STUDY OF EFFECT OF TEMPERATURE ON CHEMICAL CHARACTERISTICS OF TEXTILE EFFLUENT SLUDGE

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ABSTRACT

In Today's world construction cost is very high. Cement production requires high energy input and also it is generating greenhouse gases Due to the lack of natural resources, the production of cement requires the use of traditional materials, which leads to significant CO_2 emissions, finding affordable and environmentally suitable cement substitutes is therefore necessary. In order to reduce disposal and pollution issues caused by textile sludge, it is crucial to develop profitable building materials from textile sludge. This problem can be solved by completely or partially replacing concrete with a different material, but this is not convenient in terms of the required properties. We can save natural resources and lower CO_2 emissions into the sky if we can partially replace cement with a substance with acceptable qualities. In the presented study the textile effluent sludge is burnt at various temperature and their chemical and physical properties were analyzed. The samples were subjected to XRF, XRD, SEM tests and various physical tests as well; such as density, water absorption and specific gravity test. The chemical tests were carried out to check if the chemical compounds like lime, alumina, iron oxides and silica which are present in TES and burnt TES; as these are present in cement. This study's main goal is to choose waste materials that have valuable qualities similar to cement. The obtained result showed that burnt TES had better physical and chemical results when compared with the unburnt textile effluent sludge and the properties were quite similar to that of cement.

Keyword: - *Sustainable construction material, cement, textile effluent sludge.*

1. INTRODUCTION

Global waste production has significantly increased recently, and there are no indicators that it will slow down. Global solid waste generation is anticipated to have increased by nearly 70% to 3.4 billion metric tonnes by 2050. [1]. T As of right now, the total annual waste generated is 2.01 billion tonnes [2]. Due to the incorporation of a range of dyes and chemicals in various wet processing processes, textile sludge is composed of a cluster of organic and inorganic complexes with significant concentrations of heavy metals as Fe, Cu, Cd, Zn, and Cr. The ecosystem is significantly impacted by the pollution produced by the textile industry. A significant portion of our clothes is made of chemicals. All of our apparel is processed wet using them in the production of fibers, dyeing, bleaching, and finishing. Of the 100 billion garments produced each year, 92 million tonne end up in landfills. More than 90 million tonnes of garments are dumped in landfills worldwide each year. The 400 billion square meters of cloth produced annually throughout the world by the textile industry are produced using more than 8,000 chemicals [3]. India produces 500 million tonnes of farm waste annually, and per capita, Indian households waste 50 kg of food. The annual harvest and post-harvest losses of the most important agricultural and related products is Rs 92,651 million.[4]. Within ten years, it is anticipated that the MSW quantum would double from its current levels due to India's current tendency towards urbanization. Providing a commercial potential worth $20 billion by 2030, at around 80-85 MTs. [5] India had 1252 million people as of 2013, up from 1028 million in 2001. A significant factor in India's rising MSW is population growth [6]. Up to 7800 kilotons of textile waste are produced in India each year, with post-consumer trash from Indian consumers accounting for 51% of that total. Pre-consumer waste, which includes manufacturing waste and offcuts, accounts for 42% of that total, and imported waste, which makes up the remaining 7%, are the next two greatest contributors. Also known as the Textile City of India, it is a famous industrial town in Rajasthan [7]. India's most cotton textile factories are located in Maharashtra because to the state's accessibility to raw resources and historically skilled personnel [8]. Every year, India discards more than 1 million tonnes of textiles, the most of which are from household sources. Only 59% of the textile waste generated in India makes its way back into the textile sector through reuse and recycling, but accounting for 8.5% of the entire global amount

2. METHODOLOGY

2.1 Collection and burning of TES sample

The samples of TES were collected from various Effluent treatment plants of textiles industries. After collection the TES was prepared in the laboratory. The samples were pulverized in the pulverized and passed through various sets of sieves. The samples retained on the 300-micron sieves were further burnt at a temperature of 750°C for 1 hr. in a muffle furnace. After burning of TES following chemical and physical tests were performed.

2.2 Chemical Tests

2.2.1 XRF (X-Ray Fluorescence)

A non-destructive analytical method used to ascertain the material's elemental composition is XRF. Solids, liquids, slurries, and loose powders are just a few of the sample types that can have their chemical compositions determined by XRF test results.

