A Study on The Impact of Zeolite Powder And Sintered Flyash Aggrregate on The Mechanical Properties of M30 Grade Concrete

A. Durgarao[1], D. Appanna[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *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. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction. Natural zeolite powder can by effectively used in concrete as partial replacement of cement because of their high content of silica and pozzolanic properties which plays an important role in achieving high strength and durability in concrete. It's presently fly ash is being used in construction industries in different ways. Sintered fly ash aggregates when used as a substitute for natural aggregates benefits the preservation of natural aggregates as well as the utilization of fly ash which poses a great environmental problem for its disposal. Simultaneously, it also reduces the cost of concrete. In the present investigation, sintered fly ash aggregates have been used as a partial replacement of natural sand as fine aggregate in concrete. Varying percentages of natural fine aggregate have been replaced by sintered fly ash aggregates. The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and flexural strength of concrete with different percentages replacement of cement and fine aggregate with zeolite powder and sintered fly ash aggregates.*

Keywords- Zeolite powder, sintered fly ash aggregate, 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 zeolites 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.

The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Fly ash light weight aggregates produced by sintering at high temperature and by pelletization has proved to be a successful construction material as substitute for natural coarse aggregates. Sintered flyash aggregate can be used in the construction industry as aggregate in concrete by replacing natural aggregates.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and impact resistance of concrete with different percentages replacement of cement with zeolite powder and fine aggregate by Sintered fly ash aggregate and to study the compressive behaviour on adding zeolite powder and Sintered fly ash aggregate .

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

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 fly ash aggregate, zeolite powder 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.

AnasShahidMultani, A K Nigam (2017) Investigated on Partial Replacement of Cement with Metakaolin in Association with Super Plasticizer. Metakaolin seems to be an auspicious additional cementitious material for superior cement. Properties of cement with metakaolin are for the most part favoured added substances in superior cement. The metakaolin consolidations increment the quality of the concrete specimens. In this work, the impact of various contents of Metakaolin included to concrete containing super plasticizer its compressive quality strength and workability has been contemplated. Samples with 0%, 5%, 10%, 15%, 20% and 25% content of metakaolin replacing the cement have been evaluated for M30 grade. The outcomes have been contrasted and those for the control test and practicality of adding metakaolin to concrete has been examined. It was watched that up to 15% of concrete can be supplanted with metakaolin blended with superplasticizer.15% substitution is the ideal rate at which expanded quality of test sample is seen from the base sample test.

Takaakiwajima et al (2012): Paper sludge ash (PSA) was partially converted into zeolites by reaction with 3M NaOH solution at 90°C for 24 h. The PSA had a low abundance of Si and significant Ca content, due to the presence of calcite that was used as paper filler. Diatomite, which contains amorphous silica and dissolves easily in alkali solution, was mixed with the ash, and then added to the NaOH solution to increase its Si content during alkali reaction and thus synthesize zeolites with high cat ion exchange capacity (CEC). The original ash without addition of diatomite yielded hydroxyl sodalities with CEC ca. 0.5 mol/g. Addition of diatomite to the ash yielded zeolite-P with a higher CEC (ca. 1 mol/g). The observed concentrations of Si and Al in the solution during the reaction explain the crystallization of these two phases. The reaction products were tested for their adsorption capacity for nutrients from liquid fertilizer, such as K+, NH4+ and PO4. The product with zeolite-P exhibits high ability to absorb these nutrients from liquid fertilizer, which is desirable for application in soil improvement.

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.

Goriparthi, M. R., & TD, G. R. (2017): He arranged geopolymer concrete consolidating fly ash and ground granulated blast furnace slag (GGBS) as a limiting material, Alkaline materials Sodium silicate (Na2SiO3) and Sodium Hydroxide (NaOH) as activators. And contrasted the consequences of both OPC and geopolymer concrete and closed the accompanying aftereffects of two evaluations of concrete GPC20 and GPC50. Significant boundaries of corrosive mass misfortune factor (AMLF) by submerging in 5% of H2SO4 solution and strength properties (Compressive, Tensile and Flexure) were resolved.

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.

