# Reuse of Textile and Tannery Sludge in Concrete Fine Aggregates

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*Abstract*— In the present study the effect of addition of textile sludge and tannery sludge as sand replacement material in the concrete blocks. In this study, control concrete blocks are made using ordinary Portland cement (M-53 grade). Textile and tannery sludge as industrial wastes used in this project contains some heavy metals which are hazardous in nature. So, the present study was to examine the utilization of textile sludge along with tannery sludge in the production of concrete blocks. An experimental study was designed to find the compressive strength of blocks at periodic intervals of 7 days and 28 days according to the testing standard. The results of the study will be helpful not only in reuse of waste as resource but also to reduce the impact due to disposal of tannery & textile sludge's. Accordingly the design mix was made for M15 grade concrete and testing was performed by means of compression testing machine (CTM). It was found that optimum results are obtained at 15 % replacement of both textile and tannery sludge and also 20% replacement of textile sludge only.

***Key words:*** Ceramic Coarse Aggregate (CCA), Natural Coarse Aggregate, Compressive strength, Leachability

## I. INTRODUCTION

The textile and tannery industry is one of the oldest and largest sectors in India. According to records of the Tamilnadu State Pollution Control Board (TNPCB), there are 830 units engaged in textile industrial processes in Tirupur. They are joining together to form common effluent treatment plants (CETP) in order to economize the process.

In this study, an attempt was made to reutilize the ETP sludge from textile and tannery industry as a building material to avoid adverse impacts on environment and to provide solution for improper disposal methods for the chemical sludge. The reprocessing of sludge to value-added products holds the future key to sustainable management. The study uses Textile and Tannery waste as a partially replacement of natural coarse aggregate (10%, 15%, and 20%).

In this study examine appropriate mix design for M15 grade with textile and tannery sludge replacement as a coarse aggregate.

## II. REVIEW OF LITERATURE

Baskar and Meera Sheriffa Begum (2006) reported that use of sludge from textile common effluent treatment plant as a clay substitute to produce quality bricks. All the bricks made with mixed proportion (0-30% waste) were found to satisfy the norms for shrinkage and weight loss properties of quality bricks. The results indicate that compressive strength greatly depends on the amount of waste in the brick and the firing temperature. Compressive strength of bricks will decrease with increase of textile sludge in the bricks and increase with an increase of firing temperature. It was observed that maximum amount of sludge that can be added in the range of 6 to 9% corresponding to compressive strength value between 4.25 to 3.54 $N/mm^2$.[1]

Angeline Swarma and Venkatakrishnaiah (2014) reported that tannery sludge can replace cement up to 20% and quarry dust can replace sand up to 100% in cement bricks. in this project different proportions of cement, sludge and quarry dust are thoroughly mixed and test were performed for the property of compressive strength for 7th day and 14th days of curing and 24 hours of sun drying.[2]

Raghunathan et al (2010) used new composite material using ordinary Portland cement and Dyeing industry Effluent treatment plant sludge (DIETPS). It replaces the non-availability of natural building materials such as sand and related aggregates. The composite mixtures having high quality with low cost are selected for future use as a non-conventional building material named as Synthetic Sludge Aggregate (SSA). The fine aggregates are then used as a replacement for sand in various percentages in M20, M30 and M40 concrete. It is advisable to use only 5% of SSA as a replacement of sand present in SSA.[3]

Amiya Akram et al (2015) reported that when e-plastic alone was used, it resulted in decrease in strength but when 10% fly ash was added results comparable to control specimen were obtained even for 15% proportion of e-waste.[4]

Balasubramanian et al (2006) concluded that the use of Textile ETP sludge up to a maximum of 30% substitution for cement may be possible in the manufacture of non-structural building materials.[5]

Dhiraj Agrawal et al (2014) suggested that the use of recycled materials has positive impact through different aspects. This include the benefits in enhancing sustainability of the construction industry while reducing cost, providing solutions to environmental pollution and reducing the need for natural resources.[6]

Nirmal kumar and Siva kumar (2008) concluded that maximum increase in weight due to sulphate attack is 2.01% by using untreated tannery effluent, 1.46% by using treated tannery effluent and 1.10% by using potable water specimens, which are very negligible. When 2.0% of concare was added, the maximum increase in weight is for untreated tannery effluent which is only 1.74%. This implies that the sulphate attack is slightly reduced when added with concare admixture.[7]

Pande and Makarande (2013) concluded that concrete mixes show higher compressive rather than normal concrete. Replacement of 12.5 % of cement with rice husk ash in matrix causes reduction in utilization of cement, and expenditures, also can improve quality of concrete at the age of 90 days.[8]

Senthol kumar et al (2008) suggested that that solid waste sludge can be replaced up to 25-30% to produce bricks and 45-50% to produce concrete blocks. The bricks produced with 25-30 % sludge were observed to have good compressive strength and water holding capacity, which meets the specifications recommended.[9]

The use of tannery and textile sludge material in construction concrete as a coarse aggregate reduces the hazardous effect on environment and gave best way for disposal of sludge.

The present study focuses on the feasibility of using Textile and tannery sludge as an alternative in the usage of natural sand in concrete.

## III. MATERIALS AND METHODS

### A. *Cement:*

Similar to the structural concrete trials, the M15 grade concrete Portland cement was used in the evaluation of the concrete blocks in combination with tannery and textile sludge.

### B. *Textile and Tannery dry sludge*

Textile and tannery sludge was use as a sand replacement in the concrete up to 15%. The chemical compositions of both the sludge is given in table 1&2.

| Parameters | Result (mg/kg) |
|---|---|
| Arsenic as AS | 0.547 |
| Cadmium as Cd | 0.12 |
| Chromium as Cr | 1.6 |
| Lead as Pb | 36.05 |
| Manganese as Mn | 414.2 |
| Total organic carbon | 1.23% |
| Nickel as Ni | 25 |
| Total organic matter | 1.2% |
| Zinc | 390.6 |

Table 1: Composition of Tannery Filter Press Cake

| Parameters | Result (mg/kg) |
|---|---|
| Arsenic as AS | 0.25 |
| Cadmium as Cd | 0.5 |
| Chromium as Cr | 23.7 |
| Lead as Pb | 13 |
| Manganese as Mn | 213 |
| Nickel as Ni | 12.5 |
| Magnesium as Mg | 8.5 |
| Calcium as Ca | 22.9% |
| Titanium as Ti | 34.0 |
| Vanadium as V | 4.10 |
| Zinc as Zn | 696 |

Table 2: Compositions of Textile Lime Sludge

### C. *Aggregates (Is: 2386 (Part I) -1963):*

The aggregates used for the concrete products consisted of two fractions of crushed stones, i.e. 10 to 6mm and 6 to 3mm of coarse sand and fine sand of 0.01to 0.04 mm.

The textile and tannery dry sludge was crushed to make the same as natural coarse aggregate size as 20mm. The cubes were tested for compressive strength measurement at 7, 14, and 28 days. The optimium ratio of textile and tannery sludge's of cubes shown in table 3.

| Sample | Textile sludge (kg) / % | Tannery sludge(kg)/% |
|---|---|---|
| Mix 1 | 0.328 (90%) | 0.0364(10%) |
| Mix 2 | 0.291(80%) | 0.073(20%) |
| Mix 3 | 0.255(70%) | 0.109(30%) |
| Mix 4 | 0.219(60%) | 0.145(40%) |
| Mix 5 | 0.182(50%) | 0.182(50%) |
| Mix 6 | 0.145(40%) | 0.219(60%) |
| Mix 7 | 0.109(30%) | 0.255(70%) |
| Mix 8 | 0.073(20%) | 0.291(80%) |
| Mix 9 | 0.0364(10%) | 0.328 (90%) |

Table 3: Optimum Ratio for Textile and Tannery Sludge

Prepare 150 X 150 X 150 mm cubes were tested in a compression test machine and the compressive strength was calculated by using following equation:

$$\sigma = P/A \ (N/mm^2)$$

Where, σ = Maximum compressive strength
P = Maximum load carried by the cube before failure.
A = Cross sectional area of cube is $22500mm^2$.

## IV. RESULTS AND DISCUSSION

### A. *Strength Compression and Leachability Test:*

Compression Strength and Leachability tests were conducted on the cubes which were produced using fine aggregate partially replaced by textile and tannery sludge. The compressive strength of cubes on $3^{rd}$ day is shown in fig-1.

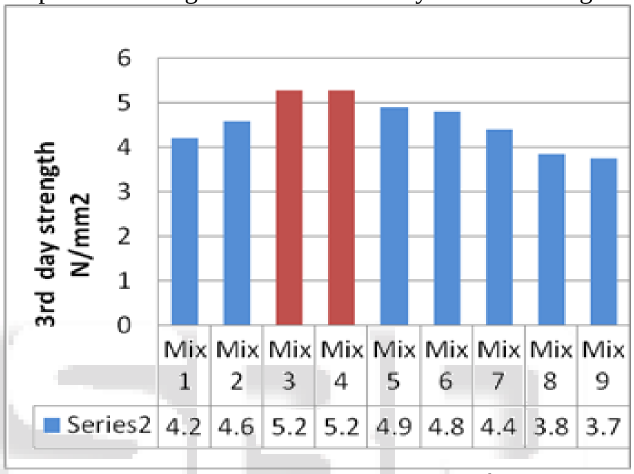


Fig. 1: Compressive Strength of Cubes On $3^{rd}$ Day (Tan-Sl & Tex-Sl)

Apart from initial nine concrete blocks, $3^{rd}$ and $4^{th}$ mix ratio only have the strength equal to the strength of nominal block (M15= $6N/mm^2$).

Leachability test was conducted for the curing liquid sample obtained from $3^{rd}$ and $4^{th}$ mix ratio concrete block and the leechate analysis have shown leaching of some metals at low concentration (Table 4 &5).

| Parameters | Results (mg/l) |
|---|---|
| Calcium as Ca | 83.9 |
| Chromium as Cr | 0.02 |
| Lead as Pb | 0.03 |
| Manganese as Mn | 0.01 |
| Nickel as Ni | 0.005 |
| Zinc as Zn | 0.008 |

Table 4: Test Report for Sample 1 (3rd Mix Ratio)

| Parameters | Results (mg/l) |
|---|---|
| Calcium as Ca | 224 |
| Chromium as Cr | 0.11 |
| Lead as Pb | 0.006 |
| Manganese as Mn | 0.026 |
| Nickel as Ni | 0.016 |
| Zinc as Zn | 0.03 |

Table 5: Test Report for Sample 2 (4th Mix Ratio)

 

3rd mix ratio was selected based on the results obtained from the leachability test and the compressive strength test conducted for above mix is given in table-8 and results presented in graph fig-2.

| Concrete blocks with (%)sludge | 10 | 15 | 20 |
|---|---|---|---|
| 7th day ($N/mm^2$) | 10 | 9.7 | 8.8 |
| 28th day ($N/mm^2$) | 17.7 | 16.1 | 15.5 |

Table 6: Compressive Strength of Cubes On 7th And 28thdays (70%Tan-Sl &30%Tex-Sl)

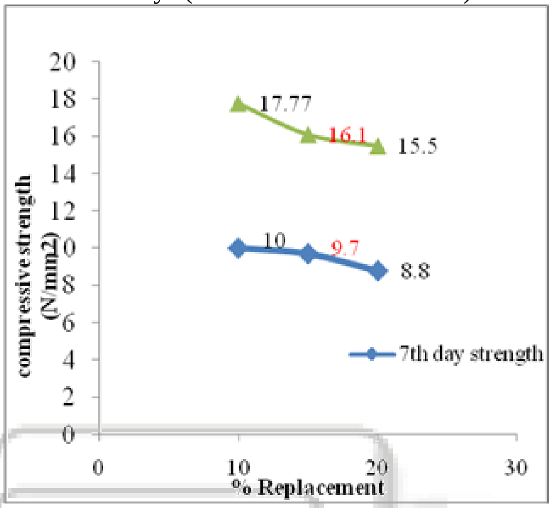


Fig. 2: Compressive Strength of Cubes On 7th And 28th Days (70%Tan-Sl &30%Tex-Sl)

From the above results obtained from Table 6, it was concluded that sand replacement was possible only up to 15% for both tannery and textile lime sludge. Sathishkumar et al (2015) concluded that partial replacement of 15% of tannery waste over fine aggregate will eventually increase the strength of the concrete and found to be optimum replacement. And also Baskar et al (2006) concluded that the maximum amount of textile sludge that can be added is in range of 6 to 9% due to the presence of chromium up to the level of 358mg/kg. But here in sand replacement was possible only up to 15% for both tannery and textile lime sludge due to the presence of chromium up to the level of 23.7 mg/kg.

Leachability results due to the curing of 3rd concrete block (3rd mix block = 70% tannery and 30% textile) with 15% replacement of sand after 7th days showed that.

| Parameters | Results (mg/l) |
|---|---|
| Calcium as Ca | 15.9 |
| Chromium as Cr | 0.009 |
| Lead as Pb | 0.005 |
| Manganese as Mn | (DL:0.001) |
| Nickel as Ni | 0.006 |
| Zinc as Zn | 2.17 |

Table 7: Test Report for 3rd Mix Ratio with 15% Replacement

Mix is suitable only up to 15% for both tannery and textile lime sludge. In another study with textile lime sludge alone as sand replacement with Portland Pozzolano cement (PPC) revealed that sand replacement is possible only up to 20% for textile lime sludge as a sand replacement material. (Table 8 & Fig3)

| Replacement % | 7th day strength ($N/mm^2$) | 14th day strength ($N/mm^2$) | 28th day strength ($N/mm^2$) |
|---|---|---|---|
| 10 | 9.56 | 15.66 | 17.77 |
| 20 | 8.36 | 14 | 16.89 |
| 30 | 6.67 | 13.5 | 15.5 |

Table 8: Compressive Strength of Cubes Made of Textile Sludge On7th, 14th &28th Day

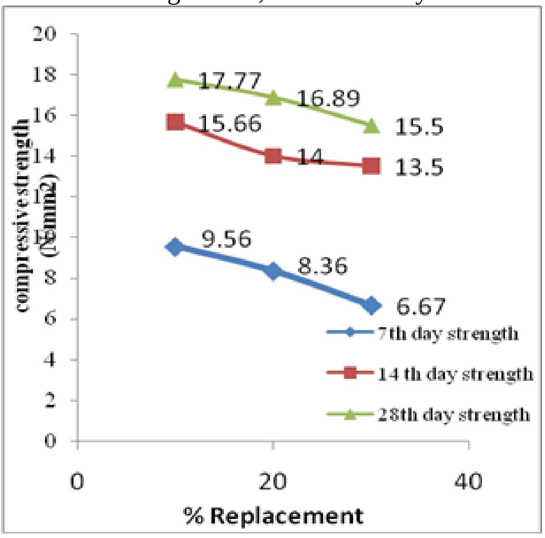


Fig.3: Compressive Strength of Cubes Made of Textile Sludge On7th, 14th &28th Day

From the above results obtained from table-8, it is concluded that sand replacement was possible only up to 20% for textile lime sludge as a sand replacement material. Raghunathan (2010) has concluded that SSA (Synthetic Sludge Aggregate) can be used only up to 5% as replacement of sand without affecting the strength of concrete. The compressive strength of the concrete cubes decreases with increase in percentage of SSA.This may be due to the presence of Chlorides of 36.85% and Sulphate of 20.63%. Both Chloride and Sulphate are deleterious to concrete. But here in sand replacement was possible only up to 20% for textile lime sludge using PPC instead of OPC.

### *B. Cost Analysis:*

The cost detail of a building with inter-dimension of 3m x 3m with wall thickness of 200mm and roof slab of 150mm with lintel beam 100mm is the cost of the replaced concrete aggregate was compared with normal concrete M-15 grade and material needed in table-9.

| Items | Dimensions | Quantity |
|---|---|---|
| Wall | 12.8m x 3m x0.2m | $7.68m^3$ |
| Deduction- | | |
| Door | (2.1m x 1.2m) x 0.2m | $0.504m^3$ |
| Window | 1.5m x1.2m x0.2m | $0.36m^3$ |

Table 9: Quantity of Material Required for Single Room Building

Total= $6.816\ m^3$

The cost of nominal concrete M15 grade with cement mortar 1:6 grade for $1m^3$ is Rs.6088.56 (including labour and mixing charge). But cost of concrete made with 15% replacement of sand with 70% Tannery and 30% Textile sludge for $1m^3$ is Rs.5990.55 and for 20% replacement with textile sludge for $1m^3$ is Rs.5957.88. Based on the cost analysis; total cost required for construction of $6.816\ m^3$ with nominal concrete is Rs.41499.63. But cost required for the production of concrete with 15% replacement of sand is Rs.40831.59 which is 1.6% lesser than former. And also cost required for the production of concrete with 15% replacement of sand is Rs.40608.91which is 2.15% lesser than nominal

## V. CONCLUSION

The present study revealed that:
Concrete is stable till after 15% replacement of sand with textile and tannery sludge together based on the strength on 7th and 28th days. The Water/cement ratio was inadequate for the 3rd mix ratio (70% tannery & 30% textile) which leads to improper bonding between sand and sludge. While using the textile lime sludge only as a sand replacement, concrete was stable up to 20% replacement of sand based on 7th day test. However, higher strength could be achieved at 30% replacement of sand for 28th day.

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