Feasibility Study on Paver Blocks blended with Textile Effluent Sludge and M-Sand

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Abstract. Textile sludge (TS) management is a huge problem for its disposal from the textile industry. It has tremendous applications, such as walking paths, street road, and fuel stations, etc. In this manner, an innovative step has been towards the manufacture of paver blocks blended with textile effluent treatment plant (TETP) sludge to use of it in reasonable extends. A different percentage of sludge starts from 10%, 15%, 20%, 25% and 30% to be taken for this study for the effective utilization of sludge to the construction industry. This thinks about looked for to experience the potential use of TS as a binding fabric for paving blocks generation. Conventional paver block is cast with full replacement of sand by using M-sand as fine aggregate. Paver blocks consist of TS in addition to distinctive proportions was casted according to the recommendation of Indian Standards (IS) 15658 (2006), also the various results was obtained through experimentally and it was compared to the conventional paver block. The different mix combinations outcome reveals that, 30% of cement replacement by effective utilization of TS from the textile industry.

1. Introduction

The textile industry is the biggest industry unit in India. A lot of environmental issues were developed due to the rapid incremental of industrialization. The textile industry generates different types of wastes over the world. For the human community, sludge management has become a great task in recent years.

The prospective reuse of TETP sludge in construction materials was studied. The basic property of sludge which was collected from the southern part of India has been studied. The various tests have been conducted for the suitability of sludge for both structural and non-structural applications with the replacement of cement by addition of 30% sludge in the mix. Perhaps it is possible for the manufacturing of non-structural building materials by the substitution of textile sludge up-to maximum of 30% and also the setting process of the elements by the addition of sludge in the mix [1]. From the study TS proportions for different Hypo sludge combinations and TS + HS combinations taken according to the design mix. According to BIS requirements, all the combinations of Mix were satisfied [2]. The permeability of the mix was decreased by 5%
replacement of cement through the addition of TS. Beyond this substitution point, penetration properties of mortars disintegrated, owing to lesser hydration response and deficiently pozzolanic activity in cement-sludge mortars [3]. The study was compared with the standard limit through experimental investigation on fly ash unburnt bricks. The characteristics of flyash which influence a major impact in the manufacturing of unburnt bricks. Simultaneously the characterizations such as chemical, physical, and mineralogical for flysah to make sure the reactivity for the process of fabrication and it was recommended by Murugesan T et al [4]. A more than 80% of paver block quality achieved within a day after fabrication which implies the time-saving. Compared to lightweight concrete, the paver blocks less chemical assault and physical stretch due to its fast curing and less water absorption property. Paver blocks were generated from plastic waste and it's more advantageous to overcome conventional concrete due to the quick development of production [5]. The basic properties and distribution of size of foundry sand and steel slag does not meet the requirements of ASTM. The basic physical properties of all industrial wastes were obtained and it’s also matched with natural sand [6]. The concrete which was made by tires rubber leads to decreases compressive and flexural strength. But at the same time, it can also supplant natural by elastic tires by kept their mechanical characteristics of concrete without elastic. The properties were improved with 10% of substitutions in the mix for making paver blocks with natural aggregates [7]. According to the IS code provision the paver blocks subjected to having more than 30 N/mm² compressive strength as well as less than 6% of water absorption used in light and non-traffic areas such as embankment slopes, public garden, and building premises. The different mix combinations were satisfied with the IS code criteria based on their flexural strength and breaking load results [8]. Predominantly change the compressive strength of Rubber Mould Textile Sludge Paver Block (RMTSPB) at 28 days by using different mix proportions. The strength was achieved by nearly 30MPa by adding up to 20% of textile sludge in the mix. The abrasion resistance of block decreased with the percentage of sludge increased. Around 1.788mm thickness was decreased during the testing of abrasion resistance by adding 20% of textile sludge. Finally, the addition of 20% of sludge replaced as cement substitutions in the mix was recommended by Kaushal Patel et. al [9]. Form experimental investigations, the compressive strength was decreased by adding more than 40% of sludge in the mix but below this percentage, the cement was replaced by sludge and fly-ash which reveals that it doesn’t make any unfavorable effect of the specimen [10].

An eco-friendly attempt is possible by adding textile sludge as composite materials in the manufacturing of paver blocks. This helps to minimize the disposal problems. There was an overwhelming future extend of the utilization of sludge was part of modern advancement of materials within the construction industry. The generation of Paver blocks blended with textile sludge results in mass transfer from industry and driving to eco-friendly attempts for the perspective situation.

