An Experimental Analysis on The Strength Improvement Characteristics of Light Weight Concrete Incorporating With Egg Shell Powder, Palm Kernel Shells & Foundary Sand

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Abstract- *With the increasing amount of concrete used, natural environment and resources are excessively exploited. Synthetic light weight aggregate produced from environmental waste like palm fuel ash, is a viable new source of structural aggregate material. The use of light weight concrete permits greater design flexibility and substantial cost savings, reduced dead load, improved cyclic loading, structural response, longer spans, better fire ratings, thinner sections, smaller size structural members, less reinforcing steel and lower foundations costs. Light Weight Aggregate is a relatively new material. In addition to the reduced dead weight, the lower modulus of elasticity and adequate ductility of light weight concrete may be advantageous in the seismic design of structures. Other inherent advantages of the material are its greater fire resistance, low thermal conductivity, low coefficient of thermal expansion and lower erection and transport costs for prefabricated members. Waste foundry sand can be used as a partial replacement for natural sand in concrete as it can improves the concrete strength & Durability. Palm Kernel Shells have good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. The purpose of this research work is to develop a concrete with Palm Kernel Shells as coarse aggregate. Egg shell powders which are rich in calcium are thrown away as a waste and palm kernel shell has good impact value. The purpose of this research work is to develop a light weight concrete with Egg Shell powder as cement replacement and fine aggregate with foundry sand and Palm Kernel Shells as coarse aggregate replacement in concrete.*

Keywords- Egg Shell powder, foundry sand, Palm Kernel Shells, Compressive strength, split tensile strength test, flexural strength test.

I. INTRODUCTION

Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country’s development. It’s known that some industrial waste products like fly ash are having some building material and silicious properties. So the use of the commercial and natural pozzolans in concrete part as cement replacement, scale back the price of constructing concrete, additionally causes improvement within the properties of concrete and scale back environmental pollution. Rapid industrial expansion produces severe difficulties all around the world, including as the depletion of natural resources and the creation of vast amounts of waste materials throughout the manufacturing, construction, and demolition stages; one option to mitigate this problem is to utilize wastes. For sustainable development, it has become mandate to use industrial wastes as alternative construction materials. This not only saves the original materials for future generations but also their successful use eliminates the problem of their disposal.

Most of the normal weight aggregate of normal concretes is natural stone such as lime stone and granite. With the increasing amount of concrete used, natural environment and resources are excessively exploited. Synthetic light weight aggregate produced from environmental waste like palmfuel ash, is a viable new source of structural aggregate material. The use of light weight concrete permits greater design flexibility and substantial cost savings, reduced dead load, improved cyclic loading, structural response, longer spans, better fire ratings, thinner sections, smaller size structural members, less reinforcing steel and lower foundations costs. Weight of light weight concrete is typically 25% and 35%

lighter but its strengths is comparable to normal weight concrete.

Light Weight Aggregate is a relatively new material. For the same crushing strength, the density of concrete made with such an aggregate can be as much as 35 percent lower than the normal weight concrete. In addition to the reduced dead weight, the lower modulus of elasticity and adequate ductility of light weight concrete may be advantageous in the seismic design of structures. Other inherent advantages of the material are its greater fire resistance, low thermal conductivity, low coefficient of thermal expansion and lower erection and transport costs for prefabricated members.

The primary objective of the research is to understand the possibilities of use of Egg Shell Powder, Palm Kernel Shell and foundry sand which partially replaced by cement, coarse aggregate and fine aggregate.

- To study the workability of the concrete by adding egg shell powder and Palm Kernel Shell.
- To study the Compressive strength, split tensile and flexural strength of Concrete.
- To verify the homogeneity of ESP and CS added concrete.
- To determine the optimum percentage of Egg Shell Powder and Palm Kernel Shell in concrete by replacing 10%, 20%, 30% and 40% of cement and coarse aggregate and with foundry sand.

1. Workability
2. Compressive strength
3. Flexure strength
4. Tensile strength

II. REVIEW OF LITERATURE

This part of the study deals with the review of several research papers related to compressive strength and workability of concrete poised by employing various source materials such as Egg Shell Powder, foundry sand and Palm Kernel Shell etc. But considering availability of material and cost considerations many researchers studied various properties of concrete are given below.

Hugo Figueiredo et al (2010): This work presents a study on the applicability of a zeolite-biomass system to the entrapment of metallic ions, starting from Cr (VI) solutions up to 100mgCr/L, in batch processes. The effect of the zeolitic support on the overall system performance was evaluated comparing two large pore zeolitic structures which differ in chemical composition and ion-exchange capacity: Faujasite (HY and Nay) and Mordenite (HMOR and NaMOR) zeolites.

