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EXPERIMENTAL INVESTIGATION ON GEO POLYMER CONCRETE WITH CONSTRUCTION DEMOLITION WASTE

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I. ABSTRACT

Geo polymers are the materials based on pure alumina silicate source materials such as fly ash, granulated blast furnace slag obtained from industrial, activated with an alkali metal hydroxide and silicate solution. Geopolymerisation is a complex multiphase exothermic process, involving a series of dissolution-reorientation-solidification reactions analogous to those observed in zeolite synthesis. High alkaline solutions are used to induce the silicon and aluminum atoms in the source material to dissolve and form Geopolymer gel. The sol gel formation (or polymerization) may be assisted by application of heat, followed by drying. The usage of ground granulated blast furnace slug made the geopolymer motor to cure at the room temperature. The Geopolymer gel binds the loose coarse aggregate, fine aggregate and un-reacted source material to form Geopolymer composites. The Portland cement free Geopolymer composites have many advantages like less curing time, earlier development of higher mechanical strength, very little drying shrinkage and very low creep, excellent resistance to sulfate attack, good acid resistance and resistance to high temperature. The strength development in Geopolymer composites depends on the chemical composition, morphology and reactivity of source materials, chemical composition of activating solution and curing process.

Keywords: Compressive strength, Construction, Flexural strength, Geo polymer concrete, Fly ash, Rice husk ash

II. INTRODUCTION

Geo polymers are the materials based on pure alumina-silicate source materials such as fly ash and rice husk ash obtained from industrial wastes or calcined clays like metakaoline, activated with an alkali metal hydroxide and silicate solution. The expression "Geopolymer"was proposed by Davidovits in the 1980's due to their setting mechanism, a polycondensation process under alkaline conditions, similar to organic polymers.

Geopolymerisation is a complex multiphase exothermic process, involving a series of dissolution-reorientation-solidification reactions analogous to those observed in zeolite synthesis. High alkaline solutions are used to induce the silicon and aluminum atoms in the source material to dissolve and form Geopolymer gel. The sol gel formation (or polymerization) may be assisted by application of heat, followed by drying. The Geopolymer gel binds the loose coarse aggregate, fine aggregate and un-reacted source material to form Geopolymer composites. The Portland cement free Geopolymer composites have many advantages like less curing time, earlier development of higher mechanical strength, very little drying shrinkage and very low creep, excellent resistance to sulfate attack, good acid resistance and resistance to high temperature. The strength development in Geopolymer composites depends on the chemical composition, morphology and reactivity of source materials, chemical composition of activating solution and curing process. These binders are currently attracting widespread attention due to their potential utilization as a high performance, environmental friendly and sustainable alternative to Portland cement.

2.1 HISTORY OF GEO POLYMER APPLICATIONS AND RESEARCH

The usage of geopolymers may go back to the Romans and Egyptians, and probably further back to the Babylonians, as they used inorganic compounds mixed with organic matter to produce strong building materials. While there are still disagreements whether or not the Egyptian pyramids were made of geopolymers, it has been confirmed that the network structure of the building blocks matches the definition of in organic polymers.

Due to the intensive research of Davidovits and Legrand, the first fire resistant building materials, containing chipboard panels with a geopolymer coating, were produced in the mid 1970's, thus initiating the geopolymer industry. Ongoing research led to improvements in the materials and broadened their applications within the field of heat protection.

Geopolymers can be produced with various microstructures in relation to the Si: Al ratio; high aluminium contents lead to three-dimensional structures and high silicon contents lead to two dimensional cross-linked structures. Because of the various microstructures, different mechanical and physical properties can be achieved. Hence, geopolymers are useful for a wide range of applications, e.g. as heat resistant materials (up to 1400°C) and sealants or encapsulation materials. Moreover, because of their properties, geopolymers could also provide a good alternative to conventional plastics ornaments.

A wider range of applications and improvements were made due to continuous research in the geopolymers field. The properties of geopolymers were exploited, drawing on the fact that they are not only heat resistant but are also highly porous and therefore light weight. Using this knowledge and applying it to the ceramics field, composite geopolymeric materials were developed with improved specific properties, resulting in more technical or advanced applications, for example aeronautical applications, wall insulation for cabins and storage bins, wire insulation and automotive parts. The applications of geopolymeric binders have been tested in pilot studies worldwide. Some products have already reached industrial applications, such as new class of special and blended cements, building products, advanced mineral binders,temperature resistant resins and ceramic composites.

