EXPERIMENTAL INVESTIGATION ON THE USE OF TEXTILE SLUDGE IN CONCRETE

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ABSTRACT

Textile sludge is the byproduct of dyeing industry. The textile industry is one of the oldest and largest sectors in India. In India there are about 240 dyeing industries and they collectively produces about 70 to 80 million tonnes of textile sludge as a byproduct every day. Thirupur itself generates about 60 tonnes of textile sludge as a byproduct every day. There are about 20 million tonnes of accumulated stokes of textile sludge in each site. The disposal of sludge from textile industry causes environmental pollution and thus its disposal or dumping is banned by the Pollution Control Board. Thus the disposal of textile sludge has become a serious techno-economic problem. This problem along with scarcity of cement and its increased cost can be rectified to some extend by replacing certain quantity of cement in concrete with sludge. Since we are replacing cement with textile sludge, the emission of carbon dioxide to the atmosphere can also be reduced. This is an important advantage of this study as carbon dioxide is a Greenhouse gas which creates various adverse effects to the environment such as global warming. Our present study deals with the experimental investigation in determining compressive strength, splitting strength and modulus of elasticity of various hardened concrete specimens containing different percentage of textile sludge content in it(i.e, 0%, 10%, 15% and 20%) at two different water cement ratios (0.4 & 0.5). Based on the experimental investigation conducted and subsequent analysis of test results the following conclusions are made. Addition of textile sludge to concrete affects the strength characteristics of concrete. Compressive strength, splitting tensile strength and modulus of elasticity has its maximum value at 0% replacement of cement and strength decreases with addition of textile sludge. The compressive strength for 10% replacement of cement with textile sludge at 0.4% water-cement ratio is 29.33MPa which is approximately equal to 30MPa which satisfies the minimum requirement of compressive strength of paver blocks as per IS15658:2006. Textile sludge concrete can be also used for constructing garden tiles, compound walls and partition walls. Thus the cost of concrete can be reduced as cement is being partially replaced. Thus this method is important in engineering, environmental and economic point of view.

KEYWORDS: *Textile Sludge, Compressive Strength, Splitting Tensile Strength, Modulus of Elasticity*.

I. INTRODUCTION

Difficulty in disposing waste is one of the serious problems faced by our country. Textile house is one of the leading and most polluting industrial sectors in India. Sludge generation and accumulation are the most serious problems faced by the treatment plants. Due to its chemical and mineral content, these industrial solid wastes are found to be hazardous in the view of environmental consideration. Unsafe disposal of the solid waste may cause harmful effects on the environment & human beings. Hence, solid waste management should be given primary importance before things becomes too convoluted. The conventional techniques for sludge disposal like compositing, land filling, agricultural utility, open dumping and thermal techniques are found to have some drawbacks such as land losing its fertility, possible contamination of underground water, requirement large surface area for storage and high cost of disposal. To overcome the drawbacks of the existing sludge disposal methods, an attempt has been made to dispose the solid sludge waste from textile house, The employment of waste sludge to produce valuable products is considered to be the most advanced trend in solid waste management.

II. TEXTILE SLUDGE

Textile waste is the combination of wastewater from various stages of production: fibers preparation, yarn, thread, webbing, dyeing and finishing. According to experts, a textile factory uses a large amount of water for manufacturing utilization in average, in which dyeing and finishing stages use almost 72.3%. Considering both the volume generated and the effluent composition, the textile industry wastewater is related as the most polluting among all industrial sectors. Important pollutants in textile effluent are mainly recalcitrant organics, colour, toxicants and inhibitory compounds, surfactants, chlorinated compounds. Dye is the most difficult constituent of the textile wastewater to treat, especially azo dyes-the class of dyes most widely used industrially, having a world market share of 60-70%. However, reactive dyes are easily washed off during the dyeing process, therefore, the residue dye always presents in the dye bath effluent, as much as 50% of the initial dye load. This is the reason why the colour and the pollutants concentration in textile wastewater are high.

