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Experimental Research Study on Geo Polymer Concrete Using Eggshell Powder with Reaction Generating Liquid

Konnoju Saikumar Chary*, Nijagala Munilakshmi

Department of Civil Engineering, S. V. U. College of Engineering, Tirupati 517502, India

Corresponding Author Email: k.saikumarchary210@gmail.com

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ABSTRACT

In this twenty-first century, Development is not only related to innovativeness in new applications but also reliability of infrastructural technology. Concrete is the main ingredient for the construction of infrastructure. When compared to other applied materials in the environment of concrete, its main component is cement. It is widely used in construction materials because of the raw materials present over the world. Nowadays Portland cement is the most popular cement concrete, but Global warming occurs due to the emission of the subsequent amount of carbon dioxide releasing quantity. So, to overcome this situation researchers are making a new step towards new alternative material named Geo Polymer concrete developed by Joseph Davidovits. It seems to be a potential alternative to standard concrete. In this we are using waste materials of combustion of coal powder waste flyash and Disposal of waste material eggshell powder for the full replacement of cement using the Reaction generating liquid with (flyash70% - eggshell 30%), (flyash80% - eggshell20%), (flyash90% - eggshell10%), (flyash100% - eggshell 0%) compressive strength, split tensile strength, Flexural strength testing experiments are performed based on their proportions. This evaluating work mainly concentrates on the change in impact factor of silica modulus consisting of Reaction Generating Liquid (RGL)(Sio2/Na2o) ranging from 0.6 to 1.5.

1. INTRODUCTION

In 1978, Joseph Davidovits started conducting geopolymer concrete and developing it, and he explained the modified substance of standard material cementations with complex dimensionality of geopolymer concrete consisting of aluminum silicate polymerized chains represented as Si-o-Al-o established by Alo_4 and Sio_4 tetrahedral atoms [1]. Following this, most of the young researchers came out and worked on flyash-based geopolymer concrete. Where flyash is the offshoot produced after the ignition of coal in power plants. Flyash is partitioned as Class F flyash and Class C flyash based on specific chemical characteristics and the source of coal also used in the ignition. Oven curing is applied for synthesizing geopolymer of Class F flyash consisting of low calcium content (Cao < 10%) [2, 3]. Low calcium flyash mainly faces problems due to low setting time, where heat curing requires low setting time for applying the process of Polycondensation [4, 5]. More calcium (Cao> 10%) quantity present in Class C flyash helps to obtain a favorable asset at room temperature. Both asset heat curing and less asset ambient curing application are shown in flyash-built Geopolymer concrete mixture [6, 7].

In this experimental conduct, we are using eggshell powder and which is used as potential waste material. Whereas, eggshell is waste disposed of in large quantities, and it is non-hazardous [8, 9]. But that eggshell material was attracted by worms and rats and it is becoming a health problem for the public [10, 11]. Municipal waste obtained from poultry forms and households is considered for landfill. Many researchers have started reusing eggshell powder and

Working on it to find out its potential strength on it [12-14]. Usage of Eggshell powder is considered a biodiesel reagent, absorbent of hefty metals, manure, and also medical substance [15, 16]. Eggshell plays a key role as a putty, binding replacement agent, and fine collective agent [17, 18]. Application of eggshell concrete of variant studies said that at present only one review [19, 20]. paper represents a detailed explanation and gathering of previous observations. Thus, to represent this gap in the available analysis of accessible studies on eggshell concrete, the proposed work consists of the effective properties of eggshell concrete auxiliary in detail [21].

2. MATERIALS AND METHODOLOGY

Generally, Pozzolana consists of siliceous and aluminous material whereas flyash has these qualities and eggshell powder consists of most lime (CaO) content. The combination of both is used as the binding material in the full replacement of cement for making geopolymer concrete with the help of reaction generating liquid (RGL), fine aggregate, and coarse aggregate. Rgl consists of a combination of sodium hydroxide pellets and sodium silicate solution and the addition of water to it is said to be reaction generating liquid. Where RGL is used as a lubricant to mix up the materials for making geopolymer concrete. Where finally we have to use the river sand for fine aggregate which is said to be void filler and for the coarse aggregate we have to choose 10mm and 20mm grades of stones for the strength properties to make the geopolymer concrete.

2.1 Flyash

For about 2,300 years ago, volcanic ashes look like flyash used for the manufacture of hydraulic cement. The other name of hydraulic cement is known as Pozzuoli in Italy and later on, it converts to pozzolan. Whereas already we know that pozzolan consists of siliceous/aluminum material when we are going to mix that material with water and lime for making a composite of cementitious materials. Now, from all the above words we are going to use the word pozzolans as the best suitable word for flyash instead of volcanoes ash in this 21st century.

Flyash Powder

By seeing the below Figure 1, we have been understanding of the particle size distribution of flyash. In that sieve particles of flyash 90% of it contains 50-micron size particles which show good fineness and also alter the greater surface area for the particle size to implicit the geopolymerisation. In the same way, the eggshell powder particle size of 300-micron size also shows good fineness, and the micron limit particle size of the eggshell powder is 75microns from an economic point of view. Moreover, the flyash and eggshell powder are said to be as cementitious materials.

