Behavioural Study On Eco-Friendly Geopolymer Tiles

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Abstract-

Geopolymer mortar is an innovative construction material which is produced by the chemical action of inorganic molecules.In Geopolymer mortar, ordinary Portland cement (OPC) is not utilized at all. The recent environmental awareness in construction industry promotes the use of alternative binders to partially or fully replace OPC as its production creates environmental pollution due to release of CO_2 into atmosphere. A great developmentaround the world in new types of inorganic cement binders in the Geopolymer. This promoted the use ofgeopolymer mortar which improves the greenness of ordinary tiles. In this experimental study, Fly ash, Bagasse ash and Rise husk ash are attempted in making eco-friendly geopolymer tiles because mechanical and durability properties of geopolymer tiles will be enhanced. The geopolymer mortar were kept in tile mould and heated at 60$^oC$for 1 day and exposed to room temperature for curing. Comparative study was attempted to study the compression strength, water abrasion, modulus ruptureof Fly ash, Bagasse ash and Rise husk ash based geopolymer tiles.

Keywords: *Geopolymer tile, Fly ash, Bagasse ash, Rise husk ash, Sodium hydroxide, Sodium Silicate*

INTRODUCTION

Davidovits [1988] proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders.

GEOPOLYMER

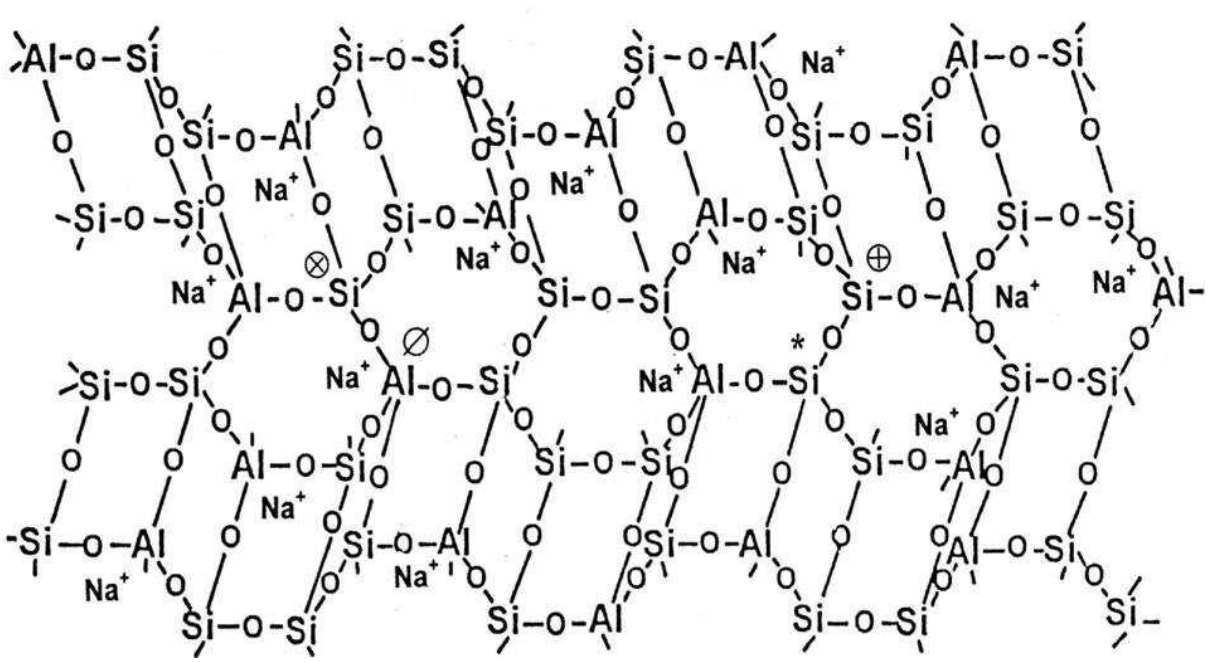
Portland cement concrete is one of the most widely used construction materials. As the demand for concrete as a construction material increases, so also the demand for Portland cement. It is estimated that the production of cement will increase from 1.5 billion tons in 1995 to 2.2 billion tons in 2010. Among the greenhouse gases, CO_2 contributes about 65% of global warming. The cement industry is held responsible for some of the CO_2 emissions,because the productionof one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere. Totally 34 billion tons of CO_2 emitted globally in 2011 and India contributing CO_2 emission of 6%. Indian cement production capacity is likely to be increased in the year 2020, from 320 million tons to 550 million tons. On the other hand one ton Portland cement production involves emission about one ton of CO_2 which is a green house gas causing global warming. More over fly ash utilization in India is only around 55% of total fly ash generated quantity of around 133 million tons. Several studies have been carried out to reduce the use of Portland cement in concrete to address the global warming issues. In this respect, the geopolymer. technology proposed by shows considerable promise for application in concrete industry as an alternative binder to the Portland cement. In terms of reducing the global warming, the geopolymer technology could reduce the CO_2 emission to the atmosphere caused by cement and aggregates industries by about 80%.