2.2.2 XRD (X-Ray Diffraction)

An X-ray is a type of electromagnetic radiation with wavelengths that can be measured in nanometers (one nanometer is equal to one billionth of a meters). This method, called constructive interference, is often used to investigate crystal structures and atomic spacing.

2.2.3 SEM (Scanning Electron Microscopes)

Using an electron beam, SEMs can image samples with a resolution of just a few nanometers. The electron source's filament emits electrons, which are then collimated into a beam. The electron column's set of lenses then focus the beam on the sample surface.

2.3 Physical Tests

2.3.1 Specific Gravity Test

The quantity of a material's strength is gauged by its specific gravity. In general stones with lower specific gravities are weaker than those with higher values. This test helps in identifying the specimen used for the sample.

$$G = \frac{W1 - W2}{(W2 - W1) - (W3 - W4)}$$

Here,

W1 = wt. of empty pycnometer

W2 = wt. of empty pycnometer + aggregate

W3 = wt. of empty pycnometer + aggregate + distilled water

W4 = wt. of empty pycnometer + distilled water

2.3.2 Water Absorption

Water absorption is used to determine the amount of water absorbed under specific conditions.

$$Water\ Content(\%) = \frac{W2 - W3}{W3 - W1} \times 100$$

Here,

W1 = Empty weight of mould

W2 = Weight of mould + TES Sample (dry)

W3 = Weight of mould + TES Sample (wet)

2.3.3 Density

Density is the measure of the weight per unit volume of solid or liquid samples.

$$Density = \frac{W3}{V}$$

Here,

W3 = Weight of TES

V = Volume

3. RESULT AND DISCUSSION

3.1 SEM with EDS

From the figures we can say that the shapes and sizes of particles are varying, the size of the burnt textile sludge is varying from 1micrometer to 30 micrometers, whereas the size of cement particle varying from 1 micrometer to 50 micrometers, from this analysis we observed that the size of burnt textile sludge is small than cement particle. *T*he smaller size of particles of textile sludge helps to improve its durability.

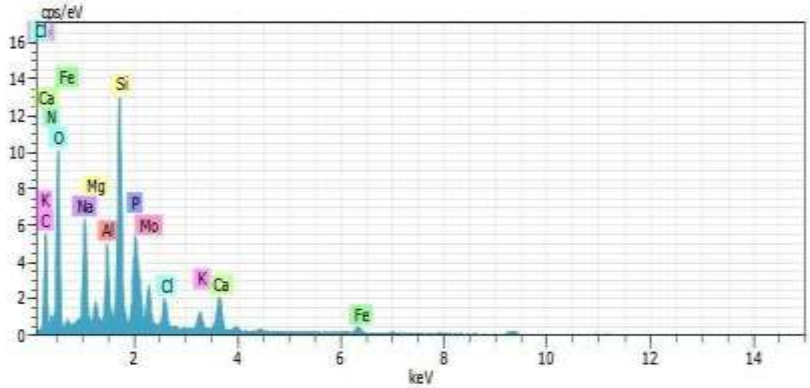

Fig -1: EDS spectrum of burnt sample

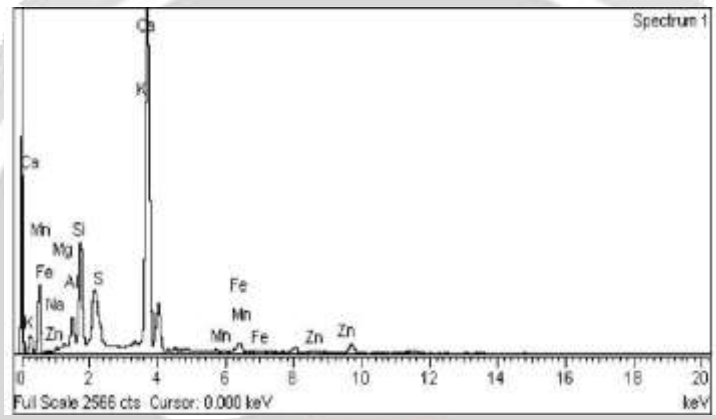

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Fig -2: EDS spectrum of cement