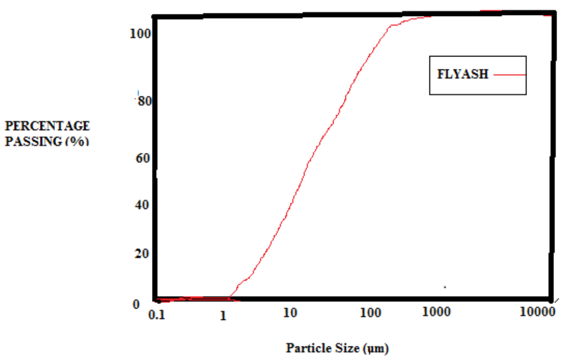

Figure 1. Particle size distribution of Flyash

Now, the chemical composition of flyash and eggshell powder was shown in the given Figure 1. The main constituents of eggshell powder were CaO with 52.2%, Sio2 with 0.09%, Al_2O_3 with 0.04%, and Fe_2O_3 with 0.03%. were, coming to flyash it contains very low lime content and it is a siliceous and aluminous material where it acts major percentage. Finally, the limits like plastic limit and liquid limit of eggshell powder take 55% and 36%.

2.1.1 Classification of Fly ash

Class F (Fly ash). The sweltering of stiffer, older anthracite coal and bituminous coal characteristically produces Class F flyash. This kind of flyash has fewer than 20% (CaO). Having pozzolanic chattels, the silica has glassy and Class F fly ash of alumina needs cementing particles like Ordinary Portland Cement, and Quick lime in the presence of water to react with the cementitious particles. To this, an additive of activator named chemicals is also to be added, and finally, the other name of class F fly ash is self-cementing.

Class C (Fly ash). This Class C Flyash has come from the boiling of fresher lignite and bituminous coal to these adding of pozzolanic content and also has self-cementing materials in it. The addition of water to this Class C flyash will be strengthened over time. The main chemical composition present in Class C flyash is 20% more than lime (CaO), alkalis and sulfate ions are also generally high compared to Class F flyash. Class F fly ash requires an activator, but Class C flyash does not require any activator. Finally, the replacement of cement is going to be done with cement with solid spherical elements and also increases the workability of concrete.

Eggshell composite. In so many countries dry eggshell powder is used as animal feed, where eggshell powder contains calcium and mainly consists of calcium carbonate ($CaCO_3$) with multiple layers. Moreover, the chemical composition of the eggshell powder is related to the limestone and fascinatingly $CaCO_3$ is the primary material of cement which consists of main compounds named to be dicalcium silicate (C_2S), tri-calcium silicate(C_3S), tri-calcium aluminate (C_3A), and tetra – calcium aluminoferrite (C4AF). Where from the above lines we understand that eggshell has potential strength for the replacement of cement, it is just because eggshell powder consists of $CaCO_3$ mainly it and other minerals like magnesium oxide, Sodium oxide, Sulphur trioxide, Silicon dioxide, Aluminum oxide, Ferrous oxide and Loss of Ignition are also present in it which was shown in Table 1 shows the chemical composition of the eggshell powder and particle size distribuition of eggshell powder were shown in Figure 2.

Table 1. Materials

i) FLYASH	BINDING MATERIAL
ii) EGGSHELL	BINDING MATERIAL
iii) FINE AGGREGATE	VOID FILLER
iv) COARSE AGGREGATE	STRENGTH
v) REACTION GENERATING LIQUID (RGL)	LUBRICANT

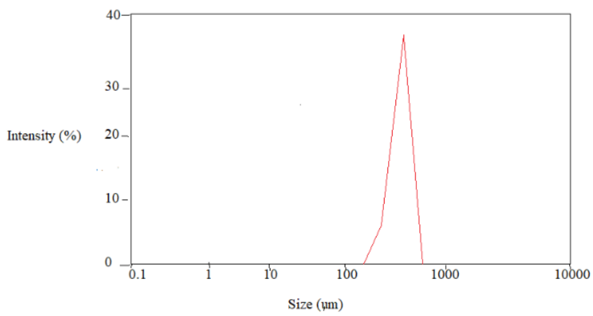

Figure 2. Particle size distribution of eggshell powder

Making of eggshell powder. For the making of eggshell powder, certain procedures and methods are to be followed for making eggshells to be turned out to be a fine powder. Now, in the first step chicken egg is to be boiled on the stove and that egg is turned into two layers that from that boiled egg shell is going to be separated and keep that shell materials dry in the sunlight which coming out from the egg. From the next day crunch the eggshell material into a very fine powder with help of any available equipment in the lab like grinders. In the next step, we have to remember that the average cement particle size is about 15-45 microns particle size. So, we have to remember that eggshell powder should also make into a very fine powder using the Sieve analysis method. The materials like Eggshell powder and cement properties were explained in the Table 2, 3, 4 and 5.

