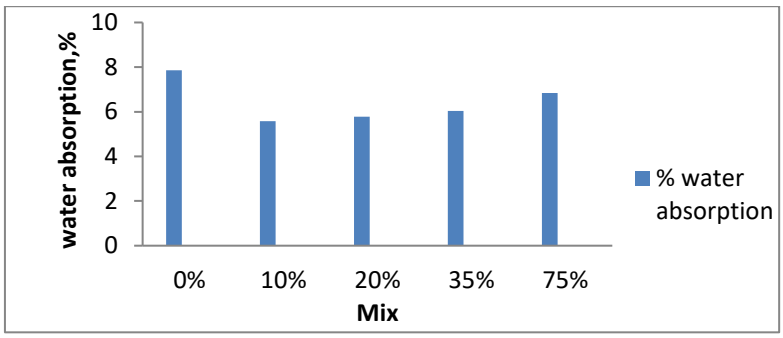

Fig.5 Comparison of water absorption of Different Mixes

3.8 Efflorescence for bricks

The presence of salts in brick is undesirable because they absorb moisture and generate patches of grey powder. In a well-ventilated room, the brick specimen is placed in a tray containing distilled water to a depth of 25mm. Add water to a depth of 25 mm after all the water has been absorbed or evaporated. The white/grey areas on the bricks were noticed after the second wetting and evaporation. The observation on presence go patches was noted and consolidated in Table 10

Table 10 Efflorescence Test Results

S.No	Observation	% replacement
1	**Nil**: No patches	0 % & 10 %
2	**Slight**: 10% of the area is covered by deposits.	20 %

3	**Moderate**: 10 to 50% of the area is covered by deposit, although there is no flaking of the surface.	35% & 75%
4	**Heavy**: More than half of the area is covered in deposits, although there is no flaking of the surface.	Nil
5	**Serious**: Excessive salt deposits with peeling of the surface.	Nil

To mean, the observation is stated as ‘nil’, ‘slight’, ‘moderate', 'heavy,' or 'serious.' As a result, this test is carried out to determine the presence of alkalis..

CONCLUSION

The chemical analysis of ETP sludge, investigation on its incorporation as a substitute for cement and clay in casting of paver blocks and brick referring to strength and other aspects, led to the inferences.

- ETP Sludge can be used in the construction of bricks as a partial replacement for clay.
- Based on the findings of this study, it is feasible to conclude that using Textile ETP sludge as a partial replacement for cement, up to a maximum of 20%, could result in high-quality paver blocks.
- It is found, when the ETP Sludge waste percentage increases the water absorption also increases.
- Therefore, the usage of ETP Sludge minimises both land and air pollution, and it is environmentally friendly.

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