Dipayan Jana (2007): most common natural zeolite occurring as widespread tuffaceous lacustrine sedimentary deposits in the Western United States was used as a pozzolan at 0 to 40 percent by mass of Portland cement replacements in concrete mixtures to investigate the effects of zeolite on fresh and hardened concrete properties, and durability. Fresh concrete properties, e.g., temperature, air content, yield, unit weight were apparently unaffected by zeolite incorporation. A reduction in bleeding, and an accelerated initial setting at 10 to 30 percent cement replacement levels was noticed by zeolite.

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. Sintered Fly ash aggregate
5. Zeolite powder
6. Super plasticizer

- ***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.

- ***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.

- ***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.

- ***Zeolite Powder***

Zeolite is also available in powder form for the partly replacement for cement in concrete. It has the good pozzolanic reactivity and ability to absorb carbon dioxide from the atmosphere. Specific gravity of zeolite powder is 2.8, fineness modulus is 3.3%, and water absorption is 1.5%. Silica content is 80.5%, alumina is 4.2%, iron oxide is 2.2%, magnesia is 1.5%, and lime is 4.3%.

- ***Sintered fly ash aggreegate***

Fly ash is finely divided residue, comprising of spherical glassy particle, ensuing from the combustion of powered coal. The sintered fly ash light-weight combination is being produced with the aid of Pelletization and Sintering accomplished at temperature vary of 1100 to 1300 diploma centigrade. The burning of the carbon in the pellets and loss of moisture creates a mobile shape bonded collectively by means of the fusion of first-class ash particles. By warmness cure these small particle can be made of combine, as a result forming the pellets or nodules which have significant strength.

- ***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

It is the important property of fresh concrete which gives the behavior of concrete from mixing to compaction. The workability of concrete is the most complex property, which is difficult to define and measure. A concrete which has high consistency and which has high consistency and which is more workable, need not be of right workability for a particular job. Every job requires a particular workability.

The vertical settlement of unsupported fresh concrete, flowing to the sides and sinking in height is known as slump. Slump is a measure indicating the consistency or workability of cement concrete.

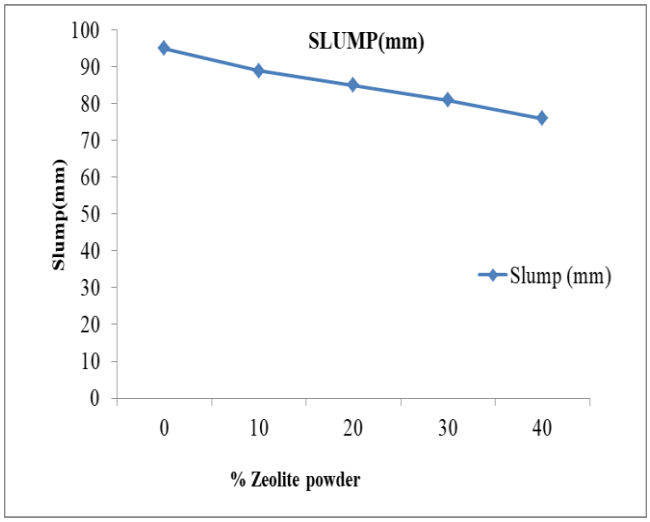

Fig 5.1: Variation of Slump Values

VI. TESTS ON HARDENED CONCRETE

6.1 VARIATION OF COMPRESSIVE STRENGTH FOR DIFFERENT MIXES

Compressive strength of concrete replaced with palm oil fuel ash for curing period of 7-days, and 28-days respectively and figure shows the summarized Compressive strength Results for different curing periods– M25 & M30 grade.

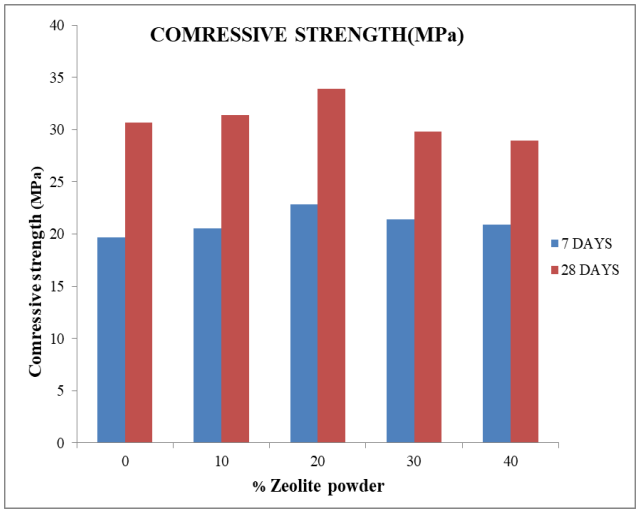

Fig 5.2: Effect of Zeolite powder on compressive strength of concrete at 7 days and 28days curing