Table 2. Eggshell powder physical properties

S. NO	Properties	Test Values
1	Specific Gravity of Eggshell powder	2.42
2	Consistency	38%
3	Setting time (Initial)	48 min

Table 3. Cement physical properties

S. NO	Properties	Test Values
1	Standard consistency	33%
2	Setting time (Initial)	30 min
3	Setting time (Final)	600 min
4	Fineness modulus	3%

Table 4. Chemical properties of cement and eggshell powder

Composition	Cement (%)	Eggshell powder (%)
Silicon dioxide	22	0.09
Aluminum oxide	6.8	0.04
Ferrous oxide	4.3	0.03
Lime (CaO)	61	52.2
Magnesium oxide	2.3	0.02
Sodium oxide	0.5	0.20
Sulphur trioxide	2.4	0.8
Loss of Ignition	2.6	45.5

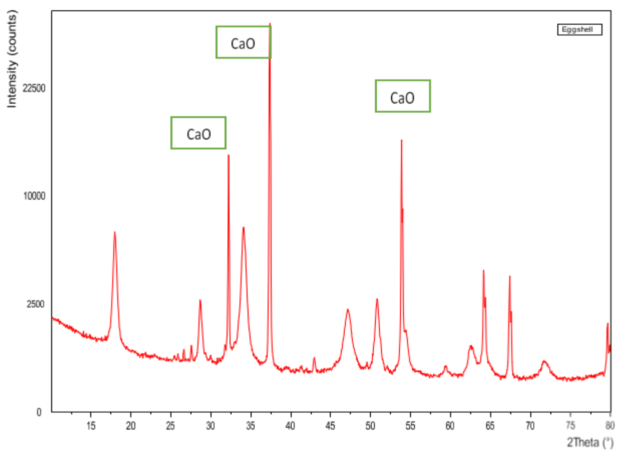

Figure 3. XRD pattern of Eggshell powder

From the Figure 3 of XRD we have been understanding that CaO (lime) content was showing higher in the graphs, especially at some point regions. Now, we are explaining them point to point in the below lines. The eggshell membranes were removed during the process of making eggshell powder process. The XRD values showing the test result peak values and crystalline phase were the main constituents of caco3 in a CaO form. As per the reference code 98-020-2225, the XRD test results on eggshell powder has showing the values of calcite at 2h angles were showing 17.20, 26.80, 28.160, 32.450, 35.320, 46.20, 55.30, 64.40, 71.10, and 72.40. Among all these XRD points highest peak point was shown as 35.320. in this study, we understood that the peaks of calcium without the crystalline were the same and eggshell powder was showing the peak value of CaO through XRD. The halo diffused point of diffraction was between 24 and 36 (2h) of the amorphous phase in calcium silicates were shown in Figure 3.

Table 5. Difference between Flyash and eggshell powder

Flyash	Eggshell powder
It contains Siliceous and Aluminous material.	It contains $caco_3$, like pure calcite material.
It is a Pozzolanic material.	It is a binding material.
It came from the combustion of coal.	It came from the eggshell powder.
It gives strength, excess causes slow setting. for Quick setting, excess lowers strength	It controls strength and soundness of the Geo-polymer concrete.

2.2 Fine aggregate

Fine Aggregate Sample

The aggregate size range of below 4.75mm or less is said to be Fine Aggregate. This fine aggregate which consists of sand, silt, clay particles, and crushed stone and gravel is going to be there in it.

Fine aggregate comes out from the river water through the mining process and the particle size of the fine aggregate is less than 4.75mm in that natural sand or any other trampled stone particles are 1/4th smaller.

Finally, the collection of fine aggregate from the river through the mining process is said to be river sand and we have to sieve this sand passed through number 4sieve with a size of mesh 4.75mm.

In the concrete, the help of fine aggregate is the material used for making the concrete as void filler to come out from the crack properties in the wall due to the lack of river sand in the concrete.

Table 6. Fine aggregate physical properties

S.NO	PROPERTIES	TEST VALUES
1	Specific gravity of Fine Aggregate	2.7
2	Fineness modulus	4.72
3	Bulking of fine aggregate	52%

Fine aggregate is going to be active as Void filler which we have shown in the Table 6.

2.2.1 Coarse aggregate

The aggregate size particles greater than 4.75mm after crushing the stone particles into pieces which are said to be of different sizes in different names like below 8mm particle size is Chips, above 8mm particle size is Stone and 40mm particle size is Boulder. These are all particles of aggregate sizes to be used for making concrete and construction of roads. In this paper, we are going to be explained the concrete, in the concrete role of coarse aggregate related to strength. Expanding the words on coarse aggregate we use the stone particle size in it, for making the concrete we have to use fine aggregate and coarse aggregate with all the materials to improve the mechanical properties of concrete, like all the materials blended into it each other in all the fill spaces between small pieces to large pieces blended for making the strength of concrete. Coarse aggregate is going to be act as strength which we have shown in the Table 7.

Coarse Aggregate Sample

Table 7. Coarse aggregate physical properties

S.NO	PROPERTIES	TEST VALUES
1	Specific gravity of Coarse Aggregate	2.67
2	Fineness Modulus	4.75
3	Aggregate impact value	24.48%
4	Flakiness index	12.56%
5	Elongation index	42.24%

RGL (REACTION GENERATING LIQUID)

The alternative of Portland cement to Geopolymers can blend the inorganic polymers to the inorganic links which showed in the below Figure.

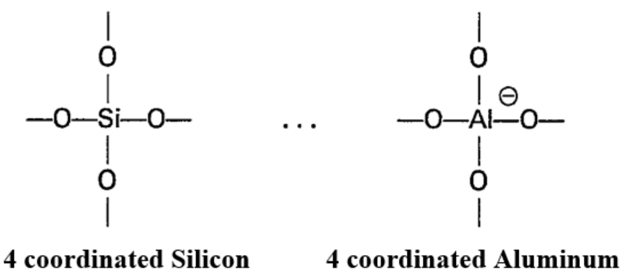

Figure 4. Basic units of geopolymer

The accompany of alkali metal ions like Sodium or Potassium for the balancing chain of 4-coordinated Silicon is substituted with 4 – coordinated aluminum with the above inorganic linkages (Figure 4).