Since geopolymers are considered as two-component systems (reactive solid base material and alkaline activation solution), they are suitable in pre-cast industry. The manufacture of products such as large-diameter pipes and roofing tiles, pre-cast concrete products, structural and non-structural members for building systems and bridgestructures, railway sleepers, electric power poles, road bases, marine structures and other products for infrastructure etc. are possible using geo polymers. Geo polymers have also been tried for production of different building material like fire resistant bricks & wood panels, panels for thermal insulation, decorative stone artifacts, foamed (expanded) geopolymer, low energy ceramic tiles, by Olsenand Berg et.al,[2](although without any industrial success).

Beside these "high-tech"applications, special geopolymer concretes have been used for repairing runways or motorways because they set and harden quickly and develop a high compressive strength within four hours. Likewise, geopolymers are used for structural and building applications. Flexible inorganic polymer fiber composites can be used to repair structures made of stone, bricks or concrete. Such fiber composites are already used in Japan and America to reinforce existing bridges and other buildings but are also used in new constructions in hazardous areas. Another important application is waste encapsulation. It has been reported that it is possible to synthesize geopolymers which trap heavy metals and radioactive materials in their network structures.

1.2.1 BENEFITS OF GEO POLYMER CONCRETE

The synthesis of geopolymers does not create greenhouse gases since there is no calcination step (heating to 1450°C) in the synthesis, thus avoiding the release of CO2 and because of this energy efficiency, inorganic polymers have become increasingly attractive. Additionally it is generally possible to produce these products using recycled materials. This is another benefit in the context of the current problems of global warming and environmental protection. In addition these alumina silicate materials possesses comparatively higher strength and are much more resistant to chemical attack, e.g. by acids, than calcium-rich Portland cement.

1.2.2 NEED FOR BLENDED FLY ASH

Fly ash is a fine powder recovered by electrostatic precipitation from the gases of burning coal during the production of electricity in thermal power plants. It is available abundantly worldwide. Presently, as per the Indian Ministry of Environment & Forest Figures, only a little percentages of fly Ash is being used in manufacturing cements, construction concrete, block & tiles and some are disposed off in landfills andembankments but a huge amount of fly ash is unutilized.

Fly ash is rich in silica and alumina. Theoretically, any aluminosilicate material can be used as a base material to produce geopolymer binder. The various aluminosilicate materials such as Metakaolin, Fly ash, rice husk ash, GGBS, Silica fume etc. have been used by many researchers as base material to make geopolymer. It is important to note here that the fundamental understanding of geopolymerisation is based on research using relatively pure raw material, like Metakaolin. In case of Metakaolin, the most of the silica and alumina in base material is converted into aluminosilicate gel during geopolymerisation process and it is relatively easy to characterize the produced geopolymer. The utilization of metakaolin in synthesis of geopolymer proved useful for research purpose, but it will be impractical for widespread application due to its processing cost. On the other hand fly ash, the solid waste generated in thermal power plants, if used properly has full potentialto use as one of the base material for producing Geopolymer binder.

The use of fly ashes from different sources, as well as different batches from the same source resulted in geopolymers with significantly differing strengths according to the available literature. Again, the trends in early strength across a particular group of fly ashes do not match the trends in final strength for the same ashes. Therefore, producing the fly ash based geopolymers with consistent physical and mechanical properties despite the variability in the raw materials is a challenging issue. Here comes the concept of blending of some supplementary material like silica fume as it is being done successfully in case of traditional cement based concrete. Addition of some supplementary materials like silica fume, which itself is capable enough to form Geopolymer binder in similar condition, as blending material with fly ash may be beneficial in this field to supplement the ultimate product properties. In case of producing blended fly ash based geopolymer, thorough understanding of synthesizing parameters and their effect on microstructure and macroscopic properties is essential for optimizing processing parameters and product properties efficiently.

1.3 MANUFACTURING OF GEO POLYMER CONCRETE

Following manufacturing process was observed for preparing geopolymer mortar specimens.