Figure 5.3 shows compressive strength of M30 concrete under normal water conditions. There is increase in compressive strength with increase in Zeolite 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 Zeolite powder. Based on the above results and graphs it is observed that 20% replacement of Zeolite powder is taken as optimum.

5.3.2 Variation of Compressive Strength for Addition of Sintered fly ash aggregate to Optimum Percentage of Zeolite powder

There is increase in compressive strength with increase in Zeolite 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 Zeolite powder. Based on the above results and graphs it is observed that 20% replacement of Zeolite powder is taken as optimum. Based on the above results and graphs it is observed that 20% replacement of Zeolite powder is taken as optimum.

Compressive strength of concrete keeping 20% Zeolite powder as constant and with different percentages of Sintered fly ash aggregate for curing period of 7-days and 28-days respectively.

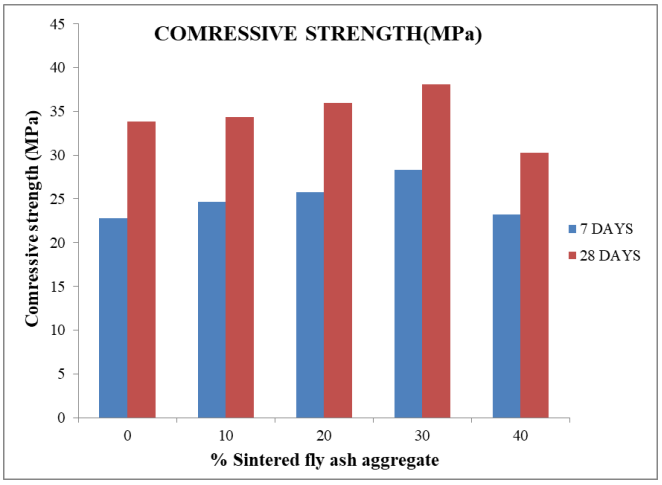

Fig 5.3 Effect of sintered fly ash aggregate on compressive strength of concrete at 7 days and 28 days curing

There is increase in compressive strength with increase in sintered fly ash aggregate up to 30 by keeping 20% Zeolite 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 30% of sintered fly ash aggregate. Based on the above results and graphs it is observed that 30% replacement of sintered fly ash aggregate is taken as optimum. Based on the above results and graphs it is observed that 20% replacement of Zeolite powder is taken as optimum.

6.2EFFECT OF SINTERED FLY ASH AGGREGATE 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/πDL
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 Zeolite powder and Sintered fly ash aggregate respectively showed higher Strength against splitting after 7 and 28 days. The 7 days Split tensile strength of mix with 20% partial replacement of Zeolite powder showed higher strength compared to other mixes. Split tensile strength of concrete keeping 20% Optimum percentage of Zeolite powder with different percentages of Sintered fly ash aggregate for curing period of 7-days and 28-days respectively and table 6.4 shows the summarized Split tensile strength Results for different curing periods– M30 grade.

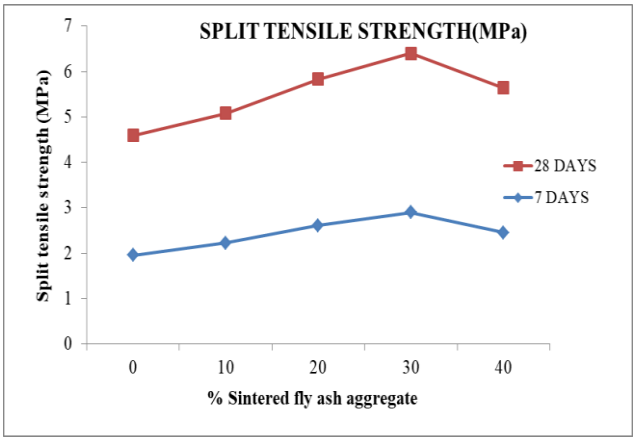

Fig 5.4 Effect of Sintered fly ash aggregate on split tensile strength of concrete at 7 days and 28 days curing

