International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.4, pp 2219-2226, 2015

Effect of Compressive Strength on Concrete by Partial Replacement of Cement with Textile Sludge and Polypropylene Fibres

Sudheesh.C[1]*, T.R.Praveen Kumar[1], Sasi Kumar.S[1]

[1]Department of Civil Engineering, Sathyabama University, Chennai-119, India

Abstract: In the present study, it is proposed to study the effect of addition of textile sludge as cement replacement material and quarry dust as fine aggregate replacement material in the paver blocks. It is also proposed to add polypropylene fibre to increase the performance characteristics of paver blocks. In this paper control concrete pavers were made using ordinary Portland cement. Textile sludge an industrial waste from bauxite ore processing contains some heavy metals which are hazardous in nature. So, the present study is to utilize textile sludge along with quarry dust in the production of concrete paver blocks.. An experimental program was designed to assess compressive strength, characteristics of paver blocks. The results of the study revealed improvements in concrete compressive strength was found by replacing a portion cement with Quarry dust and textile sludge.
Keywords: Polypropylene fibre, Textile sludge, Heavy metals, Quarry dust.

1. Introduction

The textile industry is one of the oldest and largest sectors in India. At present it is amongst the top foreign exchange earning industries for India .The textile industry involves processing or converting raw material into finished cloth employing various operations. It consumes large quantities of water and produces polluting waste effluents. About 200 tons/day of textile sludge are generated in Tirupur The inorganic salts and toxic metals in the sludge pose a threat to residents. The low efficiency of chemical operation and spillage of chemicals cause a significant pollution hazard and make the treatment of discharge water a complex problem. But in this process, a significant amount of effluent is generated which needs to be treated and during the process of treatment significant amount of sludge is generated.

The solid waste usually comprises of fibre/yarn from spinning unit, waste fabric, packaging materials and sludge from effluent treatment plants[1][2].The gaseous waste is generally produced by volatile reactants or by products and the gases from boilers. This sludge creates more negative impacts in many ways as far as the correct disposal techniques are not adopted. There is a growing need to find alternative solutions for textile sludge management[4].

The textile sludge has a high calcium and magnesium content, which comes mainly from coagulating chemicals (magnesium salts and lime). The presence of high calcium and magnesium indicates the potential use of this sludge as partial replacement of cement in the production of various non structural materials[3]. In India, nearly 250 million tones of industrial wastes are generated annually. Other industrial wastes have been used in building materials as partial replacement of cement, as replacement of clay in bricks, or for use in flooring tiles and walling materials[5]. The necessity for the addition of fibres in structural material is to increase the strength of the concrete and mortar and also to reduce the crack propagation that mainly depends on the following parameters[6].

- Strength characteristics of fibre
- Bond at fibre matrix interface
- Ductility of fibres
- Volume of fibre reinforcement
- Spacing, dispersion, orientation, shape and aspect ratio of fibre.

In the present study, it is proposed to study the effect of addition of textile sludge as cement replacement material and quarry dust as fine aggregate replacement material in the paver blocks. It is also proposed to add polypropylene fibre to increase the performance characteristics of paver blocks

2. Selection Of Materials and Mix Design

In developing the concrete mix for paver blocks, it is important to select proper, ingredients, evaluate their properties among different material for optimum usage. The ingredients used for this investigation were cement, quarry dust and sand as fine aggregate, coarse aggregates, water and textile sludge.

In this study ordinary Portland cement (Coromandel King) of 53 grade confirming to Indian standard IS 12269-1987 (BIS, 1987b)[12], with physical and chemical properties as given in Table 2.1, 2.2, has been used.

Table 2.1 Physical properties of OPC (53 grades)

Tests	Requirement of IS 12269-1987	Results
Specific gravity	---	3.15
Consistency	---	31%
Initial setting time	30 min	120 min
Final setting time	600 min	240 min

Table 2.2 Chemical composition of OPC (53 grade)

Properties	Results
Silicon Dioxide	20.78
Aluminium oxide	4.44
Ferric oxide	2.88
calcium oxide	63.78
Magnisium oxide	3.66
Sulphur Trioxide	2.75
Sodium oxide	0.46
Pottassium oxide	0.64
Loss of ignition	0.61

The normal maximum size of coarse aggregates used in production of paver blocks shall be 12 mm. In this experimental work the locally available crushed stone conforming to graded aggregate of nominal size 10 mm as per IS 383-1970 was used[11] .