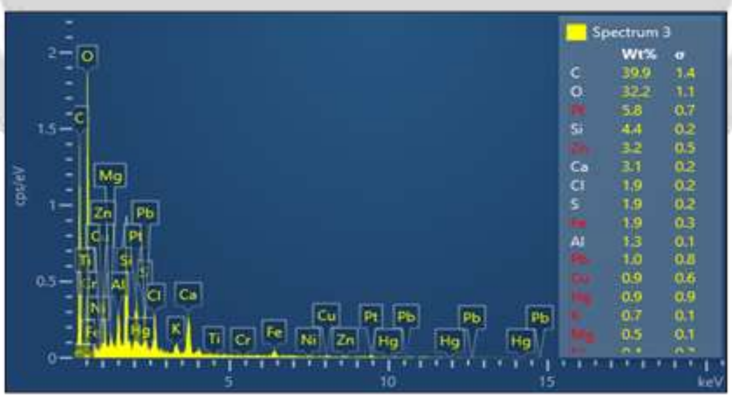

Fig -3: EDS spectrum of unburnt sample

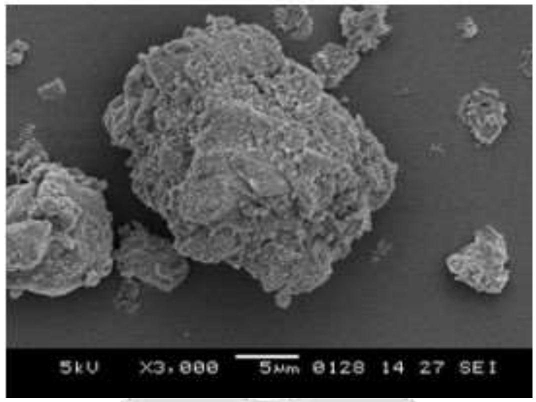

Fig-4: SEM image of burnt TES

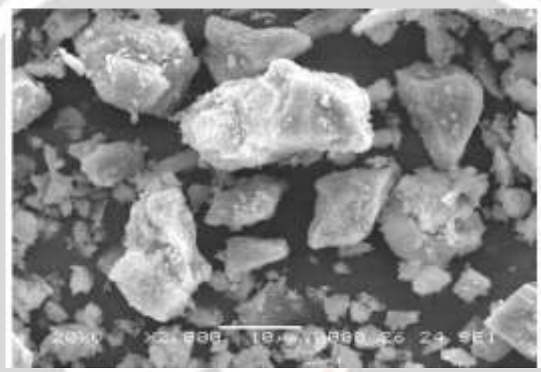

Fig-5: SEM image of cement

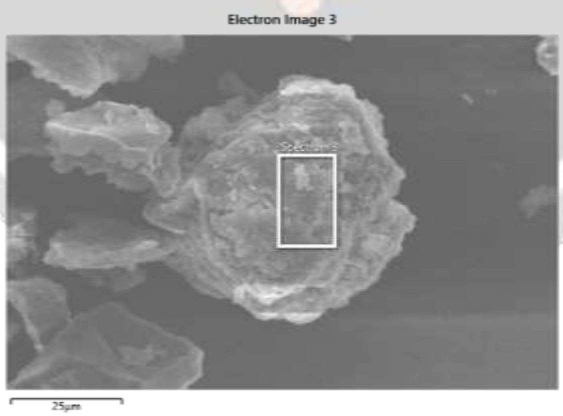

Fig-6: SEM image of unburnt TES

2.4 XRF

The XRF result represents the oxide and elemental composition of burnt and unburnt TES samples. The results are then compared with the commercially available ordinary Portland cement of grade 53. The results show the potential of unburnt and burnt TES sample to that of cement. It is observed that the composition of lime is less than that of

cement. If too much lime is used, the cement will expand and disintegrate, and it will also become unstable. To make cement without limestone, it is suggested that aragonite or calcite could be used instead.
We can also observe between the unburnt and burnt sample that the concentration of constituents of Boug's compound goes up; thus, theoretically resulting to better strength.