Figures 5.4 shows the concrete split tensile strength with the replacement of Sintered fly ash aggregate with an optimum of 20% Zeolite powder of M30 concrete under normal water conditions. There is increase in split tensile strength with increase in Sintered fly ash aggregate 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 30% of Sintered fly ash aggregate.

6.3 EFFECT OF SINTERED FLY ASH AGGREGATE 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 Zeolite powder and Sintered fly ash aggregate respectively showed higher Strength against Flexure after 7 and 28 days. The 7 days Flexural strength of mix with 20% partial replacement of Zeolite powder showed higher strength compared to other mixes. Flexural strength of concrete keeping 20% Zeolite powder as constant and with different percentages of Sintered fly ash aggregate for curing period of 7-days and 28-days respectively.

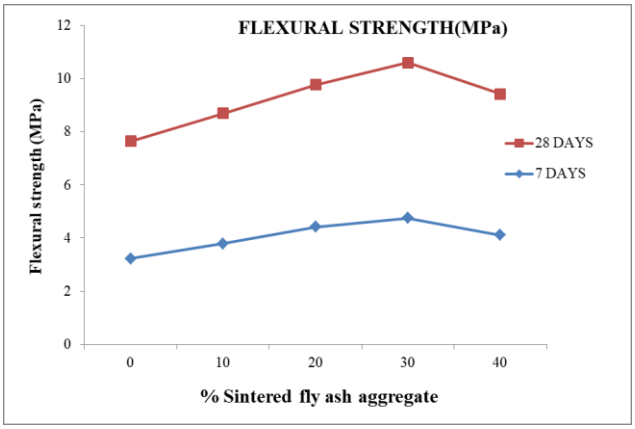

Fig 5.5 Effect of Sintered fly ash aggregate on Flexural strength of concrete at 7 days and 28 days curing

Figures 5.5 shows the concrete flexural strength with the replacement of Sintered fly ash aggregate with an optimum of 20% Zeolite powder of M30 concrete under normal water conditions. There is increase in flexural strength with increase in Sintered fly ash aggregate 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 30% of Sintered fly ash aggregate.

VII. CONCLUSIONS

Experiments are summarized and the use of zeolite powder (ZP) and Sintered fly ash aggregate (SFA) as a cement and fine aggregate replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- It has been observed that by the incorporation of zeolite in fresh and plain concrete decreases workability when compared to the workability of normal concrete.
- Zeolite powder and Sintered fly ash aggregate concrete performed better when compared to ordinary concrete up to 20% replacement of zeolite powder (ZP) and 30% of Sintered fly ash aggregate (SFA). The bond strength exhibited improvement with zeolite replacement level.
- The significant improvements in strength characteristics were observed with zeolite powder in concrete. For M30, the compressive strength achieved for 20% replacement of zeolite powder was 33.88N/mm2.
- Replacement of Sintered fly ash aggregate by keeping 20% replacement of zeolite powder as optimum shows significant improvement in the strength results. The compressive strength achieved for 30% replacement of Sintered fly ash aggregate was 38.12 N/mm2.
- Split tensile strength for cylindrical specimens is maximum at 20% zeolite powder (ZP) and 30% of Sintered fly ash aggregate (SFA) for M30 grade and it was 3.50 N/mm2 for 28 days curing.
- Flexural strength maximum at 20% zeolite powder (ZP) and 30% of Sintered fly ash aggregate (SFA) for M30 was 5.84 N/mm2 for 28 days curing.
- It is evident from the present investigation that the replacement of zeolite powder and Sintered fly ash aggregate concrete improve strength properties of the mix.
- Thus zeolite is a good alternative for replacing cement by incorporating good mechanical properties into the blended cement. The use of zeolite powder and Sintered fly ash aggregate combined is economic when compared to cement in concrete. Likewise reduces the cement price rise and intensities of CO_2 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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