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Strength Properties of Tannery Slurry Waste in Geopolymer Concrete

Dr.P.Partheeban[1]., Dr. B. Anuradha[1], Dr.L.Iyyapan[1], , R.Udayakiran[2]

[1]Professor and [2] Graduate Student
Department of Civil Engineering, Chennai Institute of Technology
Kundrathur, Chennai-600069
principal@citchennai.net; anu_bas2003@yahoo.com

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ABSTRACT: Geopolymer concrete is commonly used in the construction industries. This paper deals with an experimental study of geopolymer concrete and its physical and mechanical properties by partial substitution of tannery slurry by a different percentage of fine aggregates. The changes to the properties of geopolymer concrete upon addition of tannery slurry waste are studied in this study. Tannery waste is being utilized as a partial replacement for fine aggregates and the concrete produced is analyzedon the basis of Flexural, compressive and split tensile strength. The concrete produced with tannery waste as a substitute to fine aggregate will help in reducing the amount of M-sand and river sand used. The study concludesby identifying the optimal mix geopolymer concrete and the best mix for eco-friendly concrete that provides excellent strength in its properties is made by mixing 80% fly ash, 20% GGBFS and 80% M-sand and 20% tannery waste.

KEYWORDS: Geopolymer, Concrete, Eco-friendly, GGNFS, M-Sand.

I. INTRODUCTION

The industrial tannery waste which is the by-product that is obtained from the dying industries that are in various parts of Tamilnadu. In this study the industrial waste product is used for partial replacement of fine aggregate in casting of Geopolymer concrete. Geopolymer concrete is an inorganic polymer made up alumina-silicates derived from geologically derived silicone and aluminum material. Geopolymer concrete is a by-product material made from sodium hydroxide, fly ash, sodium silicate and tanning waste.Alkaline solutions are used to dissolve and form a gel made up of silicon and aluminum atoms present in the source materials.

This study'saim is to explore concrete's physical, mechanical, and chemical properties by partially replacing tannery waste with fine aggregates. The tannery waste is added to the concrete with various percentages of 10%, 20%, 30%,40% and 50%.This study aims to develop the standards of geopolymer concrete and thereby promote green buildingsas well as future construction of green buildings. This will also reduce the industrial toxic waste production and also the effect of global warming due to the greenhouse effect and to study about its physical, chemical and mechanical properties of the concrete. The following are the objectives of the study of geopolymer concrete with partial replacement of industrial tannery waste.

- To find out how the geopolymer concrete works by substituting fine aggregate with M-sand and tannery waste.
- To test the physical, mechanical and chemical properties of geopolymer concrete based on fly ash and GGBFS by substituting fine aggregate with M-sand and tannery waste.
- To find the optimal mix ratio of fly ash and geopolymer concrete based on GGBFS to substitute fine aggregate with M-sand and tannery waste.

II. LITERATURE REVIEW

Lenin Sundar (2017), studied about the use of tannery waste in geopolymer concrete as a partial replacement of fine aggregates. This study was conducted to learn Geopolymer concrete's compressive and tensile strengths with tannery waste. He has concluded that the tannery waste replacement of 20 percent achieved higher strength than standard M40-grade Geopolymer concrete.

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BashaMahaboob et. al. (2016) conducted a study aimed at improving the characteristic strength of geopolymer concrete, substituted by 10%, 20%, 30%, 40% and 50% of tannery waste and M-sand as a fine aggregate, and established the ideal amount of substitution.

Gayathri and. Al. (2016) studied geopolymer concrete's mechanical properties using tannery waste in concrete.In this investigation were made with replacement of sand by using tannery waste are 0%,10%,20%,30%,40% and 50%. Further the strength characteristics of cubes, beams and cylinder of geopolymer concrete with tannery waste of varying mix ratios can be carried out.

Balasubramanian et al (2016), performed an experiment to assess concrete'stensile strength, compressive strengthas well as flexural strengthby using tannery wastes as a partial substitute to coarse aggregates.Multiple forms of traditional cubes with partial substitution of tannery wastes with a percentage of 10 %, 15 %, 20 %, 25 %, and 30 % were rendered to coarse aggregatesto water cement ratio as 0.5.

Kale and Pathan (2015)analysedthe tensile strength, compressive strength, bond strength and flexural strength by means of waste concrete material (WCM), fresh concrete material (FCM) and tannery waste material. Different mixes were adopted in this study by changing the proportions of sand, cement and aggregates. All the mixes were made specifically for the strength (fck) of M25.

