A STUDY ON TEXTILE SLUDGE MANAGEMENT

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ABSTRACT

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 units are scattered all over India; out of 21076 units, Tamilnadu alone has 5285 units. The textile industry involving processing or converting raw material into finished cloth has various operations. Textile processing consumes enormous quantity of water and chemicals for various operations like washing, dyeing etc. Low efficiency of chemical operations and spillage of chemicals cause a significant pollution hazard and make the treatment of discharged wastewater 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.

INTRODUCTION

These industries have established eight common effluent treatment plants (CETPs) and several Effluent Treatment plants (ETPs) for treatment of their liquid effluents. Sludge is generated during the treatment process as a result of chemical coagulation (by the addition of Aluminium /iron/ magnesium salts and lime), flocculation and liquid/solid separation. About 200 tonnes of textile sludge is generated every day in Tirupur.

Although some of the sludge is disposed in an engineering landfill, much of the sludge is openly dumped, which leads to soil, surface water and ground water contamination. In textile industries, all the three types of wastes i.e., liquid, solids and gaseous are generated and the liquid effluent is essentially a mixture of dissolved, colloidal and suspended materials. The solid waste usually comprises of fiber or yarn from spinning unit, waste fabric, packaging materials and sludge from effluent treatment plants. The gaseous waste is generally produced by volatile reactants or by products and the gases from boilers. The sludge produced is hazardous. 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 the sludge management.

Blast furnace slag cements are in use for a reasonably long period due to the overall economy in their production as well as their improved performance characteristics in aggressive environments. Also, the use of pozzolans as additives to cement, and more recently to concrete, is well accepted in practice. Ground granulated blast furnace slag (GGBS) is one such pozzolanic material which can be used as a cementitious ingredient in either cement or concrete composites. Research work to date suggests that these supplementary cementitious materials improve many of the performance characteristics of the concrete, such as strength, workability, permeability, durability and corrosion resistance.

River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste. Quarry rock dust can be an economic alternative to the river sand. Quarry Rock Dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. Use of Quarry rock dust as a fine aggregate in concrete draws serious attention of researchers and investigators

In the present study, it is proposed to study the effect of addition of textile sludge, GGBS as cement replacement materials and quarry dust as fine aggregate replacement material in the paver blocks.

LITERATURE REVIEW

Jagdish Prasad et al., (2010) studied the compressive strength properties when GGBFS is used to make concrete. The uniaxial compression tests have been conducted on these concrete specimens with and without GGBFS at the ages of 3, 7, 28, 56, 90, 150 and 180 days. The cube compressive strength of GGBFS based concrete has been found to be lower than the compressive strength of plain concrete at all ages and for all percentage of cement replacements. However, among GGBFS based concrete, at the age of 56 days, the concrete made with 40% replacement of cement by GGBFS attains higher compressive strength as compared to the 20% and 60% GGBFS based concrete. Similar trend has also been found for cylinder compressive strength of plain and GGBFS based concrete. Therefore, 40% cement replacement has been found to be optimum among all the GGBFS based concretes at the age of 56 days.

Berndt M.L. et al., (2009) conducted studies to make material substitutions so that the environmental, energy and CO_2-impact of concrete could be reduced. This was accomplished by partial replacement of cement with large volumes of fly ash or blast furnace slag and by using recycled concrete aggregate. Five basic concrete mixes were considered. These were: (1) conventional mix with no material substitutions, (2) 50% replacement of cement with fly ash, (3) 50% replacement of cement with blast furnace slag, (4) 70% replacement of cement with blast furnace slag and (5) 25% replacement of cement with fly ash and 25% replacement with blast furnace slag. Properties investigated included compressive and tensile strengths, elastic modulus, coefficient of permeability and durability in chloride and sulphate solutions. It was determined that the mixes containing 50% slag gave the best overall performance. Slag was particularly beneficial for concrete with recycled aggregate and could reduce strength losses. Durability tests indicated slight increases in coefficient of permeability and chloride diffusion coefficient when using recycled concrete aggregate. However, values remained acceptable for durable concrete and the chloride diffusion coefficient was improved by incorporation of slag in the mix.