However, for single-batch process, these facts limited MOR performance when compared to FAU counterparts. In terms of metal retention, nay zeolite was able to retain more Cr from single-step studies (0.75% vs. 0.54% for HY). In SBR process, HY achieved a slightly higher Cr loading compared to Nay in every cycle, being 0.59%, the highest Cr loading obtained, at the end of the first cycle of HY-biomass system.

Bilir (2012) investigated the effect of non -ground coal bottom ash (NGCBA) and non-ground granulated blast furnace slag (NGGBFS) on durability properties of concrete. He concluded that replacement of fine aggregate up to 40% NGGBFS and up to 30% NGCBA, concrete has very low chloride permeability.

Khatib (2005), Rakshvir and Barai (2006), Evangelista et al. (2007), Rao et al. (2007) and Soutsos et al. (2011) studied the properties of concrete incorporating recycled aggregate. Khatib (2005) used recycled fine aggregate to study mechanical properties. The fine aggregate in concrete was replaced with 0, 25, 50 and 100% recycled aggregate. Beyond 28 days of curing, the rate of strength development in concrete containing recycled aggregate was higher than that of the control mix indicating cementing action in the presence of fine recycled aggregate.

Deb, P. S., Nath, P., & Sarker, P. K. (2014): Ground granulated blast furnace slag (GGBS) with mixture of flyash content showing huge improve in the consequences of workability and high strength contrasted with Ordinary Portland Cement (OPC). By changing dissimilar (0%,10% and 20%)contents of Ground granulated blast furnace slag (GGBS) with various proportions of flayash content showing a few blemishes, One of them is with increment in GGBS content workability is diminishing simultaneously strength is expanding. By keeping up silicates to alkaline proportions of 1.5 to 2.5 and following ACI 318 and AS 3600 codes for curing we can accomplish above outcomes when contrasted with OPC.

I.J Karthick, R.Jeyanthi , M Petchiyammal et al.,(2014) In this paper the strength properties of concrete is evaluated by replacing the cement and coarse aggregate with minimum percentage of Egg shell powder rice husk ash, silica fumes and fly ash to obtain optimum strength of concrete.

Mr. R. Srinivasan et al., has investigated on “Experimental Study on pulp Ash in Concrete” that they had ascertained that Sugar Cane pulp is fibrous waste-Product of sugar industry, and inflicting serious environmental drawback that principally contain metal particle and oxide. Hear pulp ash has been with chemicals and physically characterised, and part replaced within the quantitative relation of 1/3, 5%, 15%, twenty fifth by weight of cement in concrete.

G. Mertens, et al (2009): The Pozzolanic reaction between portlandite and different types of nearly pure natural zeolite was studied. Analcime, phillipsite, chabazite, erionite, mordenite and clinoptilolite-rich tuffs were mixed with portlandite and water (1:1:2 by weight), and the progress of the Pozzolanic reaction was quantitatively determined by thermo gravimetrical analyses from 3 to 180 days. A thorough characterization of the raw materials was performed by quantitative XRD, XRF, SEM-EDX, BET specific surface area measurements, grain-size analyses, FTIR and Cat ion Exchange Capacity measurements.

Dr. Satish Chandra & Leif Berntsson has reported on Light Weight aggregate concrete: Science, technology and applications, Noyes Publications; that the successful application of structural light weight aggregate demonstrated that light weight used for precast structural elements can be used in building construction to increase the speed of construction, enhance green construction environment such as reducing the wet trade on site and keep dust as reducing the wet trade on site and keep dust level at construction to the minimum..

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Egg Shell powder
5. Foundry sand
6. Palm Kernel Shells
7. Super plasticizer

I. Cement

Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to I.S 4031-1988.The O.P.C is classified into three grades, those are 33grade, 43grade and 53 grade, depending upon the strength of the cement in this experiment 43grade cement is used.

II. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

III. Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size.Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

IV. Egg Shell powder

The chemical composition of Eggshell powder and cement were found to be similar. The main component of eggshell was calcium carbonate (around 51%) . Eggshell waste been evolved from poultry farms, restaurants and hotels. These wastes are used in animal feeds an in many countries they are thrown off. Such waste are collected and implemented in our project.

The processing of egg shell powder is given in sequence

- Material collection, Grinding and powdering of Egg shell
- Sieving of Eggshell powder in sieve
- Mixing of Eggshell powder with cement. The sieving of Eggshell powder is done in 75 micron sieve.
- The residues retained were supplied for fertilizer industries and animal feed production industries.