Mix sodium silicate solution, sodium hydroxide pellets and water according to mix proportion, to make alkaline activator, at least one day prior to its use in manufacturing geopolymer.

For preparing geopolymer mix hand mixings, were used throughout the work. Fly ash and rice husk ash is blended in dry sate vigorously wherever reqd. Alkaline activator is mixed with the dry blend for about ten to fifteen minutes to make homogeneous paste.

In mixing first fly ash,rice husk ash are mixed well and then Na0H solution is added, then it is mixed with coarse aggregates.In mix one 10% of fly ash is replaced with rice husk ash,and same procedure is carried up to 15 and 25%.Entire mix design is done with M30.

Casting of beams is done in 150mm x 200mm x 2000mm mould in 3 layers with 25 blows by tamping rod in each layer. 3 beams are casted for each percentage. The curing for 24 hours at room temperature. Removed specimen from molds at room temperature air drying at room temperature until tested or exposed to elevated temperature.

1.3.1 OBJECTIVES OF THE EXPERIMENTAL WORK

This chapter presents the details of the preparations and the experimental investigations on geopolymer concrete with construction demolition waste conducted for studying the engineering properties of low calcium fly ash based geopolymer mortar. The main objectives of the experimental work are as under: 1) Preparation and characterization of geopolymer mortar using Indian Class F Fly ash blended with or without silica fume. Study on the effect of synthesizing parameters on the hardened properties of Geo polymer mortar i.e. Strength, Microstructure etc . Optimizing the rice husk ash as a partial replacement of flyash. Effect of RHA to Fly ash ratio of Geopolymer Mix Composition. Bulk density and Water absorption.Test for strength and uniformity. Sulfate resistance and Acid resistance.

Initially, detailed description of the raw materials used and test procedures for characterization of geopolymers are presented in this chapter. The experimental methodology was divided in to two main parts: (1) Manufacturing of Geopolymers mortar and preparation of test specimen and (2) testing and characterization. The laboratory tests were conducted as per relevant Indian standard codes and in some special tests.

2 LITERATURE REVIEW

2.1 EXPERIMENTAL STUDY ON RISE HUSK ASH & FLY ASH BASED GEO-POLYMER CONCRETE USING M-SAND

G Nanda Kishore1, B.gayathri[2] Serious environmental problems by means of increasing the production of Ordinary Portland cement (OPC), which is conventionally used as the primary binder to produce cement concrete. An attempt has been made to reduce the use of ordinary Portland cement in cement concrete. There is no standard mix design of geopolymer concrete, an effort has been made to know the physical, chemical properties and optimum mix of geopolymer concrete mix design. Concrete cubes of 100 x 100 x 100 mm were prepared and cured under steam curing for about 24 hours at temperature range of 40oC to 60oC. Fly ash is replaced partially with rice husk ash at percentage of 10%, 15% and 25%. Sodium hydroxide and sodium silicate are of used as alkaline activators with 5 Molar and 10 Molar NaOH solutions. Natural sand is replaced with manufacture sand. Test results were compared with controlled concrete mix of grade M30. The results shows that as the percentage of rice husk ash and water content increases, compressive strength will be decreases and as molarity of the alkaline solution increases, strength will be increases.

2.2 STRENGTH ASSESSMENT OF GEOPOLYMER CONCRETE USING M-SAND

S. Nagajothi* and s. ElavenilThe production of Ordinary Portland cement and the usage of normal river sand are increased due to the demand of concrete in construction Industries. The emission of Co2 increases during the production of cement and at the same time the availability of river sand is also becoming costlier and scarcity due to illegal dredging of river sand. The main intension of this research paper is to focus the eco friendly alternative material for the cement and river sand. The Geopolymer concrete material having low calcium fly ash is an inorganic non metallic alternative material for cement and manufactured sand an alternative for river sand. Concrete mix design of G30 was done based on Indian standard code (IS 10262) and modified guidelines. Concrete cubes and cylindrical specimens were tested for evolving the compressive strength and split tensile strength by varying the percentage of M-sand in Geopolymer concrete. The percentage replacement of M-sand in Geopolymer concrete is assessed from the results.