The combination of aluminum oxide and silicon dioxide is the chemicals composition which is used for the making of Geopolymer composites source materials like examples fly ash and Gabs, Rice husk ash, and any other materials which are going to be used as a liquid named to be Reaction General Liquid (RGL) which it is going to act as binding materials for the presence of the material are known as geopolymerisation.

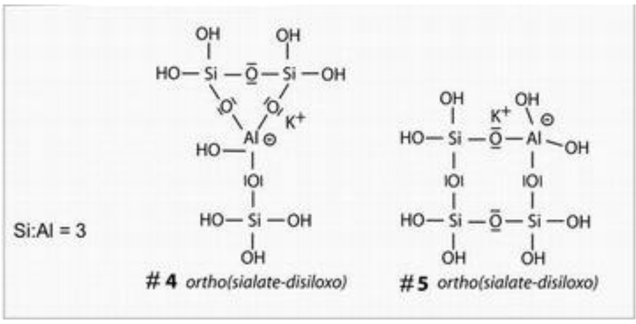

Figure 5. 4-coordinated Silicon is substituted by 4-coordinated Aluminum

To explain the Reaction Generating Liquid in the Geopolymer concrete. where most of the experiments conducted on this concrete are alkaline liquid. But, here in this research, we are using reaction generating liquid it is comprised of sodium hydroxide pellets, sodium silicate solution, and water for making blended all these materials with this liquid for making the Geopolymerisation.

Whereas compared Alkaline Liquid to Reaction Generating Liquid where is no need to prepare the sodium hydroxide pellet solution before 24hrs and there is no need to additive any chemical admixture in the Reaction Generating Liquid. But, when compared to the alkaline liquid we have to prepare the NaOH solution, and the additive of chemicals should also be done.

It may be also noted here that the main differences between conventional concretes (CC) and Geopolymer Concrete (GPC) are: Figure 4 and Figure 5.

Complete absence of Portland cement in GPCs.

Mixing water of CC mix is replaced fully by RGL.

It is observed that often many concrete-making equipment and procedures of CCs can be adopted for GPCs also (with minimum modifications) except that the water of CCs is replaced completely by RGL. The RGL was used as a lubricant which were explained about the difference between RGL and Alkaline liquid were explained in Table 8 and Table 9.

Table 8. Properties of RGL (Reaction Generation Liquid)

1	Density	0.05 – 1.20 kg/lit
2	Viscosity	25 – 50 centipoises
3	Rgl liquid suitable	Room temperature

Table 9. Difference between the liquids

Alkaline Liquid	Reaction Generating Liquid
It should prepare within 24 hours	It is readily available
It is costly	It is cheaper
Easily available	We have to give order before the prior time
Superplasticizer is needed	No need for any Superplasticizer
Water to be added	No need for any additional water

2.3 Methodology

We have to find the specific gravity of Fly ash, Eggshell powder, Fine aggregate, and Coarse aggregate. As per IS code 17452: 2020, Sio_2/Na_2o = 0.6-1.5 with different mix proportions on Fly ash: Eggshell powder ratios like 70: 30, 80: 20, 90: 10, 100: 0. proportions to be used for finding Compressive strength test, Flexural strength test and Split tensile strength test.

3. EXPERIMENTAL RESULTS

MIX DESIGN (IS 17452: 2020)

Concrete Cubes, Beams, Cylinders Samples

Table 10. 70:30 using Sio_2/ Na_20= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6. finding **compressive strength**

Fly ash: Eggshell = (70:30) = 280 Kg: 120Kg				
Sio_2/Na_20	Fine Agg (Kg)	Coarse Agg (Kg)		R.G.L (Kg)
		20mm	10mm	
0.6	337.6	331.7	221.1	126
0.8	338.9	332.9	221.9	136.5
1.1	326.5	320.8	213.8	178.3
1.2	329.5	323.7	215.8	184.6
1.4	318.3	312.7	208.5	253.8
1.5	750	738	492	232
Note: Strength in Mpa (N/mm^2)				

Table 11. 80:20 Using Sio_2/ Na_20= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6. finding **compressive strength**

Fly ash: Eggshell = (80:20)=320Kg: 80 Kg				
Sio_2/Na_20	Fine Agg (Kg)	Coarse Agg (Kg)		R.G.L (Kg)
		20mm	10mm	
0.6	458.9	450.9	300.6	126
0.8	454.5	446.6	297.7	136.5
1.1	447.5	293.1	439.7	178.3
1.2	445.2	437.5	291.6	184.6
1.4	439.2	431.6	287.7	253.8
1.5	495.0	486.4	324.3	232
Note: Strength in Mpa (N/mm^2)				

Table 12. 90:10 Using Sio_2/Na_20= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6 finding **compressive strength**

