Evaluating The Prospects For Effective Use Of Zeolite Powder And Calcinated Dolomite Powder As Partial Replacement Of Cement In Concrete

P Siva[1], D Appanna[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *The increasing demand for infrastructure due to the continuous population growth, and the high rate of urbanization, has led to increased consumption of concrete. The rapid production of cement creates big problems to environment. First environment problem is emission of CO2 during the production process of the cement. The CO2 emission is very harmful which creates big changes in environment. According to the estimation, 1 tone of carbon dioxide is released to the atmosphere when 1 tone of ordinary Portland is manufactured. As there is no alternative building material which totally replace the cement. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Dolomite is a rock forming mineral which is noted for remarkable wet ability and dispensability as well as moderate oil and plasticizers absorption. To overcome this issues Dolomite and zeolite powder are used as partial replacement of cement in concrete. Dolomite has similar characteristics of cement and has good weathering resistance. Dolomite is a preferred for construction material due to its higher surface hardness and density. Natural zeolite is Pozzolanic in nature like cement. It rich in silicate and aluminates. In recent times, Natural zeolite is being used as partial replacement for cement. The main goal is to investigate the possibility to improve the compressive strength, split tensile strength and flexural strength of concrete using Dolomite and zeolite powder.*

Keywords- Zeolite powder, Calcinated dolomite powder, workability, compressive strength, split tensile strength test, water absorption test.

I. INTRODUCTION

In the last decades, environmental sustainability has become one of the most important issues. 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 product like nano silica are having some building material and silicious properties. So the use of the commercial and agricultural wastages 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.

The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Nano silica and metakaolin do waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction. Metakaolin and Nano silica 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.

Concrete is the most versatile construction material being used in construction of structures, like, buildings and bridges. Concrete is fairly strong in compression week in tension. Concrete is made up of inert filler a chemically active binder. The binder adheres all ingredients together to forms a synthetic conglomerate. Aggregates are the solid particles that are bound together by the cement paste to create concrete. Aggregates are the fundamental components of Concrete. The coarse aggregates, being the principle control material for maximum strength, sand fills most of voids, providing lateral restrains (inter particular locking) to the coarse particles. Aggregates occupy around 40 to 30% of the volume of concrete. Generally aggregates are given less importance by assuming them to be only as economic interring fillers, but they influence the strength, dimensional Stability, wear resistance and durability of concrete.

Therefore in this investigation, it is attempted to conduct a study on a mechanical properties of Natural zeolite concrete. In this research, M30 grade concrete mix is designed and used in costing specimens (cubes, cylinders and beams). The details are given the test matrix as mentioned in Table 1. Also, compressive strength, split tensile strength, and flexural strength tests are conducted. The test results are detailed and reported in chapter 5. The primary objectives of the primary research work are

1. To study the influence of Natural zeolite on compressive strengths of M30 concrete mix proportion by replacing of cement 5%, 10%, 15% and 20% by weight.
2. To study the influence of Natural zeolite on split tensile strengths of M30 concrete mix proportions by replacing of cement 5%, 10%, 15% and 20% by weight.
3. To study the influence of Natural zeolite on flexural strengths of M30 concrete mix proportion by replacing of cement 5%, 10%, 15% and 20% by weight.
4. To study the influence of Natural zeolite on workability of M30 concrete mix proportion by replacing of cement 5%, 10%, 15% and 20% by weight.

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

A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review of nano silica and metakaolin is presented in the following sections.

It has been noted that the sunshine fastness of banana fibre is inferior to cotton. this could be attributed to the impurities gift within the banana fibre within the variety of polymer and therefore the different insoluble matter. The revealed analysis works on flexural plasticity of nylon fiber ferroconcrete beam are studied by several researches few mentioned the influence of nylon fiber issue on flexural plasticity of beam and terminated that plasticity indexes increase with increasing of fiber issue.

DTakaakiwajima 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.