CHEMICAL COMPOSITION OF GEOPOLYMER

Geopolymers are the member of family of inorganic polymers and are chained structures formed on back bone of Al and Si ions.The polymerization process carried by the chemical reaction under alkaline condition results in a three dimensional polymeric chain consists of S_i-O-Al-O bonds.

$$M_n [-(S_iO)_z–AlO]_n . wH O$$

where: M = the alkaline element or cation such as potassium, sodium or calcium; the symbol – indicates the esence of a bond, n is the degree of polycondensation or polymerisation; z is1, 2, 3 ……32.



The GP tile specimens were cured at varying temperature of 60°, 80° & 90°for the maximum period of 24 hours with minimum rest period of one hour. The influence of alkaline activators with equal dosage of admixture and elevated temperature in the mechanical properties of geopolymer concrete has been studied, 48% of sodium hydroxide solution was used as alkaline activators along with commercial grade sodium silicate at varying mix proportions and varying curing temperature for preparing Geopolymer mortar.

FIELD OF THE INVENTION

The present invention relates to a process for the production of self-glazed geopolymer tile from fly ash, rice husk ash, bagasse ash. The invention particularly relates to a process for the production of self-glazed geopolymer tile from fly ash, rice husk ash, bagasse ash, which is waste materials of local available industry.

OBJECTIVE OF THE PROJECT

The main object of the present investigation is to provide a process for the production of geopolymer tile using eco-friendly materials which obviates the drawbacks as detailed below. Another object of the present invention is to provide a process to produce geopolymer tile whereby the cost of production is appreciably lowered and the properties of the product is improved.

MATERIALS USED:

ASHES:

In this study available materials low calcium fly ash, bagasse ash, rice husk ash, obtained from local industry. The chemical composition of fly ash, bagasse ash, rice husk ash used and Ordinary Portland Cement were compared and tabulated below in Table 1. It can be observed in the table 1, that the fly ash, bagasse ash, rice husk ash contains low calcium oxide, the molar ratio of Si to Al is 2 and Iron oxide content was higher than Cement.

The specific gravity of the fly ash was 2.30 and fineness modulus was 1.38.

The specific gravity of the bagasse ash was 1.8.

The specific gravity of the rice husk ash was 2.14.

Fly ash

Bagasse ash

Rice husk ash

Composition (%)	**Cement**	**Fly Ash**
SiO2	21.0	56.8
Fe2O3	3.4	5.3
Al2O3	5.9	28.2
CaO	64.7	<3
MgO	0.9	5.2
SO3	2.6	0.7
Chloride Content	0.0004	<0.0005

ALKALINE ACTIVATORS:

A combination of sodium silicate solution and sodium hydroxide solution were chosen as the alkaline liquid. Sodium hydroxide in pellets form with 97% purity and sodium silicate solution of 0.1N were used. The sodium hydroxide (NaOH) solution was prepared by dissolving the pellets in distilled water. Preparation of NaOH solution resulted in emission of heat of 60°C. The mass of NaOH solids in a solution in the current study as 8 Molarities.

Fig.3.2 Alkaline activators (Na_2SiO_3 &NaOH)

SUPER PLASTICIZERS:

Cera Concrete tonics 350is a specially formulated dual purpose admixture for application incorporating properties of superplasticiser and corrosion inhibitor characteristics based on bi-polar technology.

ADVANTAGES:

- Substantial reduction in water-cement ratio
- Imparts high degree of corrosion resistance to concrete
- Compatible with other admixtures
- No adverse effect on workability and strength
- It can be used as an admixture to replace sulphate resisting cement
- Easy to use

Fine Aggregate:

The fine aggregate of is obtained from the river sand.The physical properties of cement are given in Table 1. The available River sand having bulk density 1.71 kg/m3 was used and the specific gravity is **2.65**. The Fineness modulus of river sand is 5.24.