Table1.1. Experimental result of solubility of textile sludge in various liquids.

LIQUIDS	SOLUBLE	PARTLY SOLUBLE	NOT SOLUBLE
CONC. HNO_3	√		
NAOH SOLUTION			√
COLD WATER			√
BOILED WATER		√	

1. Cyanide: The reagents used are aqueous sodium hydroxide (100g/l), aqueous ferrous sulfate (100g/l, freshly prepared in freshly boiled and cooled water), aqueous hydrochloric acid (100g/l). The procedure includes dilute 1 ml of sample with 2 ml of NaOH solution and add 2 ml of ferrous sulfate solution and then add sufficient HCl to dissolve the ferrous hydroxide precipitate. A blue colour is formed which indicates the presence of cynide.
2. Phenols: The reagents used are Folin-ciocelteau reagent and aqueous sodium hydroxide solution. The procedure includes dilute 1 ml of Folin-ciocelteau reagent with 2 ml of purified water and add 1 ml of NaOH solution and vortex-mix for 5 seconds. A blue colour is formed which indicate the presence of phenolic compounds. i.e, 2, 4, 6-trichlorophenol.
3. Ethanol: The reagents used are Potassium dichromate solution (2%) and Conc. H_2SO_4. The procedure involved are to 2 ml of the sample is added 0.2 ml of 2% potassium dichromate solution, followed by 1ml of Conc. H_2SO_4. The yellow colour of the dichromate changes to green which indicates the presence of ethanol.
4. Salicylates: The reagent used is neutral solution of $FeCl_3$. The procedure includes the addition of 1 ml of $FeCl_3$ solution to 2ml of sample and mix for 5 seconds. A purple colour is not formed which indicate the absence of salicylates.
5. Opium and derivatives: The reagents used are Conc. H_2SO_4 and formalin.The procedure includes the addition of a mixture of 3 ml conc.H_2SO_4 and 3 drops of formalin to the gastric fluid. A milky colour changed to reddish brown which indicate the presence of opium and derivatives.
6. Lead: The reagents used are stock lead solution, citrate-cynide reducing solution and dithizone solution. The procedure is take digested sample in a 250 ml separatory funnel. Add 10 ml of ammoniacal citratecynide solution, mix and cool to room temperature. Add 10 ml dithizone solution, shake stoppered funnel vigorously for 30 seconds, and let layers separate. Cherry red colour of the dithizone indicates the presence of Lead.

7. Iron: The reagents are aqueous HCl (2 mol/l), aqueous potassium ferricynide (10g/l) and aqueous potassium ferrocynide solution (10g/l). The procedure includes to 0.1 ml of sample add 0.1 ml of dilute HCl and 0.05 ml of potassium ferricynide solution and vortex-mix for 5 seconds. Then to a further 0.1 ml of sample add 0.1 ml of dilute HCl and 0.05ml potassium ferrocynide solution and vortex-mix for 5 seconds. Then leave for 5 minutes at ambient temperature and centrifuge for 5 minutes. Deep blue precipitate with potassium ferricynade and potassium ferrocyanideindicate the presence of ferrous and ferric iron respectively.

Table 1.2. Chemical compounds present in textile sludge.

COMPONENTS	PRESENT	ABSENT
CYANIDE	√	
PHENOLS	√	
ETHANOL	√	
SALICYLATES		√
OPIUM	√	
IRON	√	
LEAD	√	

III. EXPERIMENTAL INVESTIGATION

For investigating the strength characteristics of the concrete containing textile sludge, compressive strength test, splitting tensile strength test and modulus of elasticity test are conducted. The tests are conducted using concrete specimens prepared with 0%, 10%, 15% and 20% replacement of cement with textile sludge. The study aims at finding, the change in the strength characteristics of concrete with the addition of textile sludge and the optimum amount of textile sludge which gives maximum strength to concrete.