Hema Patel et al., (2009) conducted various tests like unconfined compressive strength, hardening time and block density on the Standard blocks of dimensions 70.6×70.6×70.6 mm, in which chemical sludge was used as a partial replacement of cement by mixing 30-70 % of sludge in cement. The compressive strength in the sludge cement blocks ranged from 2.63-22.54 N/mm^2, after 14 days of water curing and 6.48-24.89 N/ mm^2 after 28 days of water curing for30, 40, 50, 60 and 70 % replacement of cement by sludge. The block density varied between 1361and 1813Kg/m^3 after 14 days and 1386 and 1842 Kg/ m^3 after 28 days of water curing.

Swamy R.N. et al., (2009) conducted tests to determine some of the durability aspects of concrete containing 50% and 65% of slag replacement, exposed to different curing environments. The mix proportioning of the slag concretes was carried out in such a way that they had low water–binder ratios and high workability, and developed compressive strengths similar to concrete without slag from 3 days onward. The pore size distribution, microstructure and carbonation penetration, as affected by curing regime, of these concrete and their resistance to alkali–silica reaction are reported. The results show that initial water curing of about 7 days prior to exposure to a drying environment is essential to minimise the damage to microstructure that influence the durability of the slag concretes. The data also show that even when exposed to an aggressive environment, slag concretes have a refined pore structure compared to normal concrete, and a better resistance to deterioration.

Baskar R. et al., (2006) studied the effect of sludge composition (3% to 30%) at the firing temperature of 200-800 ^{o} C with a firing duration of 2 to 8 hours on the quality of bricks. Bricks with more than 9% sludge did not satisfy the prescribed norms of compressive strength at the maximum range of temperature studied. Thus textile sludge up to 9% can be effectively added in the manufacture of bricks. The amount of water absorption is also directly proportional to quantity of sludge added. Increase in the firing temperature results in decrease in the water absorption thereby increases the weathering resistance. Compressive strength increases almost linearly with the firing duration. They concluded that with less than 9 % sludge fired at 800°C for more than 8 hours satisfy the criteria for quality bricks.

Balasubramanian J. et al., (2005) Conducted experiments on pavement blocks, flooring tiles, solid blocks, bricks and hollow blocks to study the various properties.

In pavement blocks they conducted tests on compressive strength and water absorption and concluded the following. The addition of textile sludge up to 20% cement replacement levels gave 80% of the compressive strength of control blocks (without sludge). The blocks with 30% of sludge as cement replacement material attained 70- 80% of the compressive strength of the blocks without sludge. The water absorption of the pavement blocks having 30 % sludge as cement replacement material was less than 10% and that met with the BIS requirement.

Palanivelu K. et al., (2001) studied the characteristics of sludge generated from Common Effluent Treatment Plants (CETP) and Effluent Treatment Plants (ETP) put up by the textile industry. They determined the leachability of the sludge by Toxicity Characteristics Leaching Procedure (TCLP) and German leach method. The characteristics of the sludge collected from Tirupur area were found. All heavy metals were present within regulatory limits. The toxicity characteristics leaching procedure (TCLP) test was done and the concentration of heavy metals Pb, Zn, Cd, Cu, Hg and phenol present in the leachate were found to be within the regulatory limits as per the US-EPA. From German leach test it was found that multiple liners are necessary for the disposal of this sludge. The textile effluent treatment plant sludge is found to be non-hazardous depending on heavy metal concentration.

Ganesh Babu K. et al., (2000) conducted tests to quantify the 28-day cementitious efficiency of ground granulated blast furnace slag (GGBS) in concrete at the various replacement levels. It was observed that this overall strength efficiency of GGBS concretes can also be defined through a procedure adopted earlier for other cementitious materials like fly ash and silica fume. The overall strength efficiency was found to be a combination of general efficiency factor, depending on the age and a percentage efficiency factor, depending upon the percentage of replacement as was the case with a few other cementitious materials like fly ash and silica fume. This evaluation makes it possible to design GGBS concretes for a desired strength at any given percentage of replacement.

