DURABILITY EFFECT OF RICE HUSK AND RUBBER IN GEO POLYMER CONCRETE

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ABSTRACT

In civil engineering field concrete is an essential material for construction. High amount CO_2 is produced in the production of cement. Also cement production depletes significant amount of natural resources. So we have to find an alternative source for cement. So Geo polymer is invented. In this Alkali Activated Solution (AAS) is used for the preparation of binder for concrete. Normally GGBS, Fly ash is used for the preparation of the Geo polymer concrete. AAS solution is prepared atleast prior 24 hrs before the manufacturing of Geo polymer concrete. Preparation of AAS solution is exothermic reaction.

In this study AAS solution is prepared by mixing Sodium Silicate solution and sodium hydroxide solution of required Molarity. In this study 6M Sodium hydroxide solution is prepared.For preparing Geo polymer concrete AAS solution is mixed with Fly ash (Class C) and GGBS to get Specimen and labeled as C1(Control Mix). Similarly 5% Rice husk added to Geopolymer concrete by replacing 5% GGBS and labeled as C2. C3 is prepared by adding 5% Rice husk as, 5% WRP, C4 is prepared by 5% Rice husk as, 10% WRP, C5 is prepared by adding 5% Rice husk as,20% WRP to Control mix. Rice husk is used to replace Binder, ie GGBS and Waste rubber particle replacing fine aggreagete.

For Durability study, Water absorption, Water permeability carried out. Additionally UPV test carried out. To find out the property of the material Modulus of elasticity test carried out.

Keywords: Geopolymer concrete (GPC), Rice Husk Ash (RHA), Rubber Dopped Geopolymer Concrete (RGPC), GGBS (Ground granulated Blast Furnace slag,), Fly Ash.

INTRODUCTION

In the field of civil engineering, concrete is an essential building material and it is widely used in the construction of infrastructure such as building, bridges, Highways etc. Usually cement is used as a Binder material in concrete production. During cement production large volume of carbon dioxide is released. Also cement production depletes significant amount of natural resources. So we have to find an alternative source for cement.

Geopolymer is an inorganic cementitious material which attracted worldwide for the last three decades. In 1978French Professor Davidovits first coined the term geopolymer .Dr. Davidovits (1988; 1994) proposed that an alkaline liquid react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as Rice Husk Ash, Fly Ash and Red Mud to produce binders. The chemical reaction is a polymerization process, and he termed „Geopolymer" to represent these binders. Geopolymer binders is also a good acid resistant concrete. Since Geopolymer relies on alumina-silicate rather than calcium silicate hydrate bonds for structural integrity, they have been reported as being acid resistant. Geopolymerization is a very complex process . It involves multiphase a series of dissolution-reorientation-solidification reaction analogous to zeolite synthesis. It is an exothermic reaction. High alkaline solutions are used to induce the silicon aluminium atoms in the source material to dissolve, forming three dimensional polymeric structure of –Si-O-Al-O- bonds