The size of the fine aggregate is chosen as it passes through the 4.75mm sieve and retains on the 2.36mm sieve.

EXPERIMENTAL INVESTIGATION:

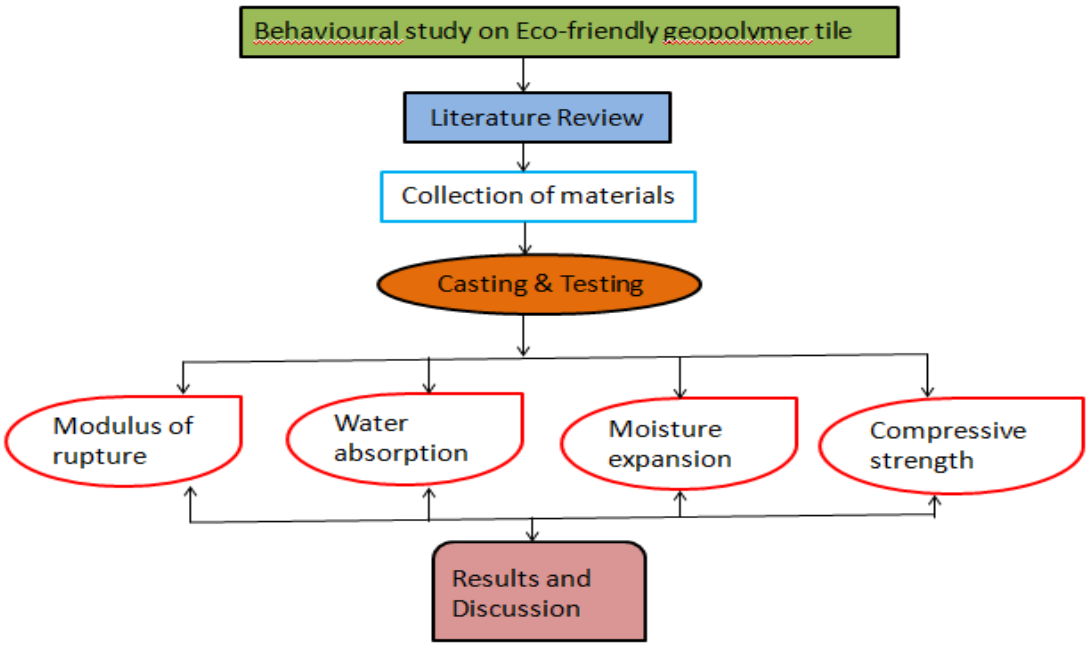
GP mortar mixtures

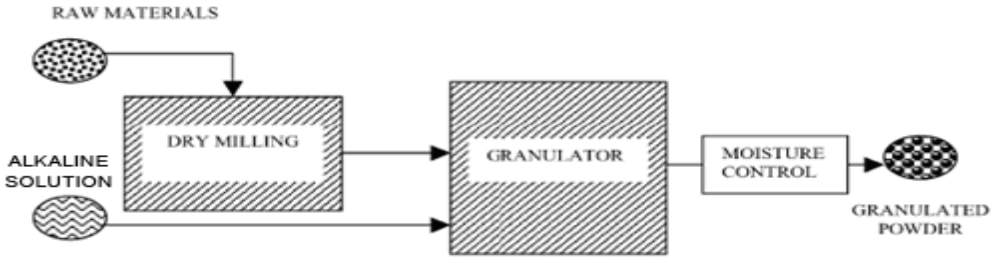
S.No	Mix ID	Ash	Ash kg/m$^{3.}$	Fine Aggregate kg/m^3	Sodium hydroxide kg/m^3	Sodium Silicate kg/m^3	Super Plasticizers kg/m^3
1	GP1	Fly ash	774	1052	78	196	12
2	GP2	Bagasse ash	774	1052	78	196	12
3	GP3	Rice husk ash	774	1052	78	196	12
4	CM	Cement	774	1052	_	_	_