V. Foundry Sand

The main constituents of foundry sand are high quality silica of uniformly sized or the lake sand obtained by mould of ferrous and nonferrous metal casting. Initially the sand will be clean before casting, but after casting, it will be rich in ferrous content of about 95 % of its own volume. The major production of foundry sand is by automotive industry and by casting of generator parts. The most popular and efficient process of casting process in industry is sand casting system. Green sand type is common sand type used for preparing the moulds for ferrous casting.

The main constituents of green sand is high quality silica and bentonite clay (about 10% as binder), water present sea coal (good casting finisher of about 2 to 5%).The type and volume of materials used for moulds depend upon the type of metal being casted in the mould, but usually the green sand owning the 90% of the about ingredients is used in large scale. For providing the cavities in the moulds of non ferrous casting proves to be impractical to produce, hence the above mixture of 97% in foundry sand is generally used with chemically bonded system known as “cores”. Every year about 10 to 15 million tons of foundry waste is produced in United States which includes dust and spent foundry sand. Usually 1 ton of foundry sand is required to produce 1 ton of steel casting.

VI. Palm kernal shell

The palm oil industry produces wastes such as palm kernel shells, palm oil fibers which are usually dumped in the open thereby impacting the environment negatively without any economic benefits. Palm kernel shells (PKS) are hard, carbonaceous, and organic by- products of the processing of the palm oil fruit. PKS consists of small size particles, medium size particles and large size particles in the range 0-5mm, 5-10mm and 10-15mm. The shells have no commercial value, but create disposal and waste management problems. The use of palm kernel shell as replacement materials should not only contribute to construction cost reduction and drive infrastructural development but also contribute to reduce stress on the environment and make engineering construction sustainable to help transform the building and construction sectors of national economies and contribute towards the realization of national and global poverty reduction strategies. Such materials should be cheap and readily available.

VII. Super plasticizer

Naphthalene based super plasticizer namely Fosroc Conplast SP430 is a chloride free, super plasticizing admixture based on sulphonated naphthalene polymer is used to upgrade or boost the workability as well as strength of concrete. The dosage is raging from 1.00 to 3.00 litres per 100 kg of cementitious material.

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262- 2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M30 grade concrete.

V. TESTS ON FRESH CONCRETE

5.1 WORKABILITY OF CONCRETE

The inner surface of the mould (Slump cone) is thoroughly cleaned and applied with a light coat of oil. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface and is then filled with fresh concrete in four layers. Each layer is tamped 25 times by the rounded end of the tamping rod, ensuring even distribution of strokes over the cross section. After the top layer is rodded, the concrete leveled with a trowel and the mould is removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. The difference in height in mm is determined as the slump of the concrete.

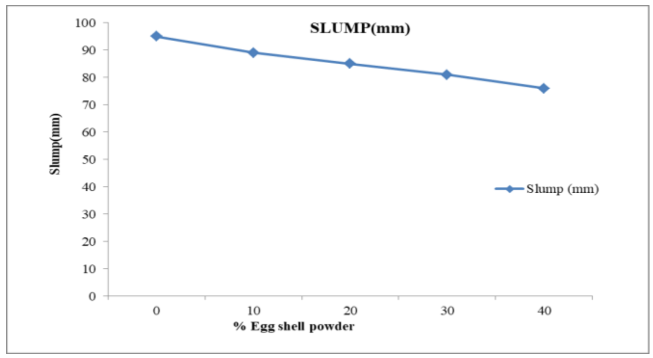

Fig 5.1: Variation of Slump Values

VI. TESTS ON HARDENED CONCRETE

6.1 VARIATION OF COMPRESSIVE STRENGTH FOR DIFFERENT MIXES

Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516:1959. The compressive strength is usually obtained experimentally by means of a compressive test. 150x150x150 mm size mould is used for the casting of compressive test specimen, after the 24 hours of casting of specimens remove the cubes from moulds and the cubes are placed in curing tank up to one day before the testing. During testing on a UTM with a capacity of 300T, the load is delivered to the cubes at a continuous rate of 140kg/sq.cm/minute. The specimen is placed in the UTM with the cast faces facing the opposite to the observer. The specimen's ultimate load is defined as the load at which it fails. At the ages of seven and twenty-eight days, this test was conducted. The average load of three specimens is used to calculate strength for each mix.