The steps in the chemical reaction process

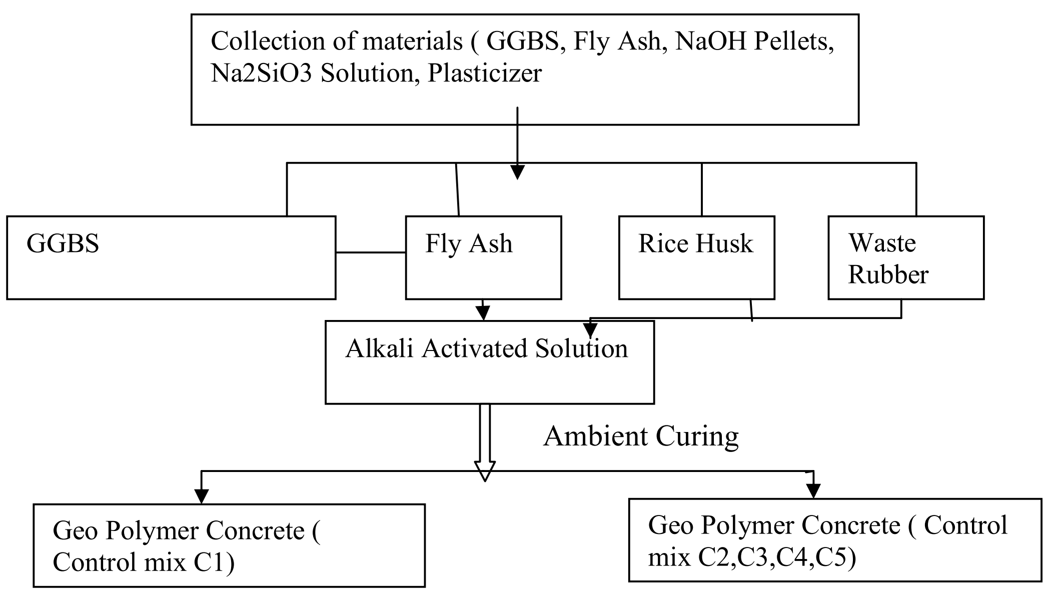
- The action of hydroxide ions dissolving the Silicon and Aluminium atoms from the source material.
- Transportation or orientation or condensation of precursor ions into monomers.
- Polymerisation/ polycondensation of monomers into polymeric structures.

OBJECTIVE

- To perform study on the fly ash added rubber doped geo polymer on durability
- Developing the durability test parameters such as water permeability, water absorption, UPV , for geopolymer concrete.
- To study the propertites at different percentage of Rubber in Rice husk added Geo polymer concrete, Modulus of Elasticity studied
- To carry out analytical study of two specimens C1 and C2 to find out the characteristics of deflection, stresses etc.

METHODOLOGY

Present study about to examine the durability properties of the Geo polymer concrete by adding different materials in different percentage. Firstly Geo polymer concrete with Fly ash, GGBS, AAS, Super plasticizer is prepared after finding out the mix design with trial and error. Then the compressive strength found out and other samples with varying materials with varying percentages are prepared. Ie, Rice husk, Waste rubber particle are added in different percentages. From journal it is seen that for rice husk optimum values are obtained in 5% . So Rice husk quantity (5%) is fixed and rubber particle added in different percentages (0%,5%,10%,15%,20%). C1 mix is prepared by Fly ash , GGBS, AAS, Super plasticizer only. C2 is prepared by adding 5% Rice husk ash to replace Binder, ie GGBS to control mix . C3 is prepared by adding 5% Rice husk as, 5% WRP, C4 is prepared by 5% Rice husk as, 10% WRP, C5 is prepared by adding 5% Rice husk as,20% WRP to Control mix. Rice husk replacing Binder, ie GGBS and Waste rubber particle replacing fine aggreagete



Flow chart showing the preparation of GPC Sample

MATERIAL

i) GGBS

GGBS is commonly used as a supplementary material for binder in Cement concrete as well as Geo polymer Concrete. Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag from a blast furnace in water or steam

Physical Characteristics of GGBS

Properties	Values
Specific Gravity	2.9
Fineness	400 m2/ kg
Colour	Off- White
Bulk Density	1250 m3

ii) FLY ASH

Fly ash generated in large quantities in coal based thermal power plants is a potential raw material for geo polymers due to the presence of silica and alumina bearing phases as major constituents. Fly ash is mainly classified into Class F -Fly ash and Class C- Fly ash. Class F -Fly ash is low Calcium Fly ash and Class C- Fly ash is High Calcium Fly ash. In this study, low calcium, Class F Fly ash was used.