They found out, Zeolite-P, tobermorite and hydroxysodalite were synthesized at low temperature (90°C) from paper sludge ash (PSA) mixed with diatomite. The zeolites exhibit higher CEC with increasing proportion of diatomite in the ash/diatomite mixture. The concentrations of Si and Al in the solution during the reaction can be used to monitor the phase change. Crystallization of only zeolite-P occurs when 64 g of diatomite is added to 100 g of ash, resulting in a much higher concentration of Si than Al. In the original ash without diatomite addition, the concentration of Al in the alkali solution always exceeded that of Si during the synthesis, and hydroxysodalite with a low Si : Al ratio (1 : 1) was formed. In the mixture of ash and diatomite, the concentration of Si always exceeded that of Al during the synthesis, and zeolite-P with a higher Si: Al ratio (5: 3) was formed. The zeolite-P phase synthesized at a high proportion of diatomite exhibits a relatively high CEC and capacity for NH4+, K+ and PO43 uptake, which is desirable for application in soil improvement.

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.

The systems were tested in single-step and in sequential processes. In single-step studies, HY zeolite was found to be the most efficient support when applied to low Cr concentrations (overall Cr removal of 93.4%), whereas for the higher initial Cr concentration, the higher ion-exchange capacity of Nay zeolite was determinant to achieve the highest overall Cr removal of 77.6%. The evolution of Cr (VI) entrapment was strongly dependant on the zeolitic support used in the system. In sequential batch processes, HY zeolite was found to be the most efficient support with a 98.2% overall Cr removal. The reduction of Cr (VI) promoted by the biomass is more suited to the dynamics of the sequential process. Nay zeolite behaved similarly to HMOR and NaMOR zeolites, as these systems removed between 87.3 and 93.4% of the initial Cr. They conclude that, The results presented in this work show that different zeolite biomass systems are able to perform the removal of Cr (VI) from solutions up to 100.0mgCr/L. Different batch processes can be used, and the chemical composition of the zeolitic support promotes different system responses, in terms of removal of Cr (VI), Bio reduction of Cr (VI) performed by A. viscous and metal retention. Due to the higher ion-exchange capacity of Nay zeolite, this support is the most efficient for long-term Cr (VI) entrapment in single-step process, achieving 77.6% Cr removal, compared to 71.6% for HY and 63–66% for MOR zeolites. For the SBR process, HY zeolite demonstrated to be the most attractive support, mainly due to the more efficient initial Cr removal ability of the system being more suited to the dynamics of the SBR process. Overall Cr removal was 98.2% with this support, whereas the other supports attained removal figures between 87 and 93%. MOR zeolites show a better behavior comparatively to Nay in SBR process, despite their lower ion-exchange capacity and Cr (VI) concentration reduction efficiency.

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.

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.

The difference in reactivity of the samples containing zeolites with varying Si/Al ratios, as well as between clinoptilolite-rich samples exchanged with different cat ions or ground to different grain sizes was assessed. The results indicate that the external surface area only influences the short-term reactivity, whereas the cat ion content has an effect on both the long- and short-term reactivity. The early reactivity of the unexchanged samples can be explained by these two parameters, but their long-term reactivity is mainly related to the Si/Al ratio of the zeolites. Samples with zeolites rich in Si react faster than their Al-rich counterparts. He absorbed that by mixing lime with tuffs consisting mainly of natural zeolite with variable Si/Al ratios or ground to different grain sizes and exchanged to different cat ions, the Pozzolanic reaction has been studied from 3 days on, based on the consumption of portlandite measured by TGA after vacuum-drying. The thickening of the reaction rim at 7–14 days marks the general evolution of the reaction from three days on. The subsequent evolution follows the behavior predicted by the Jander's equation for three dimensional diffusion processes through a layer of constant permeability.

The results in this study confirm the previous findings that finer grain sizes or higher specific surface areas of pozzolans yield a higher short-term Pozzolanic activity. It appears from the results that mainly the external surface area is important for zeolite. This parameter has however no influence on the reaction after 1 day. In addition to the surface area available for reaction, the results of this study show that the short-term reactivity is also affected to a significant extent by the cat ion content of the zeolites and the ease with which these cat ions are exchanged. For the two clinoptilolite samples exchanged with K+, Ca2+ and Na+, consistent data were obtained and a clear difference in the amount of lime combined before and after 3 days of reaction was observed. The Na+-exchanged samples had reacted with more lime during the first three days, but they combined lime more slowly afterwards when compared to the samples exchanged with Ca2+ and K+. The K+-exchanged zeolite reacts very fast after 3 days. The Ca2+- clinoptilolite had reaction exponents between the K+- and Na+- exchanged samples after three days.