Table -1: Elemental composition of burnt and unburnt TES

Elements	Conc. Unit			
	Unburnt Sample	750C	Cement (%)	
Na	3.233%	7.065%	0.39±0.0	New Element
Mg	0.820%	1.396%	0.29±0.006	
Al	6.746%	8.138%	1.04±0.04	Increase
Si	18.026%	21.275%	8.56±0.22	
P	1.088%	1.460%		Decrease
S	4.155%	4.438%	1.34±0.01	
Cl	7.782%	8.364%		
K	2.609%	2.215%	0.36±0.04	
Ca	25.211%	25.488%	49.31±0.22	
Ti	2.061%	1.664%		
V	455.7 ppm	367.5 ppm	152.5±2.5 ppm	
Cr	0.125%	839.1 ppm	120±7 ppm	
Mn	0.477%	0.320%		
Fe	23.998%	16.822%	0.13±0.001	
Ni	0.165%	972.0 ppm	44.4±3.4 ppm	
Cu	0.835%	0.433%	<3.35 ppm	
Zn	0.689%	0.370%	11.4 ppm	
Ga	-	47.3 ppm		
As	-	0 ppm		
Br	1.394%	348.5 ppm		
Rb	-	162.4 ppm		
Sr	0.143%	962.2 ppm		
Y	-	105.1 ppm		
Zr	0.118%	568.8 ppm		
Sn	0.121%	381.8ppm		
Te	0.141%	430.5 ppm		
Os	157.9 ppm	0.0 ppm		
Ir	-	0.0 ppm		
Pb	-	224.5 ppm		

Table -2: Oxide composition of burnt and unburnt TES

Oxides	Conc. Unit			
	Unburnt Sample	750C	Cement (%)	
Na2O	3.341%	7.185%	0.52±0.01	New Compound
MgO	1.015%	1.680%	0.49±0.07	
Al2O3	9.300%	10.849%	1.94	Increase
SiO2	26.957%	30.628%	17.99±0.08	
P2O5	1.656%	2.105%		Decrease
SO3	6.781%	6.840%	3.31±0.01	
Cl	4.980%	5.029%		
K2O	1.935%	1.537%	0.43±0.32	
CaO	21.054%	19.817%	68.63±0.20	
TiO2	1.924%	1.425%		
V2O5	443.9 ppm	128.9 ppm		
Cr2O3	0.102%	628.3 ppm		
MnO	0.335%	0.213%		
Fe2O3	18.459%	11.890%	4.03	
NiO	0.107%	577.7 ppm		
CuO	0.531%	0.252%		
ZnO	0.435%	0.214%		
Ga2O3	-	29.5 ppm		
As2O3	-	0 ppm		
Br	0.699%	160.9 ppm		
Rb2O	-	81.9 ppm		
SrO	844.5 ppm	524.5 ppm		
Y2O3	-	61.5 ppm		
ZrO2	794.7 ppm	354.6 ppm		
SnO2	783.9 ppm	230.6 ppm		
TeO2	905.6 ppm	258.6 ppm		
OsO4	106.2 ppm	0 ppm		
IrO2	-	0 ppm		
PbO	-	111.7 ppm		

2.5 XRD

The oxide phases that are present in the sludge could be identified using XRD analysis, and its ability to produce early calcite to create Bogue's compounds could also be analyzed. CaO, MgO, SiO2, Fe2O3, FeO, and Al2O3 were the main phases detected in the sludge. Of these oxide phases, the CaO phase had the highest concentration. It is expected that the material will change from its crystalline phase to an amorphous one when fused at a high temperature (in this case, 750°C). 003 peak shows the preferential growth along the c axis perpendicular to the plane of the glass substrate. Our sludge sample was seen as amorphous in nature which is similar to that of cement.

From the result of XRD we have found out that the peaks are broad it indicating their amorphous nature with short-range ordering and the peaks also show that textile sludge mainly consists of calcite quartz and ferric oxides. The presence of CaO, Al2O3, Fe2O3, and SiO2 in sludge and propose that it can be substituted as alternative construction material.