Physical Characteristics of Fly Ash

Properties	Values
Specific Gravity	2.8
Bulk Density	995 kg/m3

Chemical Composition of Binder Materials (%)

Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O_3	K_2O	TiO_2	Mn_2O_3	SO_3
Fly Ash	62.1	27.44	4.57	0.83	0.55	0.04	1.17	1.09	0.04	0.04
GGBS	43.4	12.5	_	40.3	1.5	0.9	0.6	_	_	_

iii)WASTE RUBBER PARTICLE

Waste rubber material especially from retreading are recycled and reused in Civil engineering In this experiment, rubber particles which passes through 2.36mm sieve is taken made from waste tires, were utilized.

iv)RICE HUSK ASH

Rice husk ash is a byproduct of the cultivation and processing of rice as a foodstuff. Rice husk is mainly removing by burning the rice husk. Ie Rice husk ash is produced. Approximately 18% of these husks, when burnt, will become ash, therefore, the production of 1 ton of rice will result in roughly 45 kg (70 lbs) of RHA, which is rich in silica (95%), with a high surface area and substantial pozzolanic properties .

Chemical Composition of Rice Husk Ash (%)

Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI	SO_3	K_2O	Na_2O_3
Rice Husk Ash	87.2	0.15	0.16	0.55	0.35	6.55	0.32	3.60	-

v) SUPERPLASTICISER

Superplasticizers are chemical admixture added to concrete to enhance the workability without increasing the water content.The dosage of super plasticizer also has an effect on the compressive strength of the concrete. (0.3% of total binder or cementitious material). In this experiment BSS Conflo Workability Aid is used

vi) FINE AGGREGATES

Fine aggregates are small size filler materials in construction. These are the particles that pass through 4.75mm sieve and retain on 0.075mm sieve. The fine aggregate used for the experimental study was M sand (Zone II)

Physical Properties of Fine Aggregate

Properties Test	Results	Recommended Values
Water Absorption (%)	0.5	0.1 to 2
Specific Gravity	2.68	2.55 to 2.75
Bulk Density (kg/m^3)	1500	1400-1600

vii) COARSE AGGREGATES

Coarse aggregates are larger size filler materials in construction. These are the particles that retain on 4.75mm sieve. The maximum size of coarse aggregate used in present study was 20mm. The physical properties of coarse aggregate are tabulated .

Physical Properties of Coarse Aggregate

Properties	Test Results	Recommended Values
Water Absorption(%)	0.5	0.1to2
Specific Gravity	2.71	2.6to2.8
Bulk Density(kg/m^3)	1500	1350-1500

ALKALINE LIQUID

The Alkaline Activator Solution (AAS) is a combinations of potassium hydroxide(KOH) and potassium silicate (K_2SiO_3) or else Sodium Silicate (Na_2SiO_3) and Sodium hydroxide (NaOH).It is the key component for the production of Alkali Activated Materials.

(i) SODIUM SILICATE (Na_2SiO_3)

Sodium silicate is the common name for compounds with the formula $Na_2(SiO_2)$. A well-known member of this series is sodium metasilicate, Na_2SiO_3. Also known as waterglass or liquid glass, these materials are available in aqueous solution and in solid form. The pure compositions are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities. Sodium silicate is commonly manufactured using a reaction in liquid phase or in solid phase. Commonly available commercial sodium silicate gel usually has a composition: SiO_2 = 30 to 35 percent, Na_2O =12 to 18 percent, H_2O = 40 to 50 percent.

(ii) SODIUM HYDROXIDE (NaOH)

Sodium hydroxide (NaOH), also known as lye and caustic soda is an inorganic compound. It is a white solid and highly caustic metallic base and alkali of sodium which is available in pellets, flakes, granules, and as prepared solutions at different concentrations. Sodium hydroxide forms an approximately 50% (by mass) saturated solution with water.

Solid sodium hydroxide is most commonly sold as flakes, prills, and cast blocks. Usually 1g of NaOH contains 0.775g of Na_2O and 0.225g of H_2O.