METHODOLOGY

In developing the concrete mix for paver blocks, it is important to select proper ingredients and evaluate their properties. The materials used for this investigation were cement, fine aggregates, coarse aggregates, water, textile sludge, GGBS and copper slag.

CEMENT

Cement is the most important ingredient in concrete. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. Different brands of cement have been found to possess different strength development characteristics and rheological behavior due to the variations in the compound composition and fineness. Hence it was decided to use cement from a single supplier. For the present investigation, Ordinary Portland Cement of 53 Grade conforming to IS 12269 - 1987 was used.
Source : Coromandel King OPC 53grade cement

Table: Physical Properties of OPC (53 grade)

S.No.	Test Particulars	Results Obtained	Requirements of IS 12269-1987
1	Specific gravity	3.15	-
2	Standard consistency (%)	31	-
3	Initial setting time (min)	120	140
4	Final setting time (min)	240	240

TEXTILE SLUDGE

The raw textile sludge was collected 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 random sampling method. The sludge had a roughly 30% moisture content. The sample of the sludge will be dried at a temperature of 105° c until the net weight will be constant. The dried sample were then ground in a ball mill for 30 mm to reduce to size of large and uneven particle into powder form' and then directly used into cement substitute.

Ground granulated blast-furnace slag (GGBS), also called slag cement, is made by rapidly quenching molten blast-furnace slag and grinding the resulting material into a fine powder. GGBS is classified by ASTM C 989 according to its level of reactivity. Depending on the desired properties, the amount of GGBS can be as high as 80 percent of the total cementitious materials content.

The use of GGBS lowers concrete permeability, thereby reducing the rate of chloride ion diffusion. For alkali-silica reaction, GGBS consumes some of the alkalis produced from the Portland cement leaving them unavailable for reaction with the aggregates. Proper proportioning of slag cement can eliminate the need to use low alkali or sulfate-resistant Portland cements.

In mass concrete applications, dosage rates of 50 to 80 percent of the total cementitious materials reduce the heat of hydration and the likelihood of thermal cracking. GGBS can also be used to enhance the strength gain at later ages. Concrete strength is usually optimized when GGBS replaces 40 to 50 percent of the Portland cement.

Fig. OPC 53 Grade Cement and GGBS

CASTING OF SPECIMENS

Casting of specimens was carried out at **"Majestic paving blocks",** Kundrathur. Rectangular paver blocks of size 200 mm x 100 mm x 60 mm were cast using hydraulically operated paver block making machine. Required quantities of materials were thoroughly mixed and placed in the steel mould. Then the surface is leveled and the mould with filled materials is placed in the machine and covered with the lid. A pressure of 120 Kg/cm^2 was applied to the specimen through the hydraulics ram until the mix gets fully compacted. The blocks were demoulded immediately after compaction and then cured.

Fig: Specimens

TESTING OF SPECIMENS

COMPRESSIVE STRENGTH TEST

The paver block specimen of size 200 mm ×100 mm × 60 mm were cast for each mix proportion. After 28 days curing, the specimen was placed in the compressive testing machine in such a manner that the load applied. The axis of the specimen has been aligned with the center of thrust of the spherically seated platen. The load has been applied without shock and increased continuously at a rate of approximately 140 kg/cm^2/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load has been recorded. Figure 13.1 shows the typical compressive testing machine.

Compressive strength (MPa) = Maximum load (N) /cross sectional area (mm^2).