A tile mold of volume 0.3m X 0.3mX 0.012m is calculated to be 0.00108 m$^{3.}$

S.No	Mix ID	Ash	Ash kg/m$^{3.}$	Fine Aggregate kg/m^3	Sodium hydroxide kg/m^3	Sodium Silicate kg/m^3	Super Plasticizers kg/m^3
1	GP1	Fly ash	0.836	1.14	0.084	0.217	0.013
2	GP2	Bagasse ash	0.836	1.14	0.084	0.217	0.013
3	GP3	Rice husk ash	0.836	1.14	0.084	0.217	0.013
4	CM	Cement	0.836	1.14	_	_	_

MANUFACTURING OF GEOPOLYMERIC TILES:



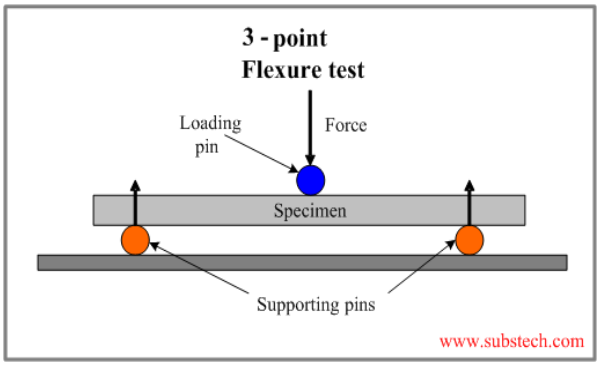


Glazing.

Glazes are used on a wide diversity of ceramic products. While the glaze layer has a negligible thickness compared to that of the body, its real purpose is to ennoble the product by improving its density, hardness, gloss, colour, etc.

TESTS ON TILES:

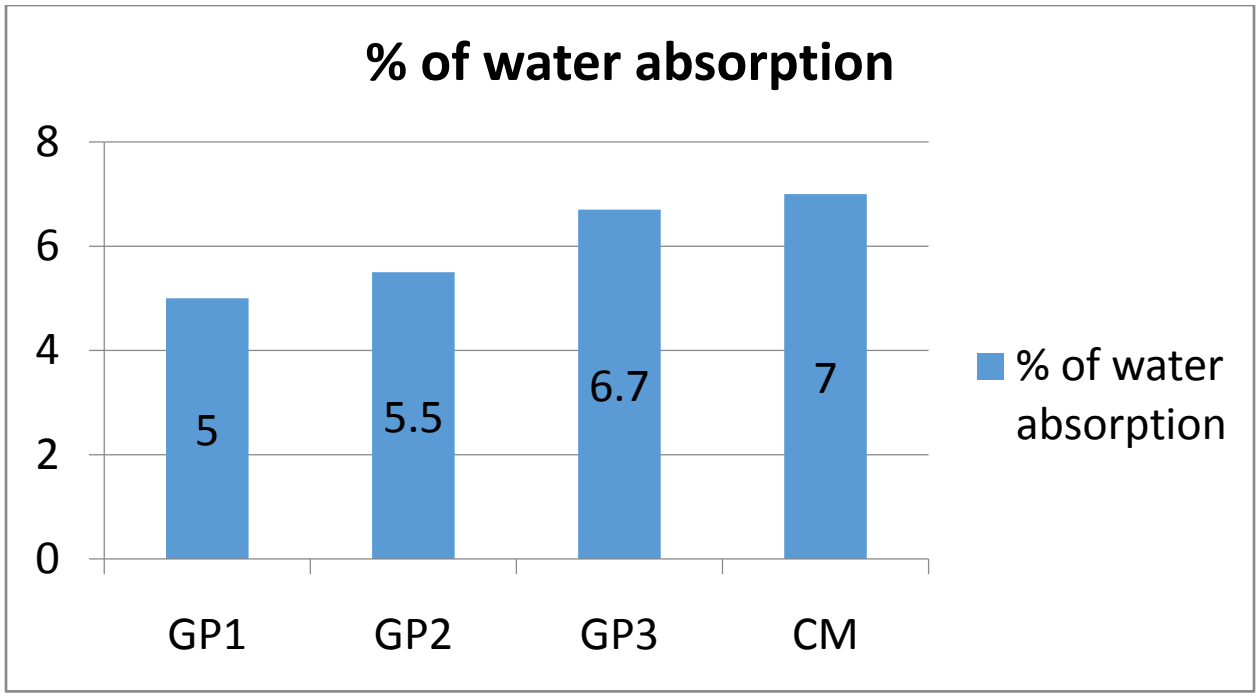
- Modulus of rupture.
- Water absorption.
- Moisture Expansion.
- Compressive strength test
- **Breaking strength,** is a direct relation to the load applied on to the tile, with a corrective coefficient that relates the distance between the supports and width of the test piece, expressed in newtons (N). the result of the test is a function of tile thickness for the same type of material.
- **The modulus of rupture**, also termed bending strength, which is derived from the magnitude breaking strength by a mathematical formula [Breaking strength divided by the square of minimum thickness at the rupture cross section]. The result of the test, expressed Newtons per square millimetre (N/mm^2), provides the approximate mechanical strength of the geopolyeric tile independently of tile thickness.
- **Breaking load,** Force necessary to cause the test piece to break, expressed in newtons (N) according to a pressure gauge reading