PREPARATION OF AAS

The Alkaline Activator Solution (AAS) is prepared by mixing sodium hydroxide, sodium silicate and water. Dissolution of sodium hydroxide is an exothermic reaction that leads to a rapid increase in temperature. Hence mixing is done carefully. The sodium silicate solution is then added to this solution only when it has reached room temperature. In this study Sodium Hydroxide solution of 6M was prepared by mixing sodium hydroxide pellet in water. The mass of NaOH solids in the solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, NaOH solution with a concentration of 6M consisted of 6 x 40 = 240grams of NaOH solids (in pellet form) per litre of solution, where 40 is the molecular weight of NaOH. The NaOH solution was prepared 24 hours prior to usage.

(iv) WATER

In general, water that is fit for human consumption (potable) is acceptable for use as mixing water. However, non-potable sources of water can also be used provided the source does not negatively impact the properties of concrete. Here potable water was used for concrete mix design.

MIX DESIGN

Mix design was proposed by trial and error method and referring the previous journals.

Mix design for GPC –Mix-1(C1)

1. Stipulations for proportioning

Grade designation : M30

Fly ash : Class F

Fly ash to GGBS ratio : 25:75

Ratio of Sodium Silicate to Sodium Hydroxide (SS:SH) : 2.5:1

Molarity of NaOH : 6M

Liquid to binder's ratio : 0.55

2. Calculation of quantity of Alkaline Activators

Binder (Fly ash + GGBS) = 400 kg/m3

Water content = 165kg

Mass of Sodium Hydroxide (NaOH pellets) = 165× 40 × 6× 10-3

= 39.60 kg/m3

(Molar mass of NaOH = 40 g/mol)

Mass of Sodium Silicate solution (Na2SiO3) = 39.60 × 2.5

= 99 kg/m3 (SS:SH=1 : 2.5)

Water in Sodium Silicate solution (55%) = 99 × 0.55 = 54.45kg/m3

Mass of liquid content (Water + NaOH + Na2SiO3)= 165+39.60+99kg/m3 ~ 303.60 kg/m3

Liquid to Binder ratio = 303.60/400 = 0.759

Water to Binder ratio = (165+39.60+54.45)/400 = 0.647

Quantities per cubic meter of GPC concrete

Materials	Quantity(kg)
FlyAsh	100
GGBS	300
AlkalineActivatorSolution(AAS)	303.60
FineAggregate	675.59
CoarseAggregate-(i)10mm	381.632
(ii)20mm	572.448
Superplasticizer- 0.3% of Binder	1.20

Mix proportion for Specimens for Test

Description	GGBS(kg)	Fly Ash(kg)	A/B (Kg)	FA (Kg)	Rubber (kg)	CA (kg)	NaOH (kg)	Na2SiO3 (kg)
C1R0AB0 (C1)	300	100	0	675.59	0	954.08	86.742	216.857
C1R0AB5 (C2)	285	100	15	675.59	0	954.08	86.742	216.857
C1R5AB5 (C3)	285	100	15	641.81	33.78	954.08	86.742	216.857
C1R10AB5 (C4)	285	100	15	608.03	67.56	954.08	86.742	216.857
C1R15AB5 (C5)	285	100	15	574.25	101.34	954.08	86.742	216.857

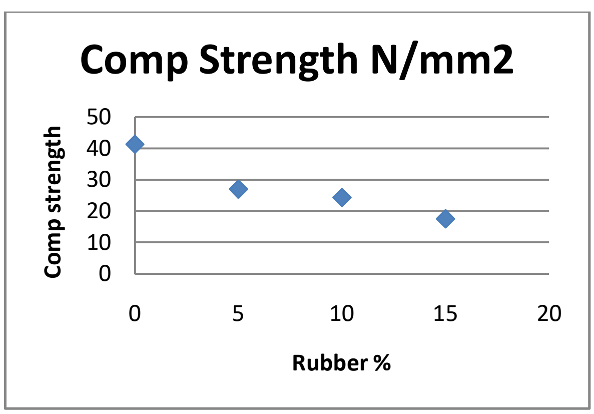
EXPERIMENTAL PROGRAMM

The strength of concrete is calculated from compressive strength and to know the modulaus of elasticity of the specimen cylinders casted and modulus of elasticity, poisson ratio of each specimen is calculated.