TejasOstwal et.al., (2014), studied the economic, sustainability, durability and strength qualities of geo-polymer concrete blocks. In his work, the author attemptedto produce geopolymer concrete at room temperature curing condition and to explore durability and strength attributes.

Sourav Das et al., (2014), has given an overall view of the process and parameters which effect the geo-polymer concrete. Geo-polymer concrete produced from partial replacement or fully Fly-ash using GGBS culminatesin reduction of CO_2emissions by 80% in comparison to OPC, but the alkaline solution is harmful to the environment to some extent.

Ganapati Naidu (2011) studied the strength of geopolymer concrete made with low Ca fly ash substitutingslag in fivevarying percentages. Sodium hydroxide with molarity 8 (41kg/m3) and Sodium silicate (103 kg/m3) solutions were the alkalis used. Slag (Mix no5) showed the maximum replacement of fly ash (28.57%).

NitendraPalankar(2015) focused on developingsubstitute binding materials for OPC. This is owing to the enormous amounts of greenhouse gases emitted during the production of Ordinary Portland Cement. An ingenious alternative to OPC is GGBFS-FA based geopolymer binders which produce high strengths as well as being eco-friendly. They are substituted at 0%, 25%, 50%, 75% and 100% by volume and different mechanical and fresh properties are researched. The findings show that the application of steel slag to geopolymer concrete resulted in a small decrease in mechanical power.

III. EXPERIMENTAL INVESTIGATION

Preparation of the geopolymer concrete is carried out after testing of materials. Skins were used to produce finished leather for garment, shoes upper etc. Leather processing chemicals, tannery machines for processing raw materials like skins and laboratory equipment for characterization of the sample solid wastes were also used. Class f fly ash is used for this study. Fly ash is a pozzolan, a materialmade up of siliceous and aluminous compounds. Physical and Chemical properties are fly ash used in this study is presented in Table 1.Upon the addition of water and lime it forms a substance akin to Portland cement.

GGBFS is a side product produced during the smelting of iron in blast furnaces. They work at around 1500 degrees Celsius and a tightly regulated blend of iron ore, limestone and coke is added. Iron is obtained from the iron ore and the leftovers form the slag floating above the iron. If the slag needs to be used to produce GGBFS, then it must be quickly extinguished in a large amount of water. Quenching maximizes cement

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qualities and the granules made are akin to coarse sand. In the manufacture of concrete, GGBFS substitutes a large proportion of standard Portland cement concrete, usually about 50%, but sometimes up to 70%.

As the levels of GGBFS increases, the durability of the cement increases. The downside of the high levels of replacement is the reduced rate of growth of early age strength. Precast and site-batched concrete also used GGBFS. But it is not economical for GGBS to be used in smaller-scale production of concrete. Other applications of GGBS include in-situ soil stabilization

Table 1 Physical Properties of Fly Ash

Sl.No	Test Carried	Results	Requirements As Per Is 3812 (Part 1)-2013	
1	Normal consistency	31.98%	Not specified	
2	Initial Settings time	326 min	Shall not be less than 300 mins	
3	Final settings time	513 min	Shall be be more than 600 mins	
4	Soundness	3.20%	-	
5	Minimum comparative compressive strength at 28 days(%)	81.56%	Not less than 80 per cent of the strength of the plain cement mortar cubes	
6	Maximum Residue on 45 microns (%)	25.56	34	50

Table 2 Chemical Properties of Fly Ash

Sl. No	Test Carried	Results %	Requirements (%) As Per Is 3812 (Part 1)-2013	
			Siliceous Pulverized Fuel Ash	Calcareous Pulverized Fuel Ash
1	Silicon di oxide (SiO_2)+Aluminum oxide (Al_2O_3)+Iron oxide (Fe_2o_3) % by mass min	74	70.0 min	50.0 min
2	Silicon di oxide (SiO_2) %by mass min	38.63	35.0 min	25.0 min
3	Magnesium oxide (MgO) % by mass max	2.96	5.0 max	5.0 max
4	Total Sulphur as Sulphur trioxide (SO_3) % by mass max	2.2	3.0 max	3.0 max
5	Available alkalis as sodium oxide (Na_2O) % By mass max	0.98	1.5 max	1.5 max
6	Loss on ignition % by mass	3.02	5.0 max	5.0 max

Leather isa natural, durable and versatile material produced by tanning raw hides and skins. The most common raw material is the hide of cattle. It can be manufactured in sizes ranging from the artisan to the global industrial scale.Waste originates from every stage of leather processing, such as traces of different chemical discharges, fine leather particles and reagents of various waste liqueurs. The waste liqueurs contain large pieces of trimmings, leather cuttings and rough shavings as well as solid hair particles, pulp fragments and paper bags.Almost 850kg of the 1000 kg of raw hide is released as solid waste as leather is processed.A normal tannery creates a significant amount of waste:

- Buffing dust, chrome splits and chrome shavings: 35-40%
- Flesh: 56-60%
- Hair: 2-5%
- Skin trimming: 5-7%

Solid waste and tannery wastewater get into surface water, through which contaminants are transported and contaminate the water used for human usage. Chromium waste can enter the soil and contaminate irrigation systems that provide local communities with a source of drinking water. Chromium can also be built up in marine animals, that are an important food source.