For the coarse aggregates, the following test has been carried out. The results are shown in Table 2.3 and conforming to IS2386 (part 1) 1963[7].

Table 2.3 Physical properties of coarse Aggregate

Tests	Results
Fineness Modulus	7.41
Specific gravity	2.83
Bulk density(compacted bulk density)	1816 Kg/m^3

For sand, the following test has been carried out and conforming to IS 2386 (part I)-1963[7].The physical properties' results are shows in Table 2.4.

Table 2.4 Physical properties of sand

Tests	Results
Fineness Modulus	3.335
Specific gravity	2.705
Bulk density(compacted bulk density)	1707 Kg/m^3

In this study the quarry dust used as fine aggregate at a replacement level of 75%. The Quarry Dust obtained from local resource was used in concrete and also confirming to grading zone I of IS 383-1970 [11](BIS, 1970). Thus the quarry dust may be examined for the physical properties by using the standard of fine aggregate. After testing the properties, the following results are obtained. The physical properties' results were shows in Table 2.5.

Table 2.5 Physical properties of quarry dust

Tests	Results
Fineness Modulus	3.25
Specific gravity	2.6
Bulk density(compacted bulk density)	1750 kg/m^3

2.1 Textile Sludge

The textile sludge was obtained from the Veerapandi common effluent treatment plant (CETP), Tirupur town, Tirupur district, Tamilnadu State, India. The sludge was collected from the sludge drying beds and land filling areas by Systematic sampling procedure. The sludge had a roughly 30% moisture content. The collected sludge was sundried to remove the moisture content present in the sample. The dried sample was crushed and then sieved through 90 micron sieve

The physical and chemical properties of textile sludge as shown in the Table 2.6.

Table 2.6 Properties of Sludge

Properties	Values
Water content	28.72 %
Specific Gravity	2.4
PH	9.13
Cadmium	3.93 mg/kg
Copper	57.48 mg/kg
Total Chromium	2.98 mg/kg
Zinc	91.60 mg/kg
Lead	0.68 mg/kg
Ferrous	12.1 mg/kg
Sulphates	180.5 mg/kg
Sulphides	1167 mg/l
Calcium	108.22 mg/l
Magnesium	154.30 mg/l
Chlorides	5445 mg/l
Total hardness as Caco3	905 mg/l
Total Volatile solids	31.85 %

2.2 Polypropylene Fiber

In nominal lengths of 6, 12 or 18 mm, polypropylene fibre is the ideal additive for concrete mixtures in order to reduce plastic shrinkage, cracking and crazing and improve the surface properties of the concrete.

Table 2.7 Physical properties of fibre

Modulus of elasticity	3,500 – 3,900 N/mm^2
Extensibility	320 – 400 N/mm^2
Melting point	160 – 170 °C
Electrical conductivity	Zero
Density (g/cm3)	0.91

3. Mix design

Table 3.1 Mix Proportion of M50

Cement Kg/m^3	Fine Aggregates Kg/m^3	Coarse aggregate Kg/m^3	Water lit/m^3
504.4	898.56	833.15	201.76
1	1.78	1.65	0.4

3.1 Mix Combinations

For the present study, twenty five mix combinations were selected as shown in Table 3.2, 3.3, 3.4, 3.5and 3.6. The textile sludge was used as a replacement of cement by 10 %, 20 %, 30 %, 40 % and polypropylene fibre were used as addition at 0.25 %, 0.5 %, 0.75%, and 1% by volume in the above combination

Table 3.2 Mix combination A (0 % Sludge & 0 to 1 % Fibre)

S.No	Mix combination	Sludge (%)	Polypropylene Fibre (%)
1	S 0 F 0	0	0
2	S 0 F 0.25	0	0.25
3	S 0 F 0.5	0	0.5
4	S 0 F 0.75	0	0.75
5	S 0 F 1	0	1

Table 3.3 Mix combination B (10 % Sludge & 0 to 1 % Fibre)

S.No	Mix combination	Sludge (%)	Polypropylene Fibre (%)
1	S 10 F 0	10	0
2	S 10 F 0.25	10	0.25
3	S 10 F 0.5	10	0.5
4	S 10 F 0.75	10	0.75
5	S 10 F 1	10	1

Table 3.4Mix combination C (20 % Sludge & 0 to 1 % Fibre)

S.No	Mix combination	Sludge (%)	Polypropylene Fibre (%)
1	S 20 F 0	20	0
2	S 20 F 0.25	20	0.25
3	S 20 F 0.5	20	0.5
4	S 20 F 0.75	20	0.75
5	S 20 F 1	20	1

Table 3.5 Mix combination D (30 % sludge & 0 to 1 % fibre)

S.No	Mix combination	Sludge (%)	Polypropylene Fibre (%)
1	S 30 F 0	30	0
2	S 30 F 0.25	30	0.25
3	S 30 F 0.5	30	0.5
4	S 30 F 0.75	30	0.75
5	S 30 F 1	30	1

Table 3.6 Mix combination E (40 % sludge & 0 to 1 % fibre)

S.No	Mix combination	Sludge (%)	Polypropylene Fibre (%)
1	S 40 F 0	40	0
2	S 40 F 0.25	40	0.25
3	S 40 F 0.5	40	0.5
4	S 40 F 0.75	40	0.75
5	S 40 F 1	40	1

4. Results and Discussions

Compressive Strength Results

4.1 Mix Combination – A (0 % Sludge & 0-1 % Fibre)

The variation of compressive strength at 7^{th} days and 28^{th} days of the paver blocks with zero percentage textile sludge with various percentages of fibre up to 1% are shown in Table 4.1 and Figure 4.1

Table 4.1 Compressive strength results for combination A

S.No	Mix combination	Compressive strength at 7th day (Mpa)	Compressive strength at 28th day (Mpa)
1.	S 0 F 0	46.3	61.45
2.	S 0 F 0.25	48	63.12
3.	S 0 F 0.5	51.25	66.11
4.	S 0 F 0.75	46.5	61.6
5.	S 0 F 1	42.03	56.83

Note; S – Sludge, F - Fibre

Table 4.1 and Figure 4.1 show the compressive strength at 7 days and 28 days for combinations of zero percentage sludge with various percentages of fibre up to 1%. From these results it was found that there is an increase in compressive strength due to the addition of fibre up to 0.5 % by the volume fraction. The rate of increase in compressive strength was 9% at 7 days and 8.5 % at 28 days.

4.2 Mix Combination – B (10 % Sludge & 0-1 % Fibre)

The variation of compressive strength at 7^{th} days and 28^{th} days of the paver blocks with 10 percentage textile sludge with various percentages of fibre up to 1% are shown in Table 4.2 and Figure 4.2.

Table 4.2 Compressive strength results for combination B

S.No	Mix combination	Compressive strength at 7th day (Mpa)	Compressive strength at 28th day (Mpa)
1.	S 10 F 0	42.33	56.09
2.	S 10 F 0.25	46.88	59.13
3.	S 10 F 0.5	48	62.86
4.	S 10 F 0.75	42.54	59.16
5.	S 10 F 1	39.5	51.43

Note; S – Sludge, F - Fibre

Table 4.2 and Figure 4.2 shows the 7 days and 28 days compressive strength at 10 % replacement level of sludge and 0-1 % fibre. From these results, it can be seen that the rate of decrease in compressive strength was 10.9 % at 7 days and 11.15 % at 28 days in the mix with sludge at 10% replacement level. It is further observed that for the same mix the maximum compressive strength was obtained when the percentage addition of fiber was 0.5 % and the rate of increase in compressive strength was 9 % at 7 days and 9.5 % at 28 days.

4.3 Mix Combination – C (20 % Sludge & 0-1 % Fibre)

The Table 4.3 shows variation of compressive strength at 7^{th} days and 28^{th} days of the paver blocks with 20 % textile sludge and 0-1 % fibre**.**

Table 4.3 Compressive strength results for combination C

S.No	Mix combination	Compressive strength at 7th day (Mpa)	Compressive strength at 28th day (Mpa)
1.	S 20 F 0	38.9	52.8
2.	S 20 F 0.25	39.7	54.83
3.	S 20 F 0.5	43.15	58.56
4.	S 20 F 0.75	39.7	55.54
5.	S 20 F 1	37	49.2

Note; S – Sludge, F - Fibre

4.4 Mix Combination – D (30 % Sludge & 0-1 % Fibre)

Table 4.4 shows the 7 days and 28 days compressive strength at 30 % replacement level of sludge and 0-1 % fibre

Table 4.4 Compressive strength results for combination D

S.No	Mix combination	Compressive strength at 7th day (Mpa)	Compressive strength at 28th day (Mpa)
1.	S 30 F 0	27.12	34.83
2.	S 30 F 0.25	32.32	40.02
3.	S 30 F 0.5	34.1	42.83
4.	S 30 F 0.75	29.63	37.73
5.	S 30 F 1	28.06	36.23

Note; S – Sludge, F - Fibre

Figure 4.3 and 4.4 shows the 7 days and 28 days compressive strength at 20 %, 30 % replacement level of sludge respectively with various percentage addition of fibre. From these results, it can be seen that the decrease in compressive strength at the rate of 11-14.3 % at 7 days and 11.8-15 % at 28 days. While adding the fibre content up to 0.5 % in the above combination the compressive strength increases at the rate of 12.6 -15.02 % at 7 days and 13.68- 15.1 % at 28 days.

4.5 Mix Combination – E (40 % Sludge & 0-1 % Fibre)

Table 4.5 shows the 7 days and 28 days compressive strength at 30 % replacement level of sludge and 0-1 % fibre

Table 4.5 Compressive strength results for combination E

S.No	Mix combination	Compressive strength at 7th day (Mpa)	Compressive strength at 28th day (Mpa)
1.	S 40 F 0	24.5	29.35
2.	S 40 F 0.25	23.14	29
3.	S 40 F 0.5	22.7	28.3
4.	S 40 F 0.75	21.37	27.62
5.	S 40 F 1	20.83	25.5

Note; S – Sludge, F - Fibre

Figure 4.5, shows the variation of compressive strength at 7 days and 28 days for the mix with 40% replacement of cement by sludge and addition of fibre at various fractions. From the results it is noted that there is no increase in compressive strength due to addition of fibres