2.3 STUDY OF STRENGTH DEVELOPMENT OF GEOPOLYMER CONCRETE USING M - SAND AS FINE AGGREGATE

Pradeepkumar. B1, Prabhakar .K2, Praveen Raj .S3, PravinkumarConstruction is going on everywhere due to this the demand for cement is increased. By taking that into consideration we are using fly ash as a binding material for concrete along with alkaline solutions, which is named as “Geo polymer

Concrete”. As a result of this we can reduce demand for cement and also decrease the emissions of pollutants into the atmosphere which are releasing by cement industries. In this paper we study the different properties of geo-polymer concrete with replacement of manufactured sand and the effect of parameters on adding different molarity of geo-polymer solution. Fly ash collected from Mettur Thermal Power station was used as the source material to make geopolymer concrete. In this investigation, a combination of sodium hydroxide solution and sodium silicate solution as shown in was used as alkaline activators for Geo-polymerization. . To prepare sodium hydroxide solution of 5,10 Molarity (5 x 40), (10 x 40) 200 g,400g of sodium hydroxide pellets are dissolved in one liter of water each. The mass of NaOH solids in the solution varies depending on the concentration requirement. The prepared NaOH solution was added with Na2SiO3 solution according to the mix, 24 hrs before casting.

2.4 STRENGTH AND DURABILITY STUDIES OF M-SAND AND FLY ASH BASED GEOPOLYMER CONCRETE

K.ArulpriyaConcrete is till now the most popular material in construction and one of the most environmentally harmful materials. During the manufacturing of Ordinary Portland Cement (OPC), a large amount of green house is released into the atmosphere causing global warming. Geopolymer is an alternative material which can act as a binder by replacing cement. It mainly makes use of waste byproduct substances like fly ash, which is cheap and will reduce environmental pollution to a large extent. Fly ash is one of the major waste materials available from thermal power plants. River sand is mined from the river beds and sand mining has disastrous environmental consequences. To overcome this tribulation, M-Sand is used as a replacement of river sand. Alkaline solution (sodium hydroxide, sodium silicate) is used for the preparation of geopolymer concrete. It will act as water in geopolymer concrete. In this experimental work have analyses the strength and durability properties of Fly ash & M-Sand based geopolymer concrete.

3 OBJECTIVE OF THE STUDY

Phase 1

- Evaluation and experimental study of Geo polymer concrete
- Evaluation of structural characteristics like compressive strength and comparing with normal concrete and normal mortar.

Phase 2

- Evaluation of structural characteristics like Flexural Strength and comparing with normal concrete and normal mortar
- Evaluation of percentage of Rice husk ash in Geopolymer concrete .

4 EXPERIMENTAL PROGRAMME

Material and grade of mix

1. Selection of type of grade of mix, mix design by an appropriate method, trial mixes and final mix proportions
2. Estimating total quantity of concrete required for the whole project work
3. Estimating quantity of Fly ash, Rice husk ash, fine aggregate, coarse aggregate, Construction demolition waste and Alkaline solutions for this project work
4. Testing of properties of Flyash, fine aggregate, coarse aggregate and Rice husk ash

4.1 Fly Ash

In the present work, typical low calcium, Class F dry fly ash obtained from Thermal Power Plant was used as the basic aluminosilicate material to manufacture geopolymers. The fly ash was bulked mixed and repacked in the plastic sealed container. Fly ah is a residual material of energy production using coal, which has been found to have numerous advantage for use in concrete some of advantage include improve workability, reduced permeability, increase ultimate strength, reduce bleeding, better surface and reduce heat of hydration. Several types of fly ash are produced depending on the coal and coal combustion process. It is a pozzolanic material and has been classified into two classes. Fly ash is one of the residues generated in combustion, and comprises the fine particles that is rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal.

4.2 Fine aggregate

Fine aggregates mainly consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Fine aggregate is natural sand which has been washed and sieved to remove particles.

4.3 Coarse aggregate

Coarse aggregates are an predominant ingredient in the concrete and having many construction applications, sometimes used on their own, such as a granular base placed under a slab or pavement. Coarse aggregates are generally categorized as rock larger than a standard No. 4 sieve (3/16 inches) and less than 2 inches.Coarse aggregate is mainly mined from rock quarries or dredged from river beds, therefore the properties of aggregate like size, shape, hardness, texture and many other properties can vary greatly based on location or source of aggregate.