Fig: Compressive strength set up

WATER ABSORPTION TEST

The test specimen shall be completely immersed in water at room temperature for 24±2h. The specimen then shall be removed from the water and allowed to drain for 1min by placing them on a 10mm or coarser wire mesh. Visible water on the specimens shall be removed with a damp cloth. The specimen shall be immediately weighed and the weight for each specimen noted. Subsequent to saturation, the specimens shall be dried in a ventilated oven at 107±7C for not less than 24 h and until two successive weighing at intervals of 2 h show an increment of loss not greater than 0.2 percent of the previously determined mass of the specimen. The dry weight of each specimen is recorded. Figure 3.12 and 3.13 shows the dry weight and saturation weight.

As per the code the water absorption of paver blocks shall not be more than 6 percent by mass in individual samples, the water absorption should be restricted to 7%.

Water absorption % = $(W_w - W_d) / W_d$ x 100

W_w = Saturation weight of the paver block (kg)

W_d = Dry weight of the paver block (kg)

Fig. Saturation weight

FLEXURAL STRENGTH TEST

The load shall be applied from the top of the specimen in the form of a simple beam loading through a roller placed midway between the supporting rollers.

Fig. Tested flexural strength specimen

The flexural strength of the specimens shall be calculated as follows,

$F = 3Pl/2bd^2$

F-Flexural strength in N/mm2

P-Maximum Load in N

l- Distance between central lines of supporting rollers in mm.

b- Average width of block in mm.

d- Average Thickness in mm.

TEST RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH RESULTS

The variation of compressive strength at 7 days and 28 days of the paver blocks with various replacement level of GGBS up to 40% are shown in Table.

Table: Compressive strength results

S.No	Mix combination	7 day Compressive strength (Mpa)	28 day Compressive strength (Mpa)
1.	S0G0	50.47	61.92
2.	S0G10	46.42	55.33
3.	S0G20	43.81	52.11
4.	S0G30	42.17	49.84
5.	S0G40	39.67	48.35

Note: S – Sludge, G-GGBS

The results show that there is decrease in the breaking load with the increase in the replacement levels of sludge and GGBS.

Fig. shows variation of flexural strength with all the mix combinations. The results show that there is decrease in the flexural strength with the increase in the replacement levels of sludge and GGBS.