3.1. Materials required

Cement: Ordinary Portland Cement of grade 43 is used for the investigation. Different tests are carried out to find the properties of cement as per IS 4031-1988.The properties of cement obtained from the tests are: fineness-2%, normal consistency-32%, specific gravity-2.9, initial setting time-35 minute, final setting time-4hours. From the tests, it is proved that the cement satisfies requirements as per IS 12269-1987.

Fine Aggregate: The properties of the fine aggregate obtained as per the test result are: Fineness modulus-2.649 and specific gravity-2.871.The fine aggregates satisfy the requirements as per IS 2386-1963.

Coarse Aggregate: Aggregate with 20mm nominal size is used. The properties obtained from the tests are-Fineness modulus-2.649, specific gravity-2.765, bulk density-1.56, void ratio-0.723 and porosity-0.419.The coarse aggregate satisfies the results as per IS 2386-1963.

Textile sludge: The textile sludge is collected from SCM dyeing, Erode. The properties of textile sludge are- Fineness- 1%, initial setting time-3hours 45minutes, final setting time- 5hours 3minutes. P^H value is 3.9 which is tested in a digital P^H meter at 30^0c. This shows textile sludge is acidic in nature.

Water: The water used for preparing concrete is clean and free from acids and organic substances.

3.2. Steps involved

Estimation of ingredients

For every type of concrete 4 cubes are prepared for testing compressive strength and a total of 3 cubical specimens are prepared for testing splitting tensile strength and modulus of elasticity. Specimens are prepared for 0%, 10%, 15% and 20% textile sludge content with water cement ratios 0.4 and 0.5.The size of cubical specimen is 150mmx150mm and size of cylindrical specimen is 150mm diameter and 300mm height. The total number of specimens is 56.Quantities of materials required for preparing concrete specimens are prepared by absolute volume method. While doing the estimation 20% extra is added to the total quantity. To prepare 4 cubical and 3 cylindrical specimens of 10% cement replacement at water-cement ratio 0.4, the quantity of ingredients required are-cement-13.14kg, fine aggregate-21.89kg, coarse aggregate-43.99kg, textile sludge-1.46kg, water-5.84kg.

Weighing and batching

The proportioning of ingredients-cement, fine aggregate, coarse aggregate, textile sludge and water are done by mass. The mass of each material is taken accurately to keep the correct proportion.

Mixing of concrete

For preparing textile sludge concrete, the first step is to mix the weighed quantity of cement and textile sludge till it become a homogenous mixture. Then fine aggregate and coarse aggregate are added to it and is mixed well. Thereafter, add water uniformly and continue mixing till a homogenous mass is obtained,

Placing of concrete in moulds

The concrete is placed in cubical and cylindrical moulds in 3 equal layers by tamping each layer with an iron rod.

Curing

Concrete specimens prepared are immersed in water 24 hours after placing the concrete. The curing is done for 28 days.

Testing of specimens

After 28 days of curing, the specimens prepared are tested. Compressive strength test, splitting tensile strength test, and modulus of elasticity test are done with the prepared specimens.

IV. RESULTS OF THE EXPERIMENTAL INVESTIGATION

4.1. Compressive strength

The compressive strength of concrete is found to be decreasing with the addition of textile sludge. The compressive strength is more for 0.4 water-cement ratio as compared to 0.5 water-cement ratio. At 10% replacement of cement with textile sludge, the compressive strength at 0.4 water-cement ratio is 29.33MPa which is approximately equal to 30MPa. As per IS 15658-2006, the minimum compressive strength to be used as a paver block is 30MPa which is satisfied here. The compressive strength at 10% replacement of cement with textile sludge is almost nearer to that of normal concrete than that of 15% and 20 %. This shows that the optimum value is between 0-10% replacement of cement with textile sludge.