Usually coarse aggregate can be characterized as either smooth or rounded (such as river gravel) or angular (such as crushed stone). Because of this variability, test methods exist to characterize the most relevant characteristics, since exact identification would be impossible.

4.4 Rice Husk Ash

Rice husk ash is obtained by burning rice husk. Rice husk ash is being collected from a rice mill,palghat, which was burnt at uncontrolled condition aggregate concrete and reported in this paper. Thus from theresults of compressive strength, flexural strength and splittensile strength it can be concluded that though the strength ofrecycled aggregate concrete is lower than that of the naturalaggregate concrete, it still lies within the usable range and hencecan be used in structural concrete.s partial replacement with rice husk is done which has binding properties.

4.5 Construction Demolition Waste

Construction and demolition wastes constitute one of the major components of wastes generated worldwide very large quantities of aggregate are used in concrete production and in construction. When the useful life of thestructure is over it will be demolished and all the demolishedwastes just find their way to landfills. Finding large areas forlandfills is becoming very difficult. On the other handcontinuous extraction and quarrying of natural aggregates forconstruction is causing depletion of natural resources.

The recycling of demolished construction waste in to aggregates to beused in new engineering application provides a promisingsolution to both the problems. In this work the usability ofdemolished waste as coarse aggregates in new concrete isattempted. This experimental investigation involves evaluatingthe properties of the constituents of concrete including thedemolished concrete wastes which shall be used as coarseaggregates in new concrete with the aim of producing highstrength concrete. The results of this experimental study isaimed at examining the properties and strength of recycledaggregate concrete made from different replacement ratios ofrecycled aggregates from natural aggregates and to evaluate thestrength of recycled aggregate concrete to check its usability asstructural concrete. The properties and results of recycledaggregate concrete is found and compared to that of natural

4.6 Activator Solution

The alkaline activator was combination of sodium silicate and sodium hydroxide solutions. Sodium-based solutions were chosen because they are cheaper. The sodium hydroxide solids were laboratory grade in pellets form, with a specific gravity of 2.15, 97% purity. To avoid effects of unknown contaminants in laboratory tap water, distilled water was used for preparing the activator solutions.

The sodium hydroxide (NaOH) solution was prepared by dissolving NaOH pellets in water. The mass of NaOH solids in a solution was varied depending on the required concentration of the solution. The chemical composition of the sodium silicate solution was Na2O=8%, Si02=26.5%, and water =65.5% by mass. The other characteristics of the sodium silicate solution were specific gravity = 1.35 gm/cc and pH of the solution was 11.The activator solution was prepared at least one day prior to its use in geopolymer mix.

4.7 Preparing of Geopolymer concrete

In the preparing of the concrete we are going for the trial mix. The chemicals like sodium hydroxide and sodium silicate are mixed and kept for 24hours for the purpose of chemical reaction take place in it. After 24hr the chemical solution is mixed with required volume of Fly ash,rice husk ash fine aggregate and partial replacement of construction demolition waste as coarse aggregate. The Geo Polymer concrete is made with different percentage of RHA and RCA.

4.8 STANDARD MIXES

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under or over rich mixes. For this reason, the minimum compressive strength has been included in many specifications.

These mixes are termed as standard mixes. IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20 and M25. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively. But in Geo Polymer concrete there is no mix standard mix design so we go for trial and error method. However there are some mix designs are available for the Geo Polymer concrete to obtain the high strength.

4.9 Mixing of concrete

The batching and mixing of the concrete are done according IS 4925-2004. The type of batching we used here is manual. Manually means operating or charging the devices using hand.

Fig 4 Mixing of concrete

4.7 CASTING OF SPECIMEN

The step by step procedure of casting of geo polymer concrete.

- Take 150mmx150mm150mm cube and oiled each inner face of the cube.
- Filled the M30grade concrete filled in three approximately equal layers (50 mm deep) by using trowel.
- Compact the concrete by using a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for ramming.

During the compaction of each layer with the compacting bar, the strokes should be

- distributed in a uniform manner over the surface of the concrete
- The minimum number of 25 strokes per layer need to be done to get maximum workability of the concrete.
- After the top layer has been compacted, a trowel should be used to finish off the surface level with the top of the mould, and the outside of the mould should be wiped clean.