Auramix 500 is a special mixture of state-of-the-art superplasticisers based on polycarboxylic ether polymers with long lateral chains. Upon mixing with concrete, occurrence of electrostatic dispersion will allow cement particles to separate each other. This method greatly decreases the need for water in flowable concrete. Auramix 500 blends the properties of water retention and reduction.

3.1 COMPRESSIVE STRENGTH TEST

All geopolymer concrete cubes and hollow blocks were used in the experimental investigation to assess compressive power. The load at which the block eventually failed is reported and the compressive strength is measured as follows. The specimen were tested as per IS 516:1959 and they were tested at the 7,14 and 28 days.

3.2 FLEXURAL STRENGTH TEST

Flexural tests on concrete can be conducted in 2 ways. The first being the ASTM C78 three-point load test or the ASTM C293center point load test. The rupture modulus derived from the center point load test configuration is approximately 15% lesser compared to the three-point load test configuration. If a larger concrete specimen is used, then a low rupture modulus is observed. Generally, it can be said that the rupture modulus has a value ofaround 10 to 15% of the concrete's compressive strength. Eventually, the weight of the specimen across the cross-section of each end and the middle is examined and the average depth and height is determined. The following expression is used to measure the modulus of rupture.

3.3 SPLIT TENSILE STRENGTH TEST

Techniques for evaluating concrete tensile strength will usually be graded as (a) a direct form, and (b) an indirect process.The direct solution suffers from various difficulties related to the meticulous care of the sample in the test sample without the introduction of tension accumulation as well as the application of uniaxial tensile load free of eccentricity to the sample.Because concrete is weak in pressure, only a slight load eccentricity will induce a combination of bending and axial force effect, and the concrete will collapse under visible tensile stress rather than tensile strength.

3.4 WATER ABSORPTION STUDIES ON GEOPOLYMER CONCRETE

The resilience of concrete was assessed in this analysis using permeability-related parameters. The absorption analysis was conducted to determine the permeability characteristics of geopolymer concrete and was performed on 7, 14 and 28 days in compliance with ASTM C 642-82.There are two forms of curing used in this research, namely curing at room temperature and curing at an elevated temperature of 60ºC in the laboratory oven. After casting, the concrete mix is allowed to settle in the mould for 30 minutes. The specimens were cooled, demolished and kept open for air cooling till the day of testing. The specimens were cured in hot air at about 60°C.

IV. RESULT AND DISCUSSION

The feasibility of geopolymer concrete using fly ash and GGBFS as a replacement for cement has been tested. The workability of the geopolymer concrete reduces with a raise in the grade of the concrete due to the reduction in the proportion of the water to the solids.Compressive strength test is conducted using Universal Testing Machine on a concrete cube where the test specimen is subjected to compressive loads before failure. The results are presented in Figure 1.

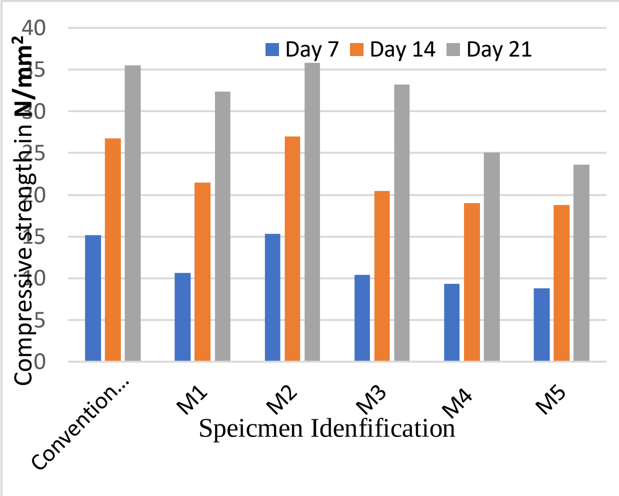

Figure 1 Compressive Strength of Concrete

Flexural strength or rupture modulus is a measure of the tensile strength of the bending cycle. Flexural strength checking is conducted on a cast concrete model. The beam is then placed at the middle of the beam until it fails. The results obtained are presented in Figure 2.