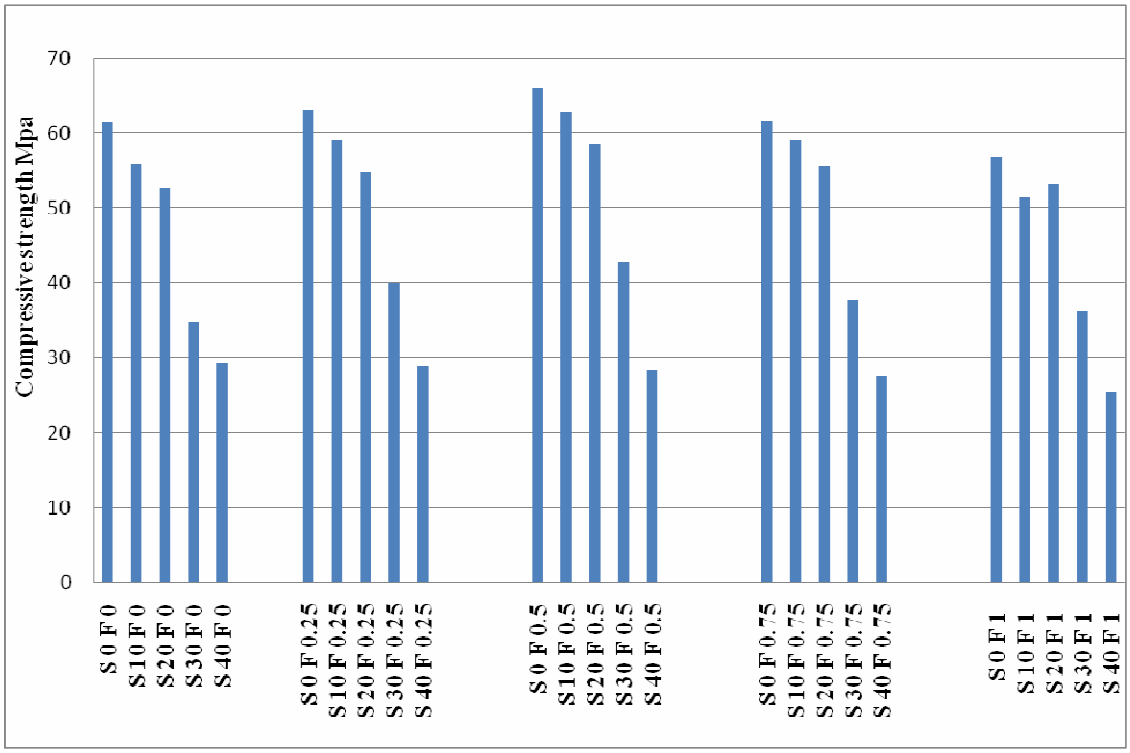

Fig 4.6 Compressive strength at 28th day

Conclusions

Extensive experimentation has been carried out to determine utilization of the textile sludge as cement replacement material in making the paver blocks and also to found out the effect of addition of polypropylene fibre. Based on the above results the following conclusions can be drawn.

- The result indicates that the compressive strength of paver blocks decreases with the increase in the amount of partial replacement of cement with sludge in paver blocks.
- The addition of fibre up to 0.5 % increases the compressive strength of paver blocks with sludge up to 30 % as cement replacement.
- The combinations obtained by replacing cement with 30% of textile sludge and fibre added at 0.75% and 1% yielded with 28 days compressive strength more than 30 Mpa and it can be used as paver blocks for non-traffic application such as building premises, monument premises, public gardens/parks, domestic drives, paths, embankment slopes, sand stabilization area etc..,

- Further the blocks with sludge at 30 % cement replacement level along with the fibre content of 0.25 % and 0.5 % yielded with 28 days compressive strength of more than 40 Mpa. Therefore the blocks can be used for medium traffic application such as city streets, low volume roads, utility cuts on roads etc ..,

- The paver blocks with the combination of sludge up to 20 % as cement replacement along with all fraction of fibres up to 1 % yielded with 28 days compressive strength of more than 50 Mpa. Therefore the blocks can be used for heavy traffic applications such as a industrial complexes, service station, and road on expansive soils etc..,

References

1. Alam M. N, Alam R, Basak R, Islam M. S. and Mahzuz H. M. A, (2009), 'Use of arsenic contaminated sludge in making ornamental bricks', International Journal of Environmental. Science., Vol 2, pp. 291-298.
2. Akilamudhan.P, Senthilkumar.K, Sivakumar.V, (2008), 'Experimental Studies On Disposal of Various Industrial Solid Wastes', Modern Applied Science.,Vol 2, pp. 128-132.
3. Balasubramanian.J, Sabumon P.C., John U. Lazar and Ilangovan.R (2006), 'Reuse of textile effluent treatment plant sludge in building materials', Waste Management., Vol 26, pp. 22–28.
4. Baskar.R, Meera Sheriffa Begum K.M and Sundaram S (2006), 'characterization and reuse of textile effluent treatment plant waste sludge in clay bricks', Journal of the University of Chemical Technology and Metallurgy., Vol 41, pp.473-478.
5. Hema Patel and Suneel Pandey (2009) ,'Exploring the Reuse Potential of Chemical Sludge from Textile Wastewater Treatment Plants in India-A Hazardous Waste', American Journal of Environmental Sciences., Vol 5, pp.106-110.
6. Shakir A. Salih and Mahan E. AL-Azaawee (2008), 'Effect of Polypropylene Fibers on Properties of Mortar Containing Crushed Brick as Aggregate', Dept. of building and construction engineering ,university of tech Eng.&Tech.., Vol.26, pp. 1508-1518.
7. IS : 2386 (Part III) – 1963, Methods of test for Aggregates for concrete
8. IS 15658: 2006, Code of practice for precast concrete paver blocks.
9. IS 10262: 2009, recommended guidelines for concrete mix design.
10. IS 456 : 2000, Plain and reinforced concrete - code of pract
11. IS 383: 1970, Specification for Coarse and fine aggregates from Natural sources for concrete
12. IS 12269:1987, Specification for 53 grade ordinary Portland cement.
13. IS 3025-1964, Method of sampling and test (physical and chemical) for water and wastewater.

*****