4.10 Finishing of concrete

Figure 5 showing the finishing of cube with trowel, the top surface of the concrete mould should be finished neatly with trowel. Care must be taken not to avoid extra cement or materials to make the mould finish. The additional or extra concrete must be cut down from the top surface of the mould to make the mould finish and for good shape. For translucent concrete same finishing procedure need to be workout.

4.10 Curing of specimen

After mixing the Geo Polymer concrete the concrete is rapidly transferred to the mold without the segregation of the ingredients or the ingress of the foreign matter in to the concrete mix normally the

workability of Geo Polymer concrete is low as compare tonormal concrete.

The concrete is placed and compacted into the mold before the initial setting time of the concrete. Normally the concrete is poured in the mould by layer by layer. First the single layer is poured and compacted 25 times by using compacting rod. Next the second layer is poured and compacted for 25 times. Similarly for third layer also. The placing method of the concrete is as such that it will not cause for segregation of the ingredients. As per the IS 456-2000 the maximum free fall of the concrete shall not be greater than 1.5 m. The Geo Polymer concrete shows less amount of workability as compare to the normal concrete. So that after the mixing of the concrete it should be immediately transfer into the moulds before it become harder. The cube, cylinder are casted so that the test like compression test is carried out by using the cube in compression testing machine. The split tensile strength of the Geo Polymer concrete is calculated by using the cylinder. The test should be carried out after the completion of 7 and 28 days curing of the Geo Polymer concrete specimens.Curing of concrete is done by removing the concrete from the mould after 24hr and placed in the presence of atmospheric air at room temperature without any disturbance. Moulds should be removed after the settling of the concrete so that the concrete does not break and gives the clear edge without any irregular surface.

5 TESTS ON SPECIMEN

5.1 Compressive Strength Test:

Fig 8 Testing of cube

Compressive strength is the most common test on hardened concrete. Concrete is strong in compression and weak in tension. Both the conventional and Geopolymer concrete, cast with same mix design, were subjected to compressive strength, split tensile strength test. The casted specimen is cured for about 7, 14 and 28 days to find the compressive strength.

Procedure: -

- The bearing surfaces of loading machine were wiped and cleaned.
- The cube was then placed in the machine such that axis of cube was carefully aligned with the axis of the loading device.

- The load was then increased continuously until the specimen fails and the load corresponding to the point of failure was recorded.
- The appearance of cracks on the surface and any other feature was noted.
- Specimen failed due to the crushing of concrete on the application of longitudinal force.

5.2 Flexural Strength Test:

The result of the tested beam specimen is tabulated with respect to the percentage of Rice husk ash (RHA) and recycled concrete aggregate (RCA) add to the Geo Polymer concrete. The table should contains the result of flexural strength value of the cube for 7^{th} day and 28^{th} day of the curing. The flexural strength are calculated with the various value of percentage of RHA and RCA like 0%, 10%, 15%, and 25% of RHA and 30% of RCA for both 7^{th} and 28th day of curing in N/mm^2.

Flexural strength = Pl/bd2

Where,
P –Load
l –Length of the specimen
b –Width of the beam
d –Depth of the beam

5.3 Static and cyclic loading

A static load is a mechanical force applied slowly to an assembly or object. This can be contrasted with a dynamic load, which is a force that is applied rapidly. Tests of static load are useful in determining the maximum allowable loads on engineering structures, such as bridges, and they can also be useful in discovering the mechanical properties of materials. This force is often applied to engineering structures that peoples' safety depends on because engineers need to know the maximum force a structure can support before it will collapse. Any force applied steadily without moving an object is considered a static load, and the knowledge of how much loading a structure can handle is useful for setting safety margins for the structure. Limiting the loading to one half of a structure's maximum will give a factor of safety of two.