Fly ash: Eggshell = (90:10) =360 Kg: 40Kg				
Sio_2/ Na_20	Fine Agg (Kg)	Coarse Agg (Kg)		R.G.L (Kg)
		20mm	10mm	
0.6	705.9	693.6	462.4	126
0.8	700.7	688.5	459.0	136.5
1.1	694.5	682.4	459.9	178.3
1.2	691.4	679.4	452.9	184.6
1.4	687.3	675.3	450.2	253.8
1.5	742.1	729.1	486.1	232
Note: Strength in Mpa (N/mm^2)				

Table 13. 100:0using Sio_2/Na_20= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6 finding **compressive strength**

Fly ash: Eggshell = (100:0) =400 Kg: 0Kg				
Sio_2/Na_20	Fine Agg (Kg)	Coarse Agg (Kg)		R.G.L (Kg)
		20mm	10mm	
0.6	700.7	689.2	459.5	126
0.8	696.6	684.4	456.3	136.5
1.1	689.4	678.2	452.1	178.3
1.2	688.1	667.2	444.8	184.6
1.4	682.1	670.2	446.8	253.8
1.5	737.9	725.1	483.4	232
Note: Strength in Mpa (N/mm^2)				

Table 14. 70:30 Using Sio_2/Na_20= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5 finding **split tensile strength**

Fly ash: Eggshell = (70:30) = 280 Kg: 120Kg				
Sio_2/Na_20	Fine Agg (Kg)	Coarse Agg (Kg)		R.G.L (Kg)
		20mm	10mm	
0.6	337.67	331.7	221.1	126
0.8	338.98	332.9	221.9	136.5
1.1	326.51	320.8	213.8	178.3
1.2	329.51	323.7	215.8	184.6
1.4	318.34	312.7	208.5	253.8
1.5	750	738	492	232
Note: Strength in Mpa (N/mm^2)				

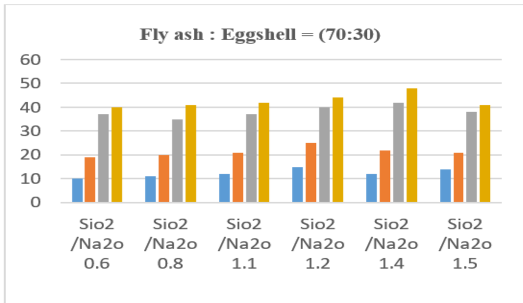

Figure 6. For 70: 30 on compressive strength in cubes

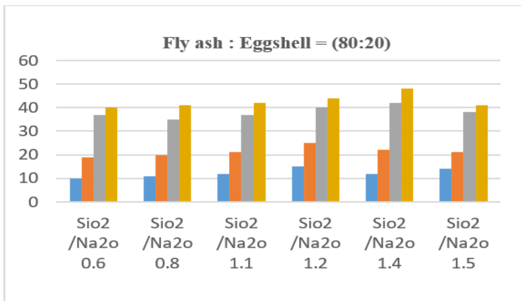

Figure 7. For 80:20 on compressive strength in cubes

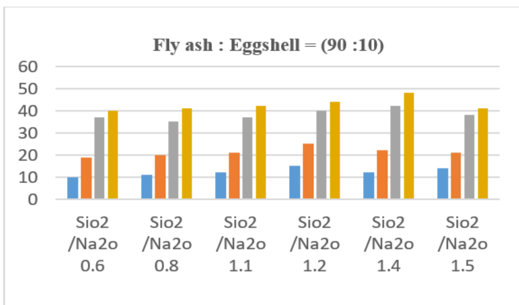

Figure 8. For 90:10 on compressive strength in cubes

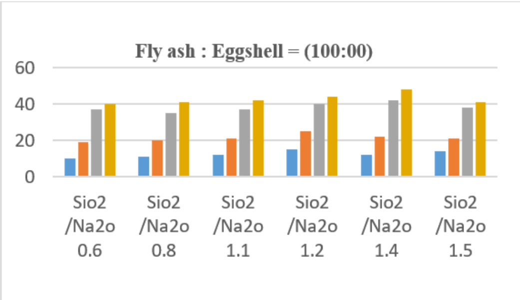

Figure 9. For 100:0 on compressive strength in cubes

Table 15. 80:20using Sio$_2$/ Na$_2$0= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6 finding split tensile strength

Fly ash: Eggshell = (80:20) =320 Kg: 80Kg

Sio$_2$/Na$_2$0	Fine Agg (Kg)	Coarse Agg (Kg) 20mm	Coarse Agg (Kg) 10mm	R.G.L (Kg)
0.6	458.9	450.9	300.6	126
0.8	454.5	446.6	297.7	136.5
1.1	447.5	293.1	439.7	178.3
1.2	445.2	437.5	291.6	184.6
1.4	439.2	431.6	287.7	253.8
1.5	495.0	486.4	324.3	232

Note: Strength in Mpa (N/mm^2)

Table 16. 90:10 Using Sio$_2$/ Na$_2$0= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5, 1.6 finding split tensile strength

Fly ash: Eggshell = (90:10) =360 Kg: 40Kg

Sio$_2$/Na$_2$0	Fine Agg (Kg)	Coarse Agg (Kg) 20mm	Coarse Agg (Kg) 10mm	R.G.L (Kg)
0.6	458.9	450.9	300.6	126
0.8	454.5	446.6	297.7	136.5
1.1	447.5	293.1	439.7	178.3
1.2	445.2	437.5	291.6	184.6
1.4	439.2	431.6	287.7	253.8
1.5	495.0	486.4	324.3	232

Note: Strength in Mpa (N/mm^2)

Table 17. 100:0 Using Sio$_2$/ Na$_2$0= 0.6, 0.8, 1.1, 1.2, 1.4, 1.5 finding split tensile strength

Fly ash: Eggshell = (100:0) =100 Kg: 0Kg

Sio$_2$/Na$_2$0	Fine Agg (Kg)	Coarse Agg (Kg) 20mm	Coarse Agg (Kg) 10mm	R.G.L (Kg)
0.6	700.7	689.2	459.5	126
0.8	696.6	684.4	456.3	136.5
1.1	689.4	678.2	452.1	178.3
1.2	688.1	667.2	444.8	184.6
1.4	682.1	670.2	446.8	253.8
1.5	737.9	725.1	483.4	232

Note: Strength in Mpa (N/mm^2)

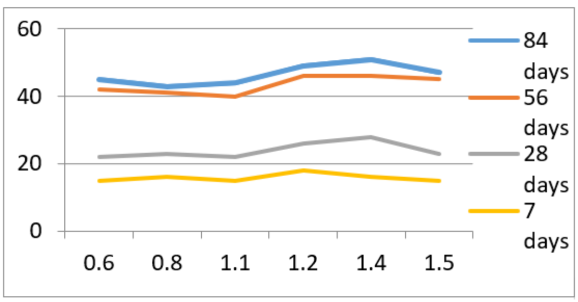

Figure 10. For 70: 30 on split tensile strength in cylinders

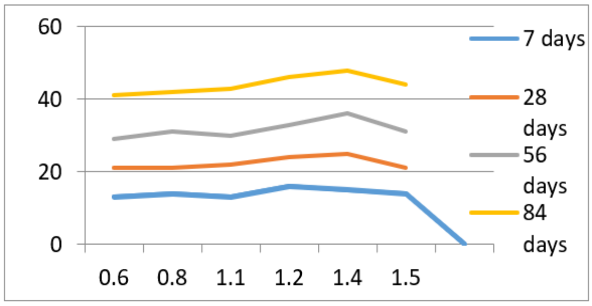

Figure 11. For 80: 20 on split tensile strength in cylinders

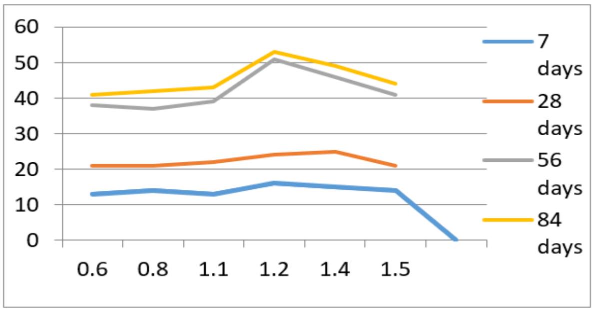

Figure 12. For 90: 10 on split tensile strength in cylinders

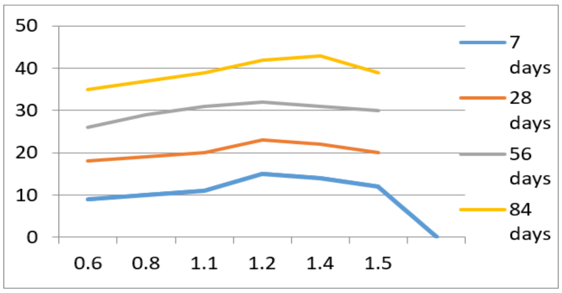

Figure 13. For 100: 0 on split tensile strength in cylinders

Table 18. 70:30 Using Sio$_2$/ Na$_2$0= 0.6, 0.8, 1.1, 1.2, 1.4,1.5 finding flexural strength

Fly ash: Eggshell = (70:30) =280 Kg: 120Kg

Sio$_2$/Na$_2$0	Fine Agg (Kg)	Coarse Agg (Kg) 20mm	Coarse Agg (Kg) 10mm	R.G.L (Kg)
0.6	337.6	331.7	221.1	126
0.8	338.9	332.9	221.9	136.5
1.1	326.5	320.81	213.8	178.3
1.2	329.5	323.7	215.8	184.6
1.4	318.3	312.7	208.5	253.8
1.5	750	738	492	232

Note: Strength in Mpa (N/mm^2)

Table 19. 80:20 Using Sio$_2$/ Na$_2$0= 0.6, 0.8, 1.1, 1.2, 1.4,1.5 finding flexural strength

Fly ash: Eggshell = (80:20) =320 Kg: 80Kg

Sio$_2$/Na$_2$0	Fine Agg (Kg)	Coarse Agg (Kg) 20mm	Coarse Agg (Kg) 10mm	R.G.L (Kg)
0.6	458.9	450.9	300.6	126
0.8	454.5	446.6	297.7	136.5
1.1	447.5	293.1	439.7	178.3
1.2	445.2	437.5	291.6	184.6
1.4	439.2	431.6	287.7	253.8
1.5	495.0	486.4	324.3	232

Note: Strength in Mpa (N/mm^2)

Table 20. 90:10 Using SiO_2/ Na_20= 0.6, 0.8, 1.1, 1.2, 1.4,1.5 finding flexural strength

Fly ash: Eggshell = (90:10) =360 Kg: 40Kg				
SiO_2/Na_20	**Fine Agg (Kg)**	**Coarse Agg (Kg) 20mm**	**10mm**	**R.G.L (Kg)**
0.6	**705.9**	**693.6**	**462.4**	**126**
0.8	**700.7**	**688.5**	**459.0**	**136.5**
1.1	**694.5**	**682.4**	**459.9**	**178.3**
1.2	**691.4**	**679.4**	**452.9**	**184.6**
1.4	**687.3**	**675.3**	**450.2**	**253.8**
1.5	**742.1**	**729.1**	**486.1**	**232**

Note: Strength in Mpa (N/mm^2)

Table 21. 100:0 Using SiO_2/ Na_20= 0.6, 0.8, 1.1, 1.2, 1.4,1.5 finding flexural strength

Fly ash: Eggshell = (100:0) =400 Kg: 0Kg				
SiO_2/ Na_20	**Fine Agg (Kg)**	**Coarse Agg (Kg) 20mm**	**10mm**	**R.G.L (Kg)**
0.6	**700.7**	**689.2**	**459.5**	**126**
0.8	**696.6**	**684.4**	**456.3**	**136.5**
1.1	**689.4**	**678.2**	**452.1**	**178.3**
1.2	**688.1**	**667.2**	**444.8**	**184.6**
1.4	**682.1**	**670.2**	**446.8**	**253.8**
1.5	**737.9**	**725.1**	**483.4**	**232**

Note: Strength in Mpa (N/mm^2)

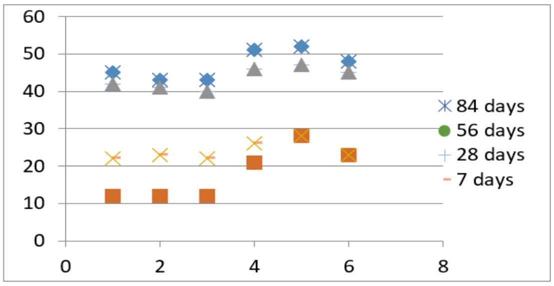

Figure 14. For 70: 30 on flexural strength on beams

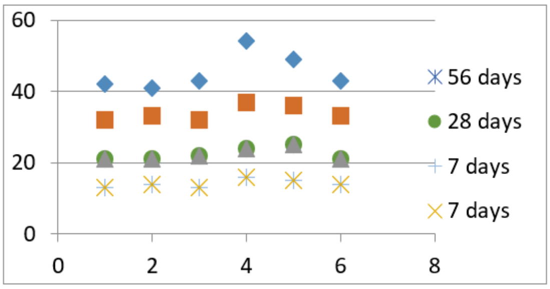

Figure 15. For 80: 20 on flexural strength on beams

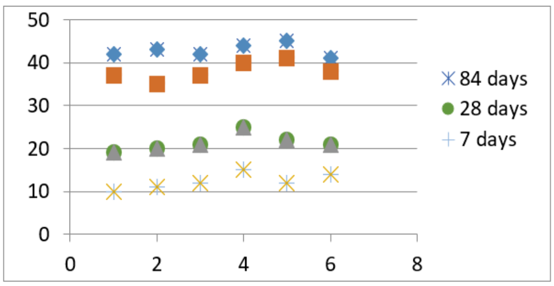

Figure 16. For 90: 10 on flexural strength on beams

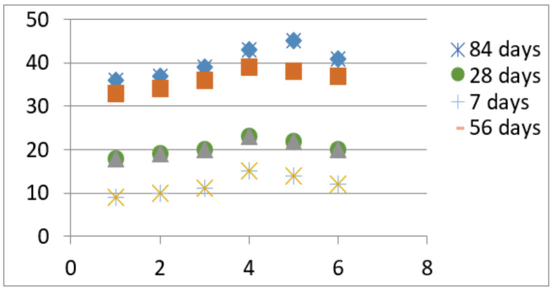

Figure 17. For 100: 00 on flexural strength on beams

Test results:

As per IS code 17452: 2020SiO_2/ Na_20trials from 0.6 -1.5 test conducted on compressive strength, split tensile strength and flexural strength test was explained in Tables 10-21 various days like 3, 7, 28, 56 days we get good values in the 70: 30 SiO_2/ Na_20 on 1.4 we get the highest value of 50mpa and the lowest value onSiO_2/ $Na_20$of 0.6 is 44 Mpa were shown in Figures 6-16.

- For 80: 20 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on compressive strength for 1.4 is 46 Mpa and the lowest is 0.6 is 44 Mpa.
- For 90: 10 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on compressive strength for 1.4 is 48 Mpa and the lowest is 0.6 is 40 Mpa.
- For 100 : 0 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on compressive strength for 1.2 is 43 Mpa and the lowest is 0.6 is 36 Mpa.
- For 70: 30 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on split tensile strength for 1.4 is 51 Mpa and the lowest is 0.8 is 43 Mpa.
- For 80: 20 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on split tensile strength for 1.4 is 48 Mpa and the lowest is 0.6 is 41 Mpa.
- For 90: 10 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct unsplit tensile strength for 1.2 is 53 Mpa and the lowest is 0.6 is 41 Mpa.
- For 100 : 0 mix proportions, the highest value for the SiO_2/ Na_20 tests conduct on split tensile strength for 1.4 is 43 Mpa and the lowest is 0.6 is 35 Mpa.
- For 70: 30 mix proportions, the highest value for the SiO_2/ Na_20 tests conducted on the flexural strength test for 1.4 is 52 Mpa and the lowest is 0.8 is 43 Mpa.
- For 80: 20 mix proportions, the highest value for the SiO_2/ Na_20 tests conducted on the flexural strength test for 1.4 is 49 Mpa and the lowest is 0.8 is 41 Mpa.
- For 90: 10 mix proportions, the highest value for the SiO_2/ Na_20 tests conducted on the flexural strength test for 1.4 is 45 Mpa and the lowest is 0.6 is 42 Mpa.
- For 100 : 0 mix proportions, the highest value for the SiO_2/ Na_20 tests conducted on the flexural strength test for 1.4 is 45 Mpa and the lowest is 0.6 is 36 Mpa.
- Now, we have to make graphs, curves, and bar diagrams based on the values for the different mix proportions.

The below SEM test (Scanning Electron Microscopy) has been conducted on the concrete cubes with different mix proportions to the microstructure of flyash and Eggshell powder with the combination of Rgl to analyze the strength properties of Geo-polymer concrete using SiO_2/Na_20 = 0.6 -1.5. From the above lines of SEM Micrographs, we have identified that CH (Calcium Hydroxide), hydrated products, C-S-H, and voids/cracks are found in concrete.

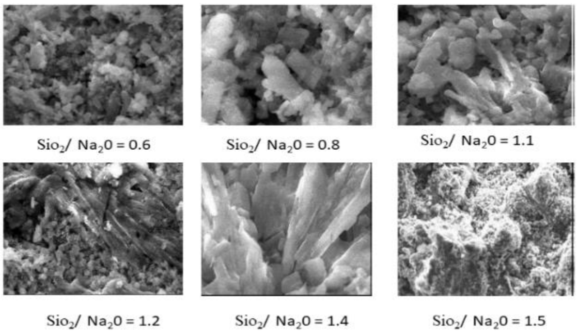

Figure 18. SEM micrographs of flyash and eggshell powder for compressive strength of concrete

Now, moreover from all the figures $Sio_2/ Na_20 = 0.6 – 1.6$, we identified that white parts can be said to be unhydrated particles, black parts are voids/cracks and finally, dark grey parts are termed to be CH, C-S-H and other hydration products are there from the SEM Micrograph images. Now, from the image of SEM micrographs, $Sio_2/ Na_20 = 0.6$ is showing that very much white and black areas were identified from the images that represent the voids/cracks and unhydrated products.in the other color area, the dark shadow of concrete in the image shows the discontinuity and non-homogeneity of concrete which shows the less compressive strength.

The SEM micrographs of $Sio_2/ Na_20 = 0.8$which has many white areas which indicate the un-hydrated products compare to $Sio_2/ Na_20 = 0.6$and it also shows the indication of a slight increase of compressive strength. Whereas the $Sio_2/ Na_20 = 1.1$ shows that the internal grains are very closely packed and it also shows the solid mass constitute of firm solid which is very closely packed shows the differences from $Sio_2/ Na_20 = 0.6$to $Sio_2/ Na_20 = 1.1$.

In the $Sio_2/ Na_20 = 1.4$ the concrete cube of blended mix represented the white and black areas showing the indication of un-hydrated products and voids/cracks in the concrete. The dark greys in the areas are said to be hydrated products. Now, some part of the black area is little voids/cracks and the other part of the white area shows the un-hydrated particles in the SEM micrograph of $Sio_2/ Na_20 = 1.4$. We also find out that so many grey areas were turned into dark grey areas of hydration products were seen. Finally, in the $Sio_2/ Na_20 = 1.5$, it is easy to find out so many black areas and shapes spherical in identifying un-hydrated products with voids/cracks. This shows the fall of compressive strength from $Sio_2/ Na_20 = 1.4$ to $Sio_2/ Na_20 = 1.5$ were shown in Figure 18.

4. CONCLUSION

For years we have been using it to make alkaline solutions with NaOH pellets, sodium silicate solution, and water. But now we are in the advanced stage to reduce effort and time by using the RGL solution. Some of the researchers have performed experimental conducts on materials like GGBS, flyash, $CaCo_3$, and some other materials. Now by conducting the experimental research on fly ash with eggshell using RGL solution. By conducting these experiments, we are concluding some highlighted points in the below lines.

Geo polymer concrete using alkaline solution has molarity issues all the time, now we are using Rgl solution in it, so that we will come out from the molarity issues Particularly, there is no need to add a superplasticizer in this while using the RGL solution.

The eggshell powder has calcium carbonate content, so it will be helpful to get good strength. The feedback regarding the eggshell powder is to overcome the smell of it while making it into fine powder. As per IS 17452: 2020Sio_2/ Na_20 trials from 0.6 -1.6. We are going to get good results on 1.1 - 1.2 from 70:30, 80:20,90:10,100:0 proportions. Pleasedon't experiment on heated eggshell powdered ash because it will lose calcium content in it while heating and it will not improve the strength of concrete. Reduction of porosity and increasing the concrete structure improve by adding eggshell powder.

The future scope of work is to conduct the Rgl with various materials on different mixed proportions.

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