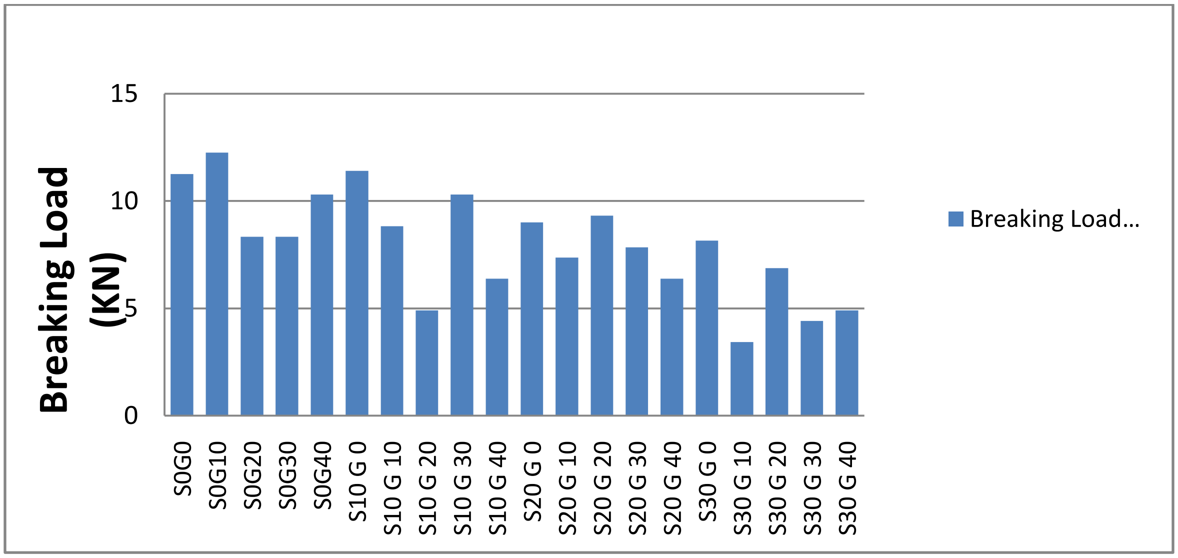

Fig. Breaking load V/s Mix combination

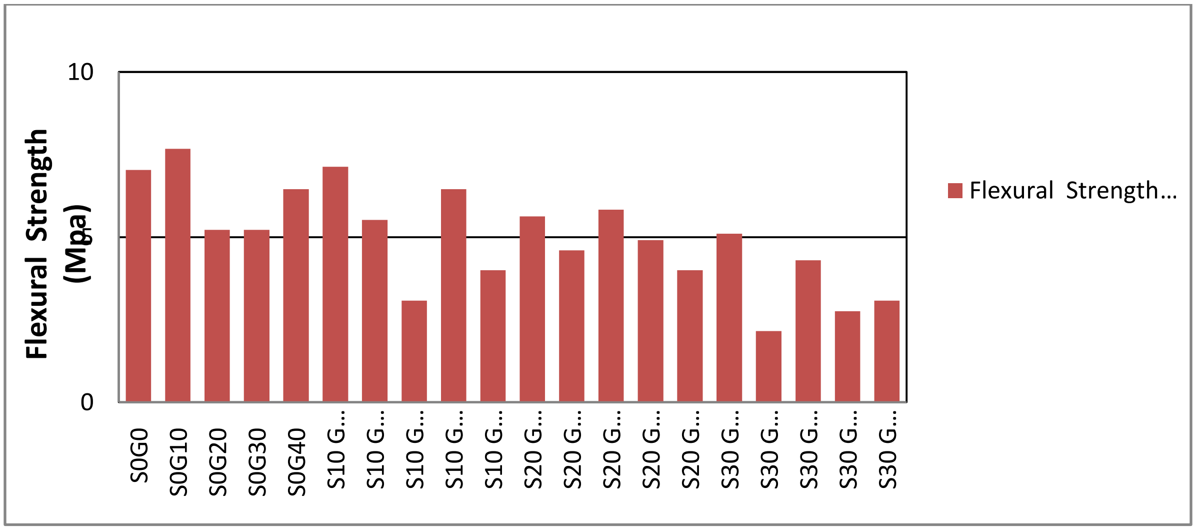

Fig. Flexural strength Vs Mix combination

CONCLUSIONS AND SUGGESTIONS

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 replacement of GGBS. 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 and GGBS in paver blocks.
- The combinations obtained by replacing cement with 10% of sludge and

GGBS from 10 to 40 percentages gave compressive strength above 30MPa and water absorption below 6%.

- The combinations obtained by replacing cement with 20% of sludge and 10-40% GGBS gave a compressive strength above 30MPa and the water absorption below 6% except for the combinations of 20% sludge and 30-40% GGBS.
- The combinations obtained by replacing cement with 30% of sludge and 10-20% GGBS gave a compressive strength above 30MPa and the water absorption above 6% for the combinations of 30% sludge and 0-40% GGBS. Other combinations gave compressive strength below 30 MPa due to increase in sludge content. They cannot be used as blocks because minimum strength required for the paver blocks is 30MPa.
- The combinations S20G30, S20G40, S30G0, S30G10, S30G20 attained compressive strength more than 40 N/mm^2 and water absorption less than 6% and they can be used for paver blocks subjected to medium traffic category such as city streets, low volume roads, utility cuts on arterial roads, etc.,
- It is recommended that the samples having compressive strength more than 30Mpa and water absorption less than 6% can be used for paver blocks subjected to non-traffic and light traffic categories such as building premises, public garden, domestic drives, embankment slopes shopping complexes, car parks, etc.,
- Based on the flexural strength and breaking load results, it was found that all the combinations were satisfied the codal requirements.
- Considering compression strength, water absorption, flexural strength tests and cost analysis it was found that S 20 G 30 as optimum combination for M40 and S 30 G 0 and S 30 G 10 as optimum combinations for M30.

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