COMPRESSIVE STRENGTH TEST

This test was done according to IS 516: 1959. For determining the compressive strength,concrete cubes of size 150x150x150 mm were casted for different specimens. Three samples were cast for each test .The cube specimens were tested for 28 days compressive strength. Initially the specimens were cleaned and their respective weights were measured. After that clean the bearing surface of the testing machine and place the specimen in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. The load shall be applied without shock and increased continuously at a rate of approximately 14N/mm2/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. Record the maximum load. Compressive strength calculated as load/area(N/mm2). After that average compressive strength is calculated.

Compressive strength Testing



Compressive strength of GPC Cubes at 28 days

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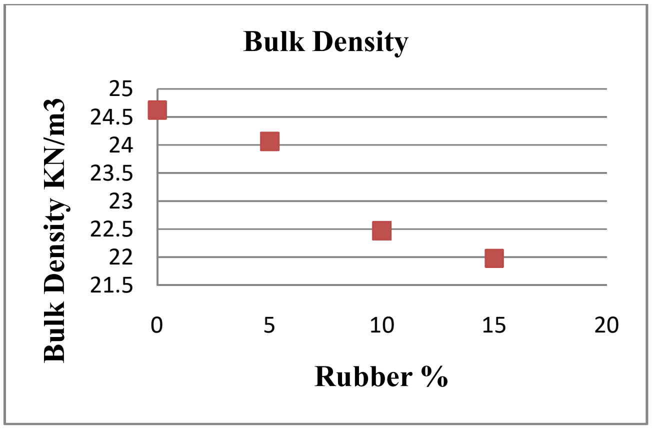
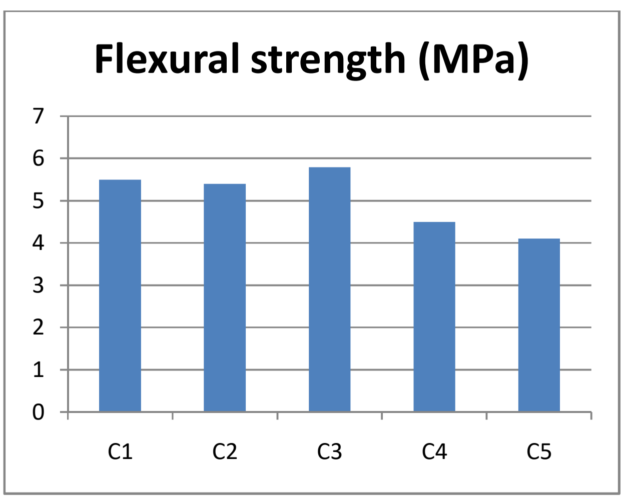


Bulk density of GPC

FLEXURAL STRENGTH OF CONCRETE

Flexural strength of concrete (Modulus of rupture) is calculated in Universal testing machine. The bed of the machine is provided with two rollers for supports. The size of the specimen is 100x100x500mm. The specimen for testing is placed in the machine. Place the specimen on the supports such that the load is applied to the upper most surface along two line 13.30cm apart. Apply the load without shock continuously increasing at a rate approximately 180kg/min. Increased the load up to which specimen failed and max load recorded. From this load and distance of crack to nearest support flexural strength calculated.

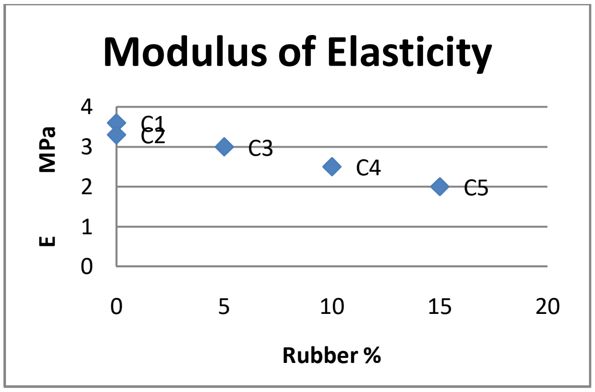


Flexural strength

MODULUS OF ELASTICITY TEST

This test was done according to IS 516: 1959. For determining the Modulus of elasticity of the specimen first calculatethe compressive strength of concrete. The size of the specimen is 150x

300mm cylinder. After finding out the strength of concrete the place the specimen in the compression testing machine and centre it. Apply the load at the rate of 140kg/cm2/minute until a stress of c+5 kg/cm2 reached. Where c is the one third of the average compressive strength of cubes calculated to the nearest of 5kg/cm2. Then unloading reading also noted. A load deflection graph is plotted and Modulus of elasticity can be calculated as stress/strain.

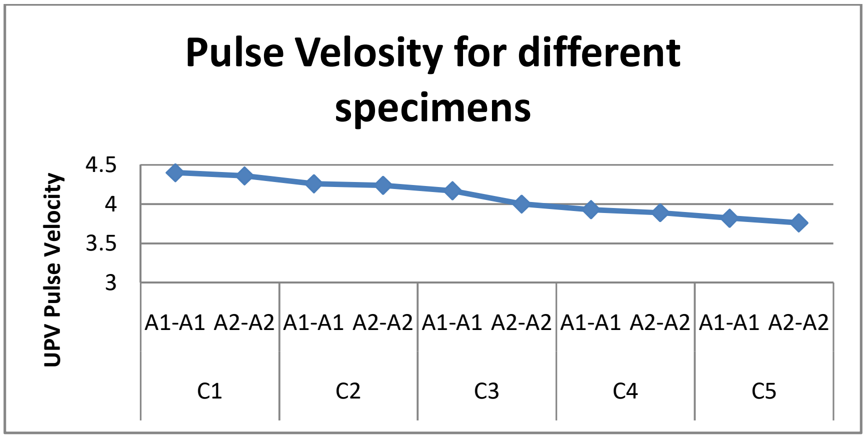


Modulus of Elasticity of GPC

UPV TEST

An ultrasonic pulse velocity (UPV) test is a non-destructive method used to assess the quality and integrity of concrete structures. It can assess by measuring the speed of ultrasonic waves traveling through them. Higher pulse velocities better concrete quality.Also the values can indicate the presence of crack , voids etc.It have a transducer and the wave transmitted through the concrete. The time takens for the pulse to travel through a known distance is measured. The pulse velocity is calculated by dividing the distance by the travel time.