Table 3.1. Result of the experimental investigation showing the compressive strengths of concrete with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

REPLACEMENT OF CEMENT,%	WATER-CEMENT RATIO	COMPRESSIVE STRENGTH, N/MM^2
0	0.4	36.79
	0.5	29.2
10	0.4	29.33
	0.5	22.2
15	0.4	26.1
	0.5	13.2
20	0.4	17.6
	0.5	9.0

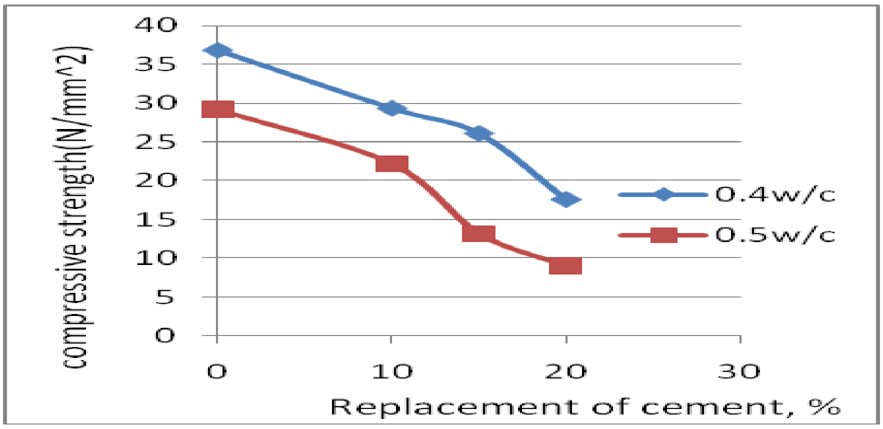

Fig 3.2. Variation of compressive strength with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

4.2. Splitting tensile strength

Splitting tensile strength values also show similar trend as in the case of compressive strength. The splitting tensile strength is found to be maximum at 0% textile sludge content with water-cement ratio 0.4. The splitting tensile value for 10% replacement of cement with textile sludge is almost nearer to that of normal concrete than that with 15% and 20% textile sludge content. Thus the optimum value is between 0 and 10% replacement of cement with textile sludge.

Table 3.2. Result of the experimental investigation showing the splitting tensile strength of concrete with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

REPLACEMENT OF CEMENT, %	WATER-CEMENT RATIO	SPLITTING TENSILE STRENGTH, N/MM^2
0	0.4	2.72
	0.5	2.47
10	0.4	2.36
	0.5	2.14
15	0.4	2.34
	0.5	1.62
20	0.4	2.12
	0.5	1.25

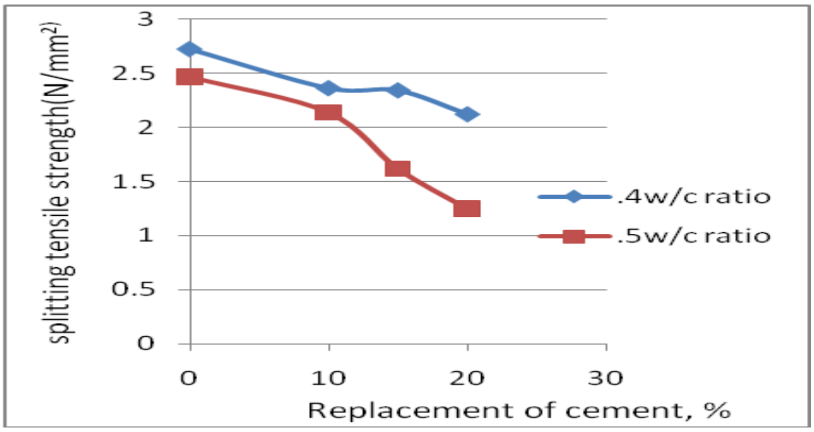

Fig 3.2. Variation of splitting tensile strength with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

4.3. Modulus of elasticity

Modulus of elasticity test is conducted to check whether the strain in concrete specimen is affected by the addition of textile sludge or only the stress is affected. By the test result, it can be inferred that the strain is not showing any significant change with the addition of textile sludge. But the stress value changes with the addition of textile sludge. Thus the modulus of elasticity changes in a way similar to the variation in compressive strength with the addition of textile sludge. The modulus of elasticity is maximum at 10% cement replacement with textile sludge at water cement ratio 0.4 than that with 15% and 20% replacement but less than that of normal concrete.