2. Experimental programme

2.1 Materials used

2.1.1 Cement
The Ordinary Portland Cement (OPC) of 53 grades as per IS 1489 (1991) available from a local source was used, the specific gravity of 3.15 and fineness modulus of 3.5%.

2.1.2 Fine and coarse aggregate
M-sand was used as a Fine aggregate and collected from a nearby local source. The M-sand has a specific gravity of 2.85, fineness modulus of 5.886 and water absorption found to be 2.14%. The Coarse aggregate (CA) was collected from locally situated quarry nearby Thoothukudi district, Tamilnadu, India. The specific gravity of CA was 2.61, fineness modulus found to be 8.247, and
water absorption to be 1.69%. According to IS 15658 (2006) standards, a 10 mm size was taken as the maximum size of the aggregate. For mixing and curing of paver blocks, the portable water was used. The batching of materials shown in Figure 1. The particle size distribution was clearly shown in Figure 2 for the M-sand and river sand.

![Figure 1](image_url)

**Figure 1.** a. Cement, b. M-sand and c. CA

![Figure 2](image_url)

**Figure 2.** Sieve Analysis

2.1.3 Textile sludge

The TS was obtained from the SIPCOT, CETP, Perundurai, Erode district, Tamilnadu state, India. By random sample technique, the sludge was collected in dry conditions from the drying beds. With the help of the trowel, the dry sludge was grounded manually within room temperature. By sieving the TS obtained from industry with the help of 150-μm sieve. Due to less thickness and very little measure issues, there was taking care done for the fabrication of specimens. Its maintenance in a heap was not conceivable in a dry state comparable to cement, since it was blown absent by a slight breeze of the discuss. This sludge appears to be finer than cement in quality. It has lower specific gravity than cement. It possesses more volume and requires more water during blending. The Basic properties of specific gravity were found to be 3.16 and % of residue left in 90μ was 2.6%. The wed textile sludge and dry textile sludge as shown in figure 3 and 4 respectively.
2.2 Mix combination for specimens

Paver blocks were manufactured using M40 grade concrete blended with M-sand with appropriate mix proportions. Textile sludge was added in different mix combinations for the replacement of cement. As per IS 15658 (2006) recommendations, the materials were selected. The below Table 1 and 2 shows mix proportions and mix combinations of specimens respectively,

| Table 1 Mix Proportion for the paver block specimen |
|-----------------------------------------------|
| **Grade of Concrete** | **Cement** | **FA(M-sand)** | **CA** | **W/c ratio** |
|-----------------------|------------|----------------|--------|---------------|
| 40                    | 1          | 2.33           | 1.82   | 0.50          |

| Table 2. Mix Combination for the specimens |
|-------------------------------------------|
| **S.No** | **Ingredients** | **Without Sludge** | **Weight of Sludge(kg)** |
|         |                |                    | 10%  | 15%  | 20%  | 25%  | 30%  |
| 1   | Cement         | 0.98               | 0.882 | 0.83  | 0.784 | 0.73  | 0.686 |
| 2   | Textile Sludge | -                  | 0.098 | 0.14  | 0.196 | 0.24  | 0.294 |
| 3   | M-Sand         | 2.30               | 2.30  | 2.30  | 2.30  | 2.30  | 2.30  |
| 4   | Coarse Aggregate | 1.80            | 1.80  | 1.80  | 1.80  | 1.80  | 1.80  |

2.3 Mix design

Design mix helps to make the concrete with effectively by using desired properties of materials. This was done by choosing the appropriate combinations of constituents such as cement, aggregates, and water. The minimum strength of the paver blocks was the primary objective. As per the recommendation of IS 10262 (2009) the mix design was carried very carefully without affecting its basic properties. The mix proportions arrived for M40 grade concrete and it’s shown in Table 1.

2.4 Casting of paver blocks

According to IS 15658 (2006) the size of the specimen 250 x 123x 80 mm was used in the study and it’s shown in Figure 5. By adding the required amount of water in the different mix combinations the paver blocks were fabricated within the stipulated temperature without affecting the mix fresh properties. The mix was placed in the mould with an appropriate manner and vibration also was given to each layer in the mould. De-moulded the specimen after a 24 Hrs curing period.
3 Results and discussion

3.1 Slump test
Before usage of concrete mix, the fresh property was conducted using a slump cone and also measure the consistency of the concrete before sets. It is performed to check the workability of freshly made concrete. The slump shall be measured and recorded as True Slump and it’s shown in figure 6.