Cyclic loading is the application of repeated or fluctuating stresses, strains, or stress intensities to locations on structural components. The degradation that may occur at the location is referred to as fatigue degradation. When cyclic stresses are applied to a material, even though the stresses do not cause plastic deformation, the material may fail due to fatigue. Fatigue failure is typically modelled by decomposing cyclic stresses into mean and alternating components. Mean stress is the time average of the principal stress. The definition of alternating stress varies between different sources. It is either defined as the difference between the minimum and the maximum stress, or the difference between the mean and maximum stress. Engineers try to design mechanisms whose parts are subjected to a single type (bending, axial, or torsional) of cyclic stress because this more closely matches experiments used to characterize fatigue failure in different materials.

5.4 FRESH CONCRETE

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet state as well as in the hardened state. The following tests are conducted to evaluate the degree of workability.

Slump Value

Slump test is used to determine the workability of fresh concrete. Slump test as per IS 1199 : 1959 is followed. The apparatus used for doing slump test were slump cone and tamping rod. The internal surface of the mould was thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould was then filled in four layers, each 1/3 of the height of the mould, each layer being tamped 25 times with a standard tamping rod taking care to distribute the strokes evenly over the cross section. After top layer had been rodded, the concrete was struck off level with a trowel and tamping rod. The mould was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed concrete to subside. This subsidence was referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as slump of concrete. The obtained slump value for controlled concrete was 80 mm.

Compacting Factor

The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete is insensitive to slump test. Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS 1199:1959. The apparatus used is compacting factor apparatus.

The sample of concrete to be tested was placed in the upper hopper up to the brim. The trap-door was opened so that the concrete falls into the lower hopper. Then, the trap-door of the lower hopper was opened and the concrete was allowed to fall into the cylinder. The excess concrete remaining above the top level of the cylinder was then cut off with the help of plane blades supplied with the apparatus. The outside of the cylinder was wiped clean. The concrete was filled up exactly up to the top level of the cylinder. It was weighed to the 10 grams. This weight was known as “weight of partially compacted concrete”. The cylinder was emptied and then refilled with the concrete from the same sample in layers approximately 5 cm deep.

The layers were heavily rammed or preferably vibrated so as to obtain full compaction. The top surface of the fully compacted concrete was then carefully struck off level with the top of the cylinder and weighted to the nearest 10 grams. This weight was known as “weight of fully compacted concrete”.

Compacting Factor = (Weight of partially compacted concrete) /
(Weight of fully compacted concrete) The obtained compacting factor value for controlled concrete is 0.8.

5.5 HARDENED CONCRETE

One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh and hardened concrete are inseparable part of any quality control programme for concrete, which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regard to both strength and durability. The test methods should be simple, direct and convenient to apply. The controlled concrete is cast and cured for 28 days and the tests for hardened concrete such as compressive strength, split tensile strength and flexural strength are done.

6 RESULTS AND DISCUSSIONS

6.1 GENERAL

The concrete is tested to study their properties. The purpose of testing of hardened concrete is to confirm that the concrete used at site has developed the required strength. It also gives assurance of the concrete with regard to both strength and durability. The results obtained from each tests are tabulated below.

6.2 PHYSICAL PROPERTIES OF MATERIALS

Experimental test were conducted to study the mechanical and physical properties of materials such as cement. Coarse aggregate, fine aggregate an fly ash, rice husk ash and results are tabulated.

6.2.1 Properties of Fly ash

The experiments were conducted to study the physical properties of as per IS code. Table 6.1 shows the properties of cement which are tabulated

Physical properties	Values
Specific gravity	2.3
Fineness modulus	7.86

Compressive Strength Test

The result of the tested cube specimen is tabulated with respect to the percentage of RHA and RCA add to the Geo Polymer concrete. The table should contain the result of compressive strength value of the cube for 7th day and 28th day of the curing. The compressive strength are calculated with the various value of percentage of RHA and RCA like

0%, 10%, 15%,25% of RHA and 30% of RCA for both 7th and 28th day of curing in N/mm^2

Cube specimens	Compressive strength N/mm^2	
	7^{th}day	28^{th}day
Cube specimens with 0%of RHA and 30%ofRCA	16.46	25.46
Cube specimens with 10 % of RH 30% of RCA	16.44	24.44
Cube specimens with 15% of RHA and 30% of RCA	12.04	20.9
Cube specimens with 25% of RHA and 30% of RCA	4.54	15.3

Table.6.5 Compressive Strength cube specimens

The graph is plotted with respect to the compressive strength of the cube. The X axis of the graph contains the compressive strength value and the Y axis of the graph contains the percentage of the RHA added to the Geo Polymer Concrete. The compressive strength value of both $7^{th}$and 28^{th}days curing is plotted with respect to the percentage of RHA and RCA. By using the graph the compressive strength of the Geo Polymer Concrete is easily studied.

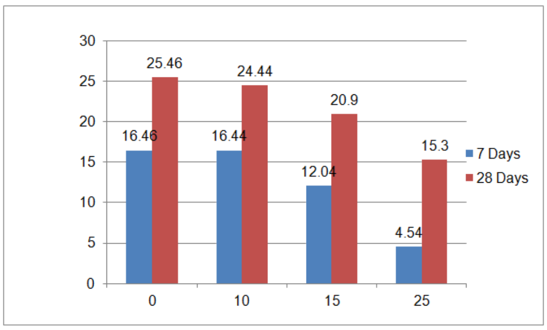

Fig 10: Compressive Strength cube specimens

6.3.3 SPLIT TENSILE STRENGTH OFSPECIMENS

The result of the tested cylinder specimen is tabulated with respect to the percentage of RHA and RCA add to the Geo Polymer concrete. The table should contains the result of split tensile strength value of the cube for 7thday and 28thday of the curing. The split tensile strength are calculated with the various value of percentage of RHA and RCA like 0%, 10%, 15%, and 25% for both 7thand 28th day of curing inN/mm^2.

Cylinder specimens	Split tensile strength N/mm^2	
	7thdays	28thdays
Cylinder specimens with 0% of RHA and 30% ofRCA	1.4	2.12
Cylinder specimens with 10% of RHA and 30% of RCA	1.34	2.1
Cylinder specimens with 15% of RHA and 30% of RCA	0.99	1.6
Cylinder specimens with 25% of RHA and 30% of RCA	0.63	1.27

Table.6.6Split Tensile Strength of specimens

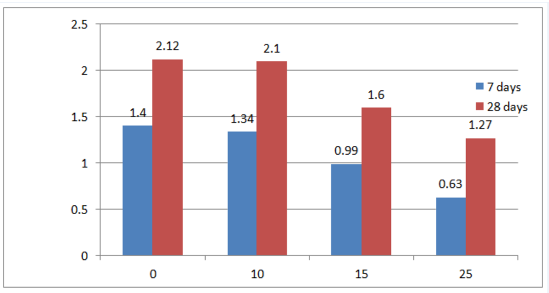

Fig 11: Split Tensile Strength of specimens

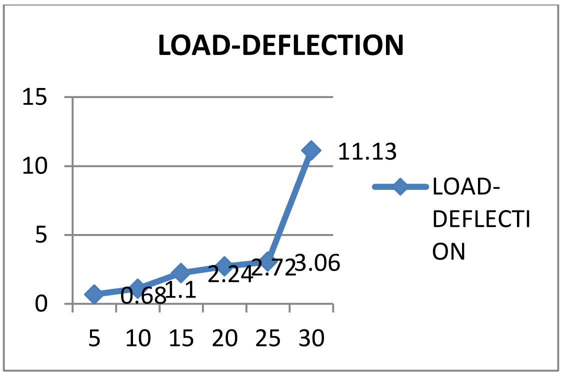

Fig load-deflection for beam specimensBeam specimens with 15% RHA and 30% of RCA

Results

Based upon the results of experimental and analytical study are carried out the following conclusions can be drawn

- The control specimen where tested under the two-point loading and the results were satisfactory.
- Experimental results shows that as the percentages of rice husk ash increases then compressive strength decreases
- Up to 10 and 15 % of fly ash can be replaced with rice husk ash, beyond the bonding in between alkaline liquids, rice husk ash and fine aggregates is not so strong. Strength obtained with no replacement of fly ash is nearly equal to 10% replacement with rice husk ash, that implies rice husk ash can also be used a alternate binder in geo polymer concrete As the molarity concentration increases, compressive strength also increases, not only on molarity but also on temperature and number of days of curing.

- Compressive strength is directly proportional to temperature. The strength of the Geo Polymer concrete increase as the molarity of Alkaline solution in the concrete increase

References

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