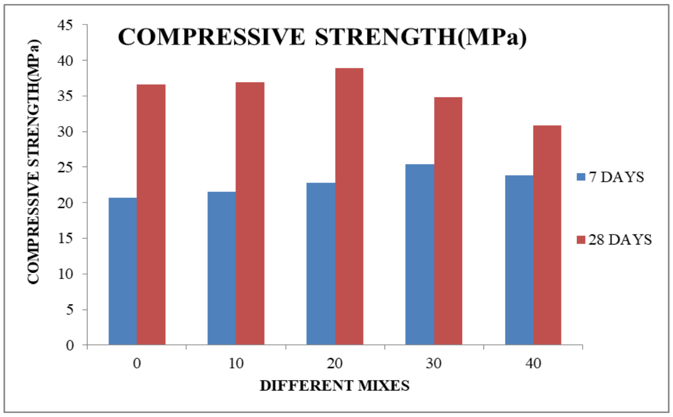

Fig 5.2 Effect of Egg shell powder on compressive strength of concrete at 7 days and 28 days curing

5.3.2 Variation of Compressive Strength for Addition of Palm kernal shell and foundry sand to Optimum Percentage of Egg shell powder

There is increase in compressive strength with increase in Egg shell powder up to 20% in any curing condition, where for 30% gets reduced. For 7 days potable water curing and 28 days water curing the compressive strength is increased for 20% of Egg shell powder. Based on the above results and graphs it is observed that 20% replacement of Egg shell powder is taken as optimum. Based on the above results and graphs it is observed that 20% replacement of Egg shell powder is taken as optimum.

Compressive strength of concrete keeping 20% Egg shell powder as constant and with different percentages of Palm kernal shell and foundry sand for curing period of 7-days and 28-days respectively.

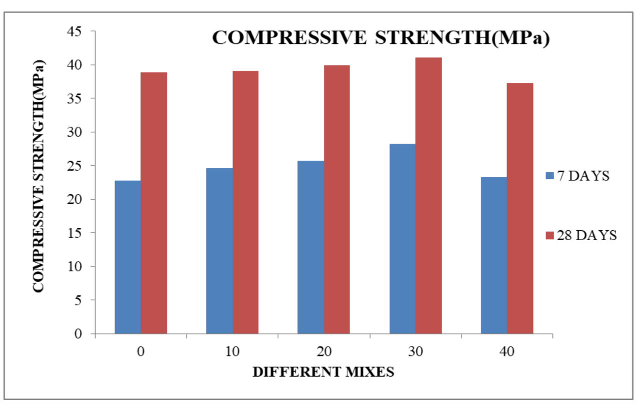

Fig 5.3 Effect of Palm kernal shell and foundry sand on compressive strength of concrete at 7 days and 28 days curing

There is increase in compressive strength with increase in Palm kernal shell and foundry sand up to 30 by keeping 20% Egg shell powder in any curing condition, where for 40% gets reduced. For 7 days potable water curing and 28 days water curing the compressive strength is increased for 15% of Palm kernal shell and 15% of foundry sand. Based on the above results and graphs it is observed that 30% replacement of Palm kernal shell is taken as optimum. Based on the above results and graphs it is observed that 20% replacement of Egg shell powder is taken as optimum.

6.2Effect of Palm kernal shell and foundry sand on Splitting Tensile Strength of concrete

The average of three specimens was reported as the split tensile strength provided the individual variation is not more than 15% of average value.

Split tensile strength $=2P/\pi DL$
Where
P = compressive load on the cylinder.
L=length of the cylinder.
D=diameter of the cylinder.

The Split Tensile strength of the concrete mix for M-30 with partial replacement of cement by Egg shell powder and Palm kernal shell and foundry sand as fine aggregate replacement respectively showed higher Strength against splitting after 7 and 28 days. The 7 days Split tensile strength of mix with 20% partial replacement of Egg shell powder showed higher strength compared to other mixes. Split tensile strength of concrete keeping 20% Optimum percentage of Egg shell powder with different percentages of Palm kernal shell and foundry sand for curing period of 7-days and 28-days respectively and fig shows the summarized Split tensile strength Results for different curing periods– M30 grade.

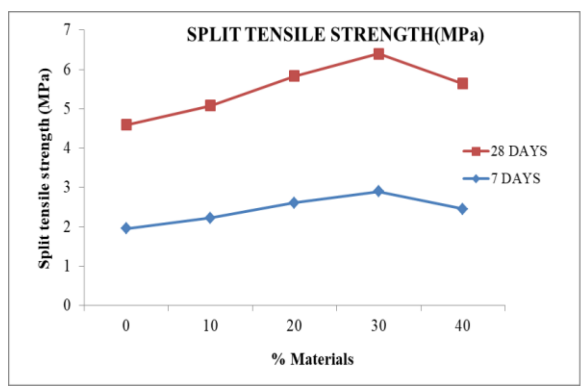

Fig 5.4Effect of Palm kernal shell and foundry sand on split tensile strength of concrete at 7 days and 28 days curing

Concrete split tensile strength with the replacement of Palm kernal shell with an optimum of 20% Egg shell powder of M30 concrete under normal water conditions. There is increase in split tensile strength with increase in Palm kernal shell up to 30% in any curing condition, where for 40% gets reduced. For 7 days water curing and 28 days water curing the split tensile strength is increased for 15% of Palm kernal shell and 15% of foundry sand. .

6.3 Effect of Palm kernal shell and foundry sand on Splitting Tensile Strength of concrete

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

After 7 and 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading. The Flexural strength of the concrete mix for M-30 with partial replacement of cement by Egg shell powder and Palm kernal shell respectively showed higher Strength against Flexure after 7 and 28 days. The 7 days Flexural strength of mix with 20% partial replacement of Egg shell powder showed higher strength compared to other mixes. Flexural strength of concrete keeping 20% Egg shell powder as constant and with different percentages of Palm kernal shell for curing period of 7-days and 28-days respectively

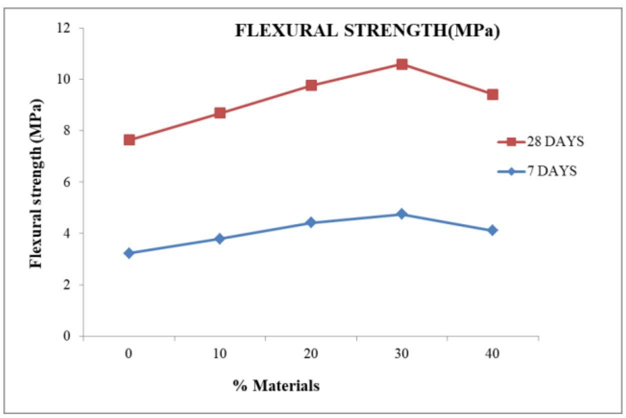

Fig 5.5 Effect of Palm kernal shell and foundry sand on Flexural strength of concrete at 7 days and 28 days curing

Concrete flexural strength with the replacement of Palm kernal shell and foundry sand with an optimum of 20% Egg shell powder of M30 concrete under normal water conditions. There is increase in flexural strength with increase in Palm kernal shell up to 30% in any curing condition, where for 40% gets reduced. For 7 days water curing and 28 days water curing the flexural strength is increased for 15% of Palm kernal shell and 15% of foundry sand.

V. CONCLUSIONS

- According to the experimental investigation the results were analyzed. On the basis of result of partial replacement of cement with Egg Shell Powder and Coarse Aggregate with Palm Kernel Shell and fine aggregate with foundry sand up to 10%, 20% 30% and 40% following conclusions were made:
- Slump value decreases with increase in replacement percentage of cement content
- By increasing the replacement of cement , fine aggregate and coarse aggregate with egg shell powder , foundry sand and Palm Kernel Shell, concrete losing its workability.
- It was observed that the optimum percentage of cement by egg shell powder in concrete up to 10% gives approximately similar value as compared to convetional concrete.
- It is found that 20% replacement of cement with egg shell powder shows highest compressive strength i.e 38.88 MPa.
- Replacement of foundry sand and Palm Kernel Shell as fine and coarse aggregate replacement by keeping 20% replacement of egg shell powder as optimum shows significant improvement in the strength results. The compressive strength achieved for 15% replacement of foundry sand and 15% replacement of Palm Kernel Shell was 41.11 N/mm2.
- By using 20% Egg shell powder as a partial replacement to the cement the compressive strength is promising.
- The light weight aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose.
- Split tensile strength for cylindrical specimens is maximum at 20% egg shell powder 15% replacement of foundry sand and 15% replacement of Palm Kernel Shell for M30 grade and it was 3.50 N/mm2 for 28 days curing.
- Flexural strength maximum at 20% egg shell powder 15% replacement of foundry sand and 15% replacement of Palm Kernel Shell for M30 grade and it was 5.84 N/mm2 for 28 days curing.
- .It is evident from the present investigation that the replacement of egg shell powder foundry sand and Palm Kernel Shell concrete improve strength properties of the mix.
- Thus egg shell powder is a good alternative for replacing cement by incorporating good mechanical properties into the blended cement. The use of egg shell powder and Palm kernal shell and foundry sand combined is economic when compared to cement in concrete. Likewise reduces the cement price rise and intensities of CO2 release by the

cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.

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