3.2 Density
Density is an estimation that analyzes the measure of issue an item has to its volume. An article with a lot matter in certain volume has high thickness an item with minimal issue in a similar measure of volume has a low density. Density of the specimen was carried according to the IS code and its shown in figure 7. The test results for 7 & 28 days were tabulated in Table 3 and described in figure 8.
Table 3 Density of the specimen

| S.No | %   | Specimen | Weight (Kg)  | Density(Kg/m³) | Density(Kg/m³) |
|------|-----|----------|--------------|----------------|----------------|
|      |     | 7 days   | 28 days      | 7 days         | 28 days        |
| 1    | 0   | CPB1     | 5.345        | 5.575          | 2812.8         | 2391.26        |
|      |     | CPB2     | 6.120        | 6.190          |                |                |
|      |     | CPB3     | 5.410        | 5.610          |                |                |
| 2    | 10  | TSPB1    | 5.305        | 5.450          | 2171.41        | 2166.67        |
|      |     | TSPB2    | 4.565        | 5.215          |                |                |
|      |     | TSPB3    | 6.155        | 5.040          |                |                |
| 3    | 15  | TSPB1    | 5.030        | 5.630          | 2145.12        | 2140.92        |
|      |     | TSPB2    | 5.480        | 5.110          |                |                |
|      |     | TSPB3    | 5.320        | 5.005          |                |                |
| 4    | 20  | TSPB 1   | 5.555        | 5.335          | 2133.47        | 2168.02        |
|      |     | TSPB 2   | 5.225        | 5.405          |                |                |
|      |     | TSPB 3   | 5.215        | 5.260          |                |                |
| 5    | 25  | TSPB 1   | 5.405        | 5.630          | 2128.05        | 2239.84        |
|      |     | TSPB 2   | 5.060        | 5.420          |                |                |
|      |     | TSPB 3   | 5.335        | 5.480          |                |                |
| 6    | 30  | TSPB 1   | 5.350        | 5.350          | 2134.00        | 2199.19        |
|      |     | TSPB 2   | 5.245        | 5.245          |                |                |
|      |     | TSPB 3   | 5.410        | 5.410          |                |                |

Figure 8. Density of the specimens

3.3 Compressive strength test
With the help of 2000 kN capacity CTM (figure 9), the compressive strength was done as per the IS code. As per IS 15658 (2006) recommendation M40 grade concrete is used for nontraffic areas as well as M55 for traffic pavements. Also it recommends that the 20 years life span of the structures by using specified concrete in the work. The various mix combinations were shown in Table 2 for fabricating of paver blocks with the TS. According to the combinations, the results are discussed and tabulated in Table 4. The results was discussed in figure 10.
Figure 9. Compressive Strength of the Specimen

Table 4. Compressive Strength of the specimen

| S.No | % of TS | Specimens | Ultimate Load (KN) | Area (mm²) | Average Compressive Strength (N/mm²) |
|------|---------|-----------|--------------------|------------|-------------------------------------|
|      |         |           | 7 days  | 28 days | 7 days  | 28 days | 7 days  | 28 days |
| 1    | 0       | CPB1      | 1000    | 1350    |         |         | 28.03   | 43.80   |
|      |         | CPB2      | 900     | 1280    |         |         |         |         |
|      |         | CPB3      | 950     | 1410    |         |         |         |         |
| 2    | 10      | TSPB1     | 770     | 990     |         |         | 25.03   | 34.90   |
|      |         | TSPB2     | 730     | 1080    |         |         |         |         |
|      |         | TSPB3     | 810     | 1150    |         |         |         |         |
| 3    | 15      | TSPB1     | 730     | 950     |         |         | 24.17   | 30.57   |
|      |         | TSPB2     | 760     | 990     |         |         |         |         |
|      |         | TSPB3     | 740     | 880     |         |         |         |         |
| 4    | 20      | TSPB1     | 720     | 700     |         |         | 26.99   | 24.17   |
|      |         | TSPB2     | 780     | 750     |         |         |         |         |
|      |         | TSPB3     | 990     | 780     |         |         |         |         |
| 5    | 25      | TSPB1     | 700     | 610     |         |         | 24.20   | 19.95   |
|      |         | TSPB2     | 690     | 650     |         |         |         |         |
|      |         | TSPB3     | 750     | 580     |         |         |         |         |
| 6    | 30      | TSPB1     | 590     | 650     |         |         | 18.86   | 19.62   |
|      |         | TSPB2     | 540     | 590     |         |         |         |         |
|      |         | TSPB3     | 610     | 570     |         |         |         |         |

Figure 10. Compressive Strength of the specimen
3.4 Water absorption test

The water absorption, being the normal of three units, when decided in the way portrayed in Addition C, will not be in excess of 6 percent by mass and in singular examples; the water ingestion ought to be limited to 7 percent. (According to IS 15658: 2006). The average of three specimen units shall not be more than 6 percent by mass of sample, and it should be restricted to 7 percent as per IS code. Finally the dry density was used in the range of 2100 to 2165 kg/m³. The water absorption test shown in figure 11 and the results were discussed in figure 12.