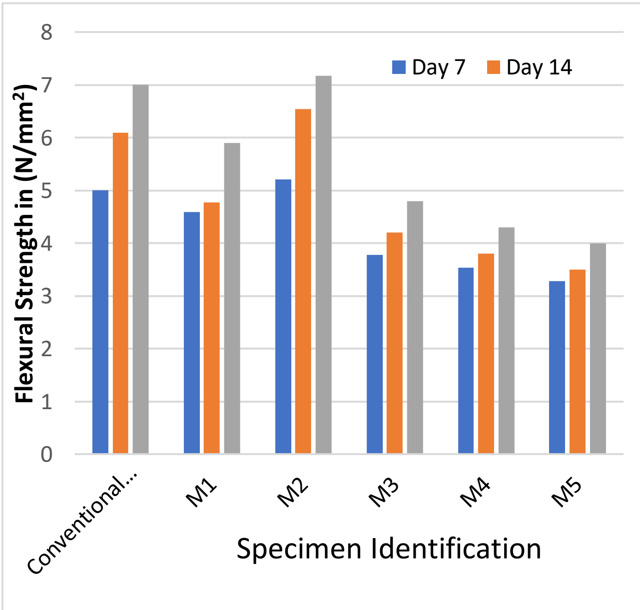

Figure 2 Flexural Strength of Concrete

Concrete’s most essential and necessary property is tensile strength. Using a concrete cylinder to measure tensile strength is a prevalent method. Figure 3 show the split tensile strength of the geopolymer concrete.

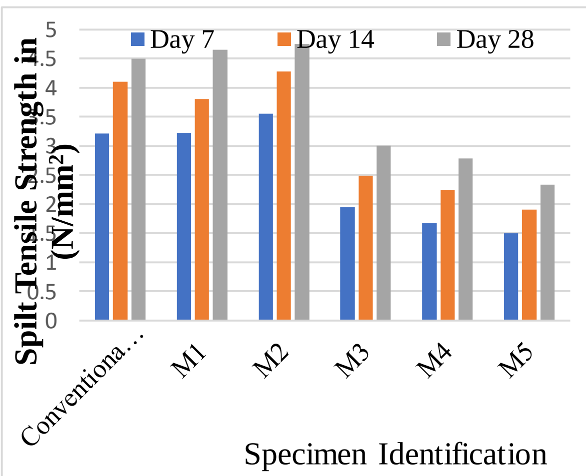

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Figure 3 Split Tensile Strength

The absorption of water is used to calculate the amount of water consumed under defined conditions. At first, the cubes are weighed. The concrete cubes had been submerged in water for 24 hours, and then the cubes had been removed and cleaned, and then weighed again. The level of water absorption decreases with an increase in the NaOH concentration from M1 to M4.The final absorption tests of these mixtures indicate that the absorption rate of the geopolymer concrete is lower

The most popular strength test, the compressive stress, is performed on a concrete cube specimen, and the test specimen is subjected to compressive load before failure. Figure 4 show the residual compressive strength.

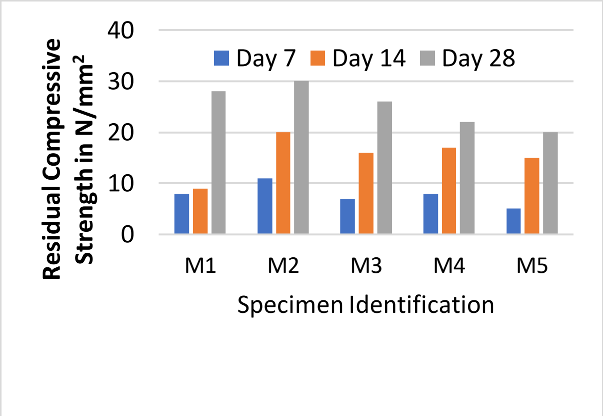

Figure 4 Residual Compressive Strength

Another of concrete's essential and simple properties is residual tensile strength and this tensile strength is tested on a concrete cylinder(Refer Figure 5).

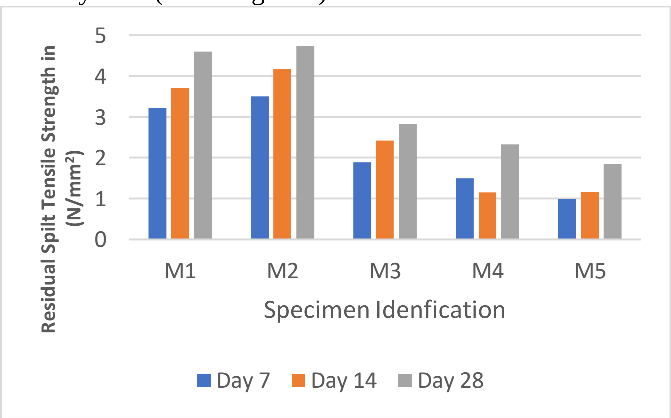

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Figure 5 Residual Spilt Tensile Strength for Different Mix

Geopolymer concrete has made a steady change of weight, although it has begun with a considerably high value and shown in Figure 6. The concrete cubes of various mixes are weighed in weighing machine and compared with one another. The specimen is then subjected to tensile load until failure.

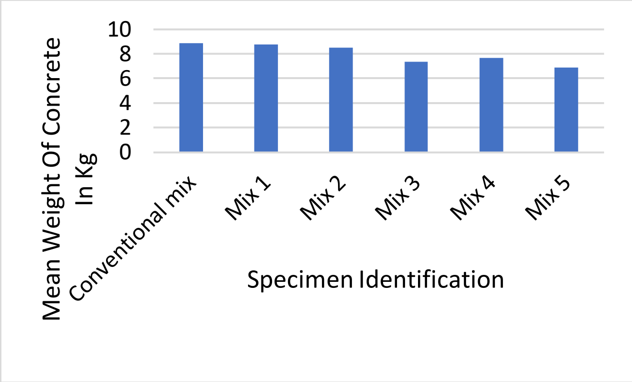

Figure 6 Change in Weight of Concrete

pH Measurements on 28 days hardened mortar samples were measured, by diluting 20 grams of crushed ≤4 mm mortar sample in 200 ml demineralized water or distilled water (15°C). Total liquid is stirred for ±10 min before pH measurement. To determine pH value of the solution pH meter is used and the results are shown in Figure 7.

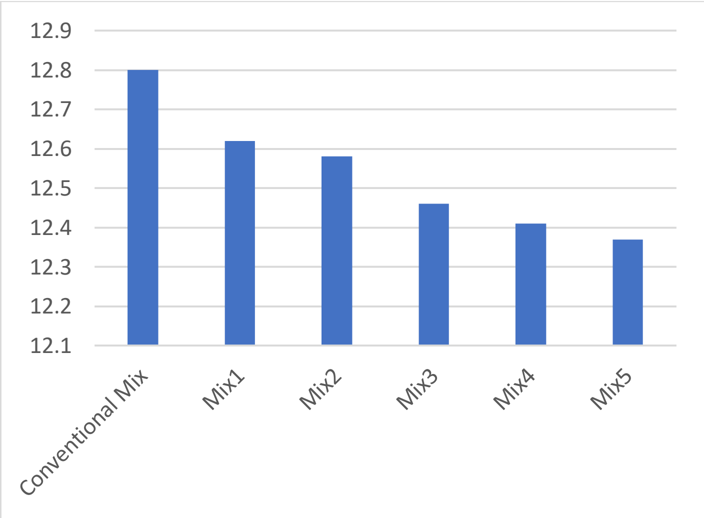

Figure 7 pH value of concrete

V. CONCLUSIONS

The following theories are developed on the basis of the results of the experimental research. Geopolymer concrete built on GGBS and Fly ash has reached low temperature power over an earlier period of time.The need for heat curing of concrete was removed by adding GGBS and floating ash into a concrete mix. The power of the geopolymer concrete was improved by the percentage of GGBS in the mixture. Originally, Mix 1 demonstrated greater compressive strength. Mix 2 was found to have a maximum compressive strength of 35 KN/mm3.GGBS and Fly ash-based geopolymer concrete have outstanding compressive strength and are ideal for structural applications.

The use of fly ash and GGBS has both environmental and economic benefits. The tannery wastes used for producing the binding system in concrete have environmental benefits at this optimal ratio. However, the use of Tannery Waste environmentally benefits, it fails in economic. The mix 3, mix 4 and mix 5 shows poor performance in its all experimental properties as Tannery Waste steadily reacts with alkaline solution and changes the colour of the concrete and does not allow the cementitious material to bind one another. Thus, results in lower strength of the hardened mortar. The optimal mix of eco-friendly concrete, which gives excellent strength in its properties, is therefore achieved by mixing 2 i.e. 80% fly ash, 20% GGBFS and 80% M-sand and 20% Tannery waste.

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