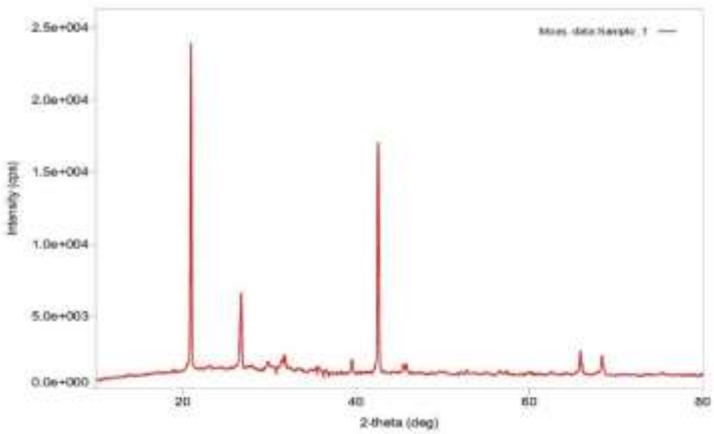

Fig-7: XRD of unburnt TES

2.6 Specific Gravity

Table -3: Specific Gravity result

Material	Specific Gravity
Unburnt TES	0.8
Burnt TES	1.727
Cement	3.1-3.16
Coarse aggregate	2.5-3
Sand	2.65

The specific gravity of the burnt TES is low as compared to base materials (but higher than unburnt) such as coarse aggregate, fine aggregate, cement, and fly ash. Hence, the lower the specific gravity, the lower will be the proportions of concrete, the higher the volume requirement of the base material, and the lower will be the density of the sustainable material. Since the TES sample has lower specific gravity hence lower compressive strength may be observed for TES incorporated products because the specific gravity is directly proportional to the compressive strength. Therefore, it is preferable to replace sludge in small quantities with coarse aggregates, fine aggregates, cement, and fly ash

2.7 Water Absorption

Table -4: Water Absorption result

Material	Water Absorption
Unburnt TES	56.66%
Burnt TES	12%
Unwashed Sand	2.5-3%
Washed Sand	2-2.5%
Cement	4-5%

2.8 Density

Table -5: Density result

Material	Density
Unburnt TES	996 kg/m^3
Burnt TES	1727 kg/m^3
Concrete	1520-1680 kg/m^3
Cement	1440 kg/m^3

4. SUMMARY AND CONCLUSION

Reducing or partially reusing waste materials Environmental changes brought about by replacement in the concrete industry may result in a pollution-free and tranquil atmosphere. It might end up being more affordable than conventional concrete, and it also resolves the issue of where to deposit the trash generated by various sectors. By utilizing this waste in concrete, we can prevent water pollution, air pollution, and land contamination caused by damping and other processes. The ultimate goal is to create affordable, environmentally friendly concrete that has all the desired qualities and strengths that are obtained from using standard concrete materials; to improve the strength, workability, and durability of concrete; future work will involve removing all of the cement from it and replacing it with a suitable combination of cement substitutes. Therefore, by Using the various eco-friendly materials in industries, we can safely guard our environment from disasters. Making use of Industrial waste can reduce the generation of wastes by reusing it as a useful material. This creates the pollution free Environment.

The following conclusions have been drawn after various chemical and physical characterization:

1.By using the XRF test we can see that the concentration of hazardous elements like Gallium Trioxide, Rubidium Dioxide, Yttrium Oxide, Lead Monoxide have gone down as compared to unburnt sample since their concentration were found in negligible amount i.e., in ppm (parts per million) so they can be neglected as they will not affect the strength of cement.

2.By using XRF test we can also observe between the unburnt and burnt sample that the concentration of constituents of Boug's Compound goes up; thus, theoretically resulting to better strength.

3.The burnt sample when compared to cement; has more SiO_2 (more strength & settling time), Al_2O_3 (more strength) , Fe_2O_3 (less workability) & less CaO.

4.The concentration of heavy metals like Cr, Ni, Pb, Zn, Cd has also decreased and when compared with the Indian rules reveal that all the heavy metal is not available or less than the regulatory limit.

5.The specific gravity of the burnt sample has increased when compared to unburnt sample but still less than cement so, the resulting weight of mix of cement & burnt sample will be more than the cement & unburnt mix. But still lighter than only using cement.

6.The water absorption of the burnt sample is lower than unburnt which means low porosity resulting in more strength.

7.After XRD test we can conclude that the burnt sample is amorphous in nature just like cement.

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