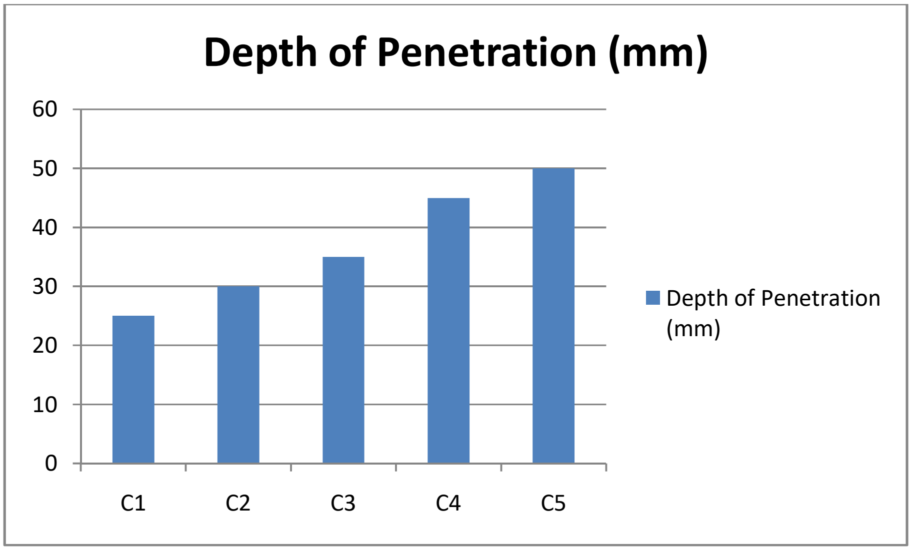
UPV Test of GPC



UPV Test of GPC

DEPTH OF PENETRATION OF WATER UNDER PRESSURE TEST

This test is carried out as per IS 516(Part 2/Sec1):2018.The depth of water penetration under pressure test for hardened concrete assesses the concrete's resistance to water intrusion under specific pressure conditions. The test involves applying water pressure to a concrete specimen, splitting it, and measuring the depth of water penetration. The method is particularly useful for dense concrete with low permeability.



Depth of penetration Test of GPC

Depth of penetration Test of GPC

WATER ABSORPTION

A water absorption test for concrete measures how much water penetrates a concrete sample when submerged, indicating its water tightness and durability. Lower absorption rates suggest better resistance to moisture penetration. The test typically involves drying a concrete specimen, weighing it, submerging it in water for a specified time, and then re weighing it to calculate the percentage of water absorbed.

The test is carried out based on BS 1881- Part 122-1983 . In this test cylindrical core of 75mm dia is cut from the cube specimen of 150mmx150mmx 150mm and the oven dried for 72 hrs and then the specimen is placed in Silica desiccator for absorbing moisture for 24 hrs and then the specimens are immersed in water for half an hour. The weights at both time calculated and from that Water absorption is calculated. A correction is applied to get the values for cube specimen from cylinder specimen. A picture of samples taken from Cubes are as shown below

Water absorption samples

Water absorption Results

Sl No	Specimen ID	Bulk Density (KN/m^3)	Water Absorption(%)
1	C1	24.88	3.6
2	C2	24.62	4.3
3	C3	24.06	4.5
4	C4	22.47	4.7
5	C5	21.98	5.00

CONCLUSION

Tests are carried out on different specimens of GPC (C1,C2,C3,C4, C5) and following results ascertained. Compressive strength of the specimens analysed. GPC with No rice husk and rubber gives better results. But adding rubber on it the strength get reduce considerably. To countereffect the reduction of strength by adding Rubber Rice husk is added. Previous journals shown that 5% Rice husk is the optimum percentage and adding rubber on it reduces the strength considerably.

Also study the modulus of Elasticity shows that adding rubber reduces the Value. By adding Rubber Water absorption , it increases considerably. The water permeability results shows that it increases with adding Rubber. Ie previous journal shows that the strength reduces by adding Rubber, this study shows the durability property also adding rubber reduces the property. Some journal studies shows that by using some modifier to rubber certain extent (nominal) the strength increases. So appropriate modifiers have to find in future studies to increase the bonding of rubber with other constituents of concrete. Also it is seen that by adding rubber/rice husk in higher percentage workability decreases and AAS solution to be added additionally to get workable mix.

Rubber particles had a higher specific surface area in comparison to replaced M sand, which increased the total wetting area of aggregates. Also it is concluded that Rubber particle could interact with the alkaline solution during Geopolymer mixing and consume free alkaline solution in the GPC mixture. Therefore, Rubber aggregates require more water and alkaline solution for workability and required GPC Flow. Also rubber particles rougher surface and irregular shape created more resistance to GPC flow and hence more AAS Solution needed in high concentration of Rubber added GPC. Also slump get reduced considerably.During the Flexural test it is seen that when rubber added 5% and Rice husk 5% the flexural strength slightly increases but after that it decreases with percentage of WRP

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