Water Absorption

Water absorption characteristics of the concrete plays an important role for the durability of the structure. Ingress of water detoriates concrete and in reinforced concrete structure, corrosion of the bars took place which results it no cracking and spalling of the concrete and ultimately reduce the life span of the structure.

Notation	Oven dry weight (w2)	Wt. after immersion for one day (w1)	% of water absorption
GP1 (Fly ash)	1.32	1.39	5
GP2 (Bagasse ash)	1.38	1.46	5.5
GP3 (Rice husk ash)	1.25	1.34	6.7
CM (Cement)	2.15	2.31	7



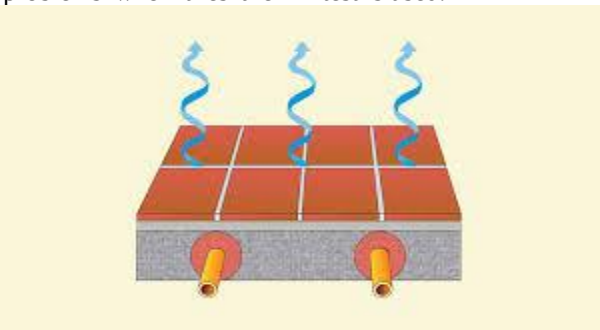
Compressive strength

Four geopolymer concrete mixture proportions used in laboratory studies. Numerous batches of these mixtures were manufactured during a period of four years. For each batch of geopolymer concrete made, 30cm X 30cm tiles specimens were prepared. At least three of these tiles were tested for compressive strength at an age of seven days after casting. The unit-weight of specimens was also determined at the same time. For these numerous specimens made from Mixture is heat-cured at 60^0C for 12 hours.

S.no	Geopolymer Mix	Compressive strength attained (MPa)
1	Fly ash	35.70
2	Bagasse ash	31.45
3	Rise husk ash	30.10
4	Cement	33.65

Moisture Expansion

Moisture expansion is the proportional accelerated expansion that results from subjecting reheated tiles to extended immersion in boiling water.The boil time is usually 24 hours.The majority of glazed and unglazed tiles have negligible natural moisture expansion that does not contribute to tiling problems when tiles are correctly fixed.However, with unsatisfactory fixing practices and in certain climatic conditions, natural moisture expansion may aggravate problems, especially when tiles are directly fixed to inadequately aged concrete substrates. In these cases, a maximum limit of 0.06% moisture expansion is recommended when the test is used.



RESULT & DISCUSSION

Result properties of various geopolymer mix

Fly ash

PROPERTIES	STANDARDS
Compressive strength	35.70N/mm^2
Surface finish	Glazed
Bulk density	1.9gm/cc
Water absorption	5%

Bagasse ash

PROPERTIES	STANDARDS
Compressive strength	31.45 N/mm^2
Surface finish	glazed
Water absorption	5.5%

Rise husk ash

PROPERTIES	STANDARDS
Compressive strength	30.10 N/mm^2
Surface finish	glazed
Water absorption	6.7%

Cement

PROPERTIES	STANDARDS
Compressive strength	33.65 N/mm^2
Surface finish	glazed
Water absorption	7%

ADVANTAGES

- Manufacturing process of geopolymer tiles is simple and easy compared to conventional tiles.
- Geopolymer tiles are cheaper than ceramic tiles.
- Cost of geopolymer tiles mainly depends on sodium silicate solution.
- Cost of geopolymer tiles can be further reduced by increasing the molarity of NaOH solution instead of increasing (sol/binder).
- Automatic surface finish is obtained during vibration.
- Extra water added to mixture is important parameter which governs the surface finish.

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