Table 3.3. Result of the experimental investigation showing the Modulus of Elasticity of concrete with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

REPLACEMENT OF CEMENT,%	WATER-CEMENT RATIO	MODULUS OF ELASTICITY, N/MM^2
0	0.4	40000
	0.5	37500
10	0.4	33000
	0.5	27500
15	0.4	28000
	0.5	22500
20	0.4	24000
	0.5	13600

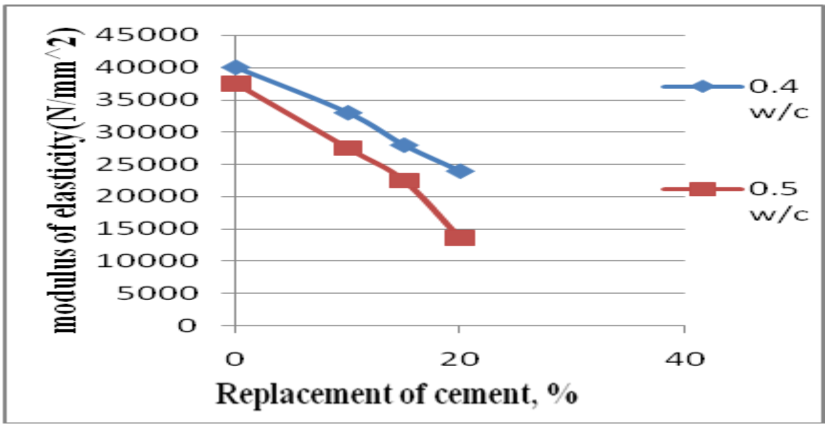

Fig 3.2. Variation of Modulus of Elasticity with different percentage replacement of textile sludge at water-cement ratios 0.4 and 0.5

V. CONCLUSION

From the experimental investigation of textile sludge concrete we can arrive at the following conclusions-

1. Addition of textile sludge to concrete affects the strength characteristics of concrete. Strength of concrete decreases with increase in percentage of textile sludge.
2. Compressive strength, splitting tensile strength and modulus of elasticity has its maximum value at 0% replacement of cement with textile sludge, it reduces considerably if the percentage replacement is more than 10%.Thus the optimum amount of textile sludge to be added to concrete is between 0% and 10%.
3. At 10% replacement of cement with textile sludge, the compressive strength at 0.4 water-cement ratio is 29.33MPa which is approximately equal to 30MPa. As per IS 15658-2006, the minimum compressive strength to be used as a paver block is 30MPa which is satisfied here. Thus the specimen can be used for constructing paver blocks in building premises and public garden or parks.
4. The textile sludge concrete can be also used for constructing compound walls, partition walls, garden tiles, foot path slabs where RCC is not used as textile sludge can corrode reinforcements and all other temporary structures.
5. The durability of the specimen used for these purposes depends upon the age of the textile sludge used in it. As age increases durability will decrease and vice versa.
6. There will be significant reduction in the cost of concrete as cement is replaced by textile sludge.

7. Carbon dioxide emitted from the worldwide production of Ordinary Portland Cement corresponds to approximately 7% of the total Greenhouse gas emissions into the atmosphere. So if we replace cement with textile sludge, it can reduce the CO_2 emission which is cost effective and eco-friendly.
8. The use of textile sludge in concrete in place of cement is a long lasting solution to its disposal as it is banned by the Pollution Control Board.

VI. FUTURE WORK

This work can be done in future with textile sludge content between 0% to 10% for which it is expected to obtain more strength. Also the same work can be done for the partial replacement of fine aggregate in concrete.

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