![Figure 11. Water absorption test](image)

Table 5. Water Absorption of the specimen

| S.No | % | Specimen of 7 Days | Specimen of 28 Days | W1 7 Days (kg) | W2 7 Days (kg) | W1 28 Days (kg) | W2 28 Days (kg) | Water absorption for 7 Days % | Water absorption for 28 days % |
|------|---|-------------------|-------------------|----------------|----------------|----------------|----------------|-------------------------------|-------------------------------|
| 1    | 0 | CPB1              | CPB 4             | 5.575          | 5.635          | 5.545          | 5.635          | 0.93                          | 1.8                           |
|      |   | CPB2              | CPB 5             | 6.190          | 6.240          | 6.120          | 6.240          |                               |                               |
|      |   | CPB3              | CPB 6             | 5.520          | 5.600          | 6.200          | 6.320          |                               |                               |
| 2    | 10| TSPB1             | TSPB 4            | 5.305          | 5.320          | 5.450          | 5.590          | 0.45                          | 2.36                          |
|      |   | TSPB2             | TSPB 5            | 4.565          | 4.600          | 5.215          | 5.345          |                               |                               |
|      |   | TSPB3             | TSPB 6            | 6.155          | 6.175          | 5.040          | 5.150          |                               |                               |
| 3    | 15| TSPB1             | TSPB 4            | 5.030          | 5.060          | 5.630          | 5.755          | 0.56                          | 2.44                          |
|      |   | TSPB2             | TSPB 5            | 5.480          | 5.510          | 5.110          | 5.240          |                               |                               |
|      |   | TSPB3             | TSPB 6            | 5.320          | 5.350          | 5.005          | 5.125          |                               |                               |
| 4    | 20| TSPB 1            | TSPB 4            | 5.555          | 5.690          | 5.335          | 5.375          | 2.98                          | 0.71                          |
|      |   | TSPB 2            | TSPB 5            | 5.225          | 5.415          | 5.405          | 5.440          |                               |                               |
|      |   | TSPB 3            | TSPB 6            | 5.215          | 5.380          | 5.260          | 5.300          |                               |                               |
| 5    | 25| TSPB 1            | TSPB 4            | 5.405          | 5.505          | 5.630          | 5.670          | 2.02                          | 0.99                          |
|      |   | TSPB 2            | TSPB 5            | 5.060          | 5.160          | 5.420          | 5.450          |                               |                               |
|      |   | TSPB 3            | TSPB 6            | 5.335          | 5.460          | 5.480          | 5.575          |                               |                               |
| 6    | 30| TSPB 1            | TSPB 4            | 5.350          | 5.390          | 5.350          | 5.375          | 0.73                          | 0.406                         |
|      |   | TSPB 2            | TSPB 5            | 5.245          | 5.283          | 5.245          | 5.265          |                               |                               |
|      |   | TSPB 3            | TSPB 6            | 5.410          | 5.450          | 5.410          | 5.430          |                               |                               |

*CPB-Conventional Paver Block
*TSPB – Textile Sludge Paver Block
Figure 12. Water Absorption

4 Conclusion

From the experimental investigation, the preliminary properties of materials obtained and verified with IS code. The percentage of sludge varies from 5 % to 35 % for the replacement of cement and used as binding material for the manufacture of paver blocks. The following results are summarized for the manufacture of specimens in a very effective manner by utilizing textile sludge in the construction industry,

- With the addition of textile sludge and M-sand in the mix proportions, the density of the samples was decreased around 0.9 percentage of conventional paver block. This leads to making the concrete is in lightweight condition.
- For M40 grade concrete 1:2.33:1.82 mix proportions arrived and various percentage of sludge has to take for the investigation. The conventional paver blocks were cast and the compressive strength of the specimen was obtained as 44 N/mm² using 2000kN Capacity CTM.
- Around 70 % of compressive strength of the concrete was obtained by adding up to 15 % of TS in the mix compare to CPB. Beyond the 15% of TS addition in Concrete, it leads to a decrease in the compressive strength of concrete predominantly.
- The water absorption of the TSPB was within the limit and also it satisfies the IS 15658:2006.

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