The difference in reactivity can be related to the influence of the cat ions on the pH of the pore solution. Massazza suggested that at longer ages, the Pozzolanic reaction is controlled by other factors such as the silica and alumina active contents. These findings are confirmed by the present data. The exponents of reaction succeeding the first three days can indeed be explained by the zeolite Si/Al ratios. Samples with zeolite having higher Si/Al ratios have lower reaction exponent, thus reacted faster. Only the Analcime-rich sample (‘Ana’) showed a deviant behavior, which is probably governed by its slow release of Na+, leading to a retarded increase of Na+ in the pore solution with a retarded increase in pH as a consequence.

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. Fine aggreegate
3. Coarse aggregate
4. Water
5. Dolomite powder
6. Zeolite powder

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. 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.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. 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.

4. Dolomite powder

Dolomite, also known as "dolostone" and "dolomite rock," is a sedimentary rock composed primarily of the mineral dolomite, $CaMg(CO_3)_2$. Dolomite is found in sedimentary basins worldwide. It is thought to form by the post depositional alteration of lime mud and limestone by magnesium-rich groundwater. Dolomite and limestone are very similar rocks. They share the same color ranges of white-to- gray and white-to-light brown (although other colors such as red, green, and black are possible).They are approximately the same hardness, and they are both soluble in dilute hydrochloric acid. They are both crushed and cut for use as construction materials and used for their ability to neutralize acids.

Fig 3.1: **Dolomite Powder**

Table 3.1 Chemical Composition Of Dolomite

S.No	Property	values
1	calcium oxide(Cao).	90%
2	Silica(Sio2)	2.71%
3	Aluminium Oxide(Al2O3)	-
4	Ferrous Oxide (Fe2o3)	0.52%
5	Magnesium Oxide (Mgo)	1.84%

5. Zeolite powder

In this project Natural zeolite used as partial replacement of cement in NCC. The Natural zeolite obtained from Sri Annapurna Agencies Kakinada. Natural zeolite is Pozzolanic in nature like cement. It rich in silicate and aluminates .in recent times, Natural zeolite is being used as partial replacement for cement in NCC. Various tests are conducted on Natural zeolite to study the properties.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. 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 M35.

V. RESULTS AND DISCUSSIONS

This session provides an outline of the experimental results and endeavors to draw some conclusions. The take a look at result covers the workability, mechanical properties and sturdiness properties of concrete with and while not admixtures. The results of the experimental investigation on nano silica and metakaolin concrete wherever nano silica and metakaolin has been used as partial replacement of cement in concrete mixes. On commutation cement with completely different percentages of Dolomite powder and zeolite powder the workability, compressive strength is studied then to the optimum share of dolomite powder ,keepingdolomite powder constant the cement is replaced with zeolite powder and studied the compressive strength, flexural strength for various mixes then studied.

5.1 REPLACEMENT DETAILS

The replacement details of nano silica and metakaolin has been given in the below table. The replacement of cement percentages by 0, 5, 10, 15, 20% with dolomite powder and after getting optimum percentage keeping optimum dolomite powder constant varying the cement replacement percentages by zeolite powder.

5.2 VARIATION OF SLUMP VALUES FOR PERCENTAGE REPLACEMENT OF NANO SILICA

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability. Critical mix has high workability compared to other mixes which may be due to the particle size of nano silica and metakaolin is lesser than cement. So in short, mixes with high percentages of nano silica are more workable than the control one.

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The slump of the freshly mixed concrete was measured by using a slump cone in accordance to ASTM C143. A concrete, which is considered workable for mass concrete foundation, is not workable for concrete to be used in roof construction, even in roof construction, concrete considered workable when concrete is to be compacted by hand. Workability was measured by Slump Cone Test..

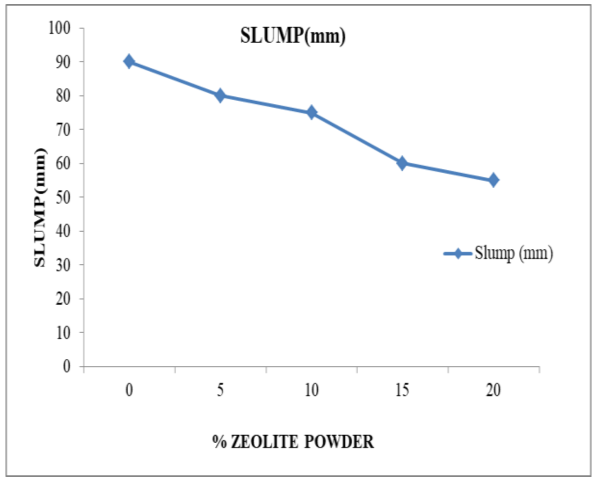

Fig 5.1: Plot shows the Variation of Slump Values for % replacement of natural zeolite

5.3.1 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strain.

Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days.

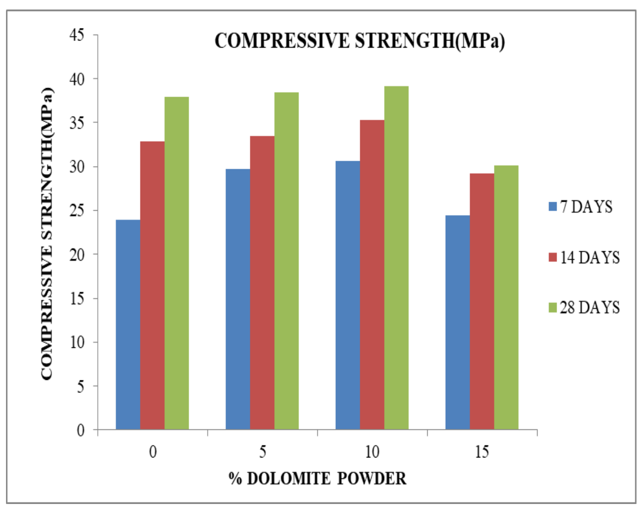

Fig 5.2shows the Variation in Compressive Strength for % Replacement of dolomite powder

As the percentage of Dolomite powder increases the compressive strength of concrete tends to increase up to certain percentage and then start's decreasing with the increase of Dolomite content.

The strength of 10% Dolomite powder concrete is more than 5% Dolomite powder concrete. This shows that till 10% Dolomite powder concrete the strength increases while percentage of Dolomite powder increases.

5.4 VARIATION OF COMPRESSIVE STRENGTH FOR ADDITION OF ZEOLITE POWDER TO OPTIMUM PERCENTAGE OF DOLOMITE POWDER

The strength of 10% Dolomite powder concrete is more than 5% Dolomite powder concrete. This shows that till 10% Dolomite powder concrete the strength increases while percentage of Dolomite powder increases. Compressive strength of concrete keeping 10% Dolomite powder as constant and with different percentages of zeolite powder for curing period of 7-days, 14-days and 28-days respectively and figures shows the summarized Compressive strength Results for different curing periods– M30 grade.

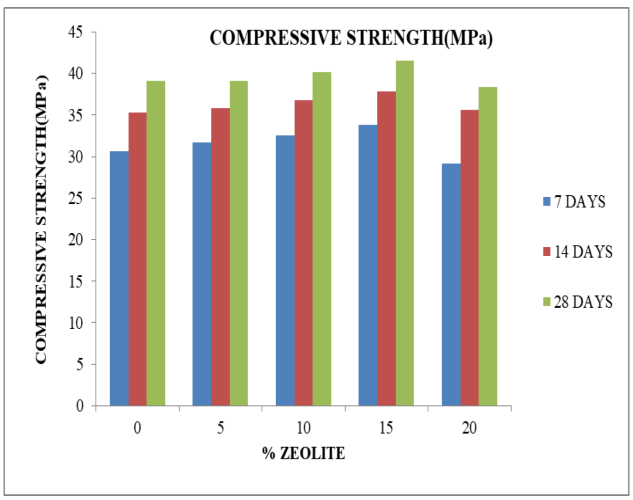

Fig 5.3 shows the variation in Compressive Strength for % replacement of zeolite

As the percentage of natural zeolite increases the compressive strength of concrete tends to increase up to certain percentage and then start's decreasing with the increase of zeolite content.

The strength of 15% natural zeolite concrete is more than 10% natural zeolite concrete. This shows that till 15% natural zeolite concrete the strength increases while percentage of natural zeolite increases.

This increase in strength in natural zeolite concrete is due to presence of Silica in natural zeolite. Silica in natural zeolite react with residual CH after the formation of C-S-H gel, and increase the amount of C-S-H gel and results in increase the strength.

5.5 EFFECTOF NATURAL ZEOLITE ONSPLITTENSILE STRENGTH OF CONCRETE

Split tensile strength of concrete keeping 10% natural zeolite and 25% Dolomite powder as constant and with different percentages of natural zeolite for curing period of 7-days, 14-days and 28-days respectively and table shows the summarized Split tensile strength Results for different curing periods– M30 grade.

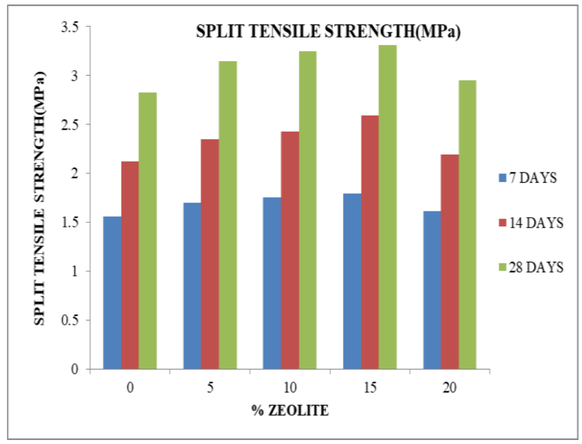

Fig 5.4 shows the Variation in Split Tensile strength for different percentages of zeolite mixes

From the results it is evident that with the increase of zeolite content the tensile nature of the concrete also increases results in higher values compared to that of Plain concrete.

The figure shows that the test results of splitting tensile strength of specimens after water curing, it is concluded that the percentage increase in strength increases with the increase in percentage of natural zeolite content. Also, from the results it is evident that compressive and split tensile strength also increases with the increase of power content.

5.6 EFFECTOF NATURAL ZEOLITE ONFLEXURAL STRENGTH OF CONCRETE

Tensile stress is developed in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is important. We measure the tensile strength of concrete in indirect method like flexural test. In flexural test we find the modulus of rupture (extreme fibre stress in bending), this value depends up on the dimension of beam manner of loading. In the flexural test two types of loading conditions, there are central point loading, third point loading. In our experimentation I use third point loading with a size of beam is 70 x 15 x 15 cm. this test performed as per IS: 516 codes.

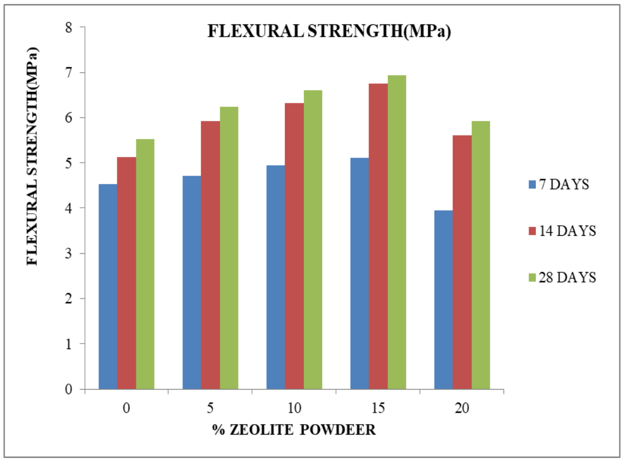

Fig 5.5: Plot shows the Variation in flexural strength for different percentages of zeolite mixes

From the results it is evident that with the increase of zeolite content the flexural strength of the concrete also increases results in higher values compared to that of Plain concrete.

The figure shows that the test results of flexural strength of specimens after water curing, it is concluded that the percentage increase in strength increases with the increase in percentage of natural zeolite content. Also, from the results it is evident that compressive, split tensile and flexural strength also increases with the increase of pozzolans content.

VI. CONCLUSIONS

The Conclusions and Recommendations that could be drawn from the results of this project and experiments are summarized and the use of Dolomite powder and natural zeolite as a cement replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- Addition of natural Zeolite to concrete mix results in reduction in workability. The reduction in workability increases with increase of natural zeolite quantity.
- As the percentage of Dolomite powder increases the compressive strength of concrete tends to increase up to 10% and then start's decreasing with the increase of Dolomite content.
- Keeping 10% dolomite powder constant, Natural zeolite added with percentages of 5%, 10%, 15% and 20%.
- Natural zeolite concrete performed better when compared to ordinary concrete up to 15% replacement of natural zeolite. The bond strength exhibited improvement with natural zeolite replacement level.
- Compressive strength of concrete increased for all the mixes 5%, 10%, 15% and 20% replacement of zeolite. At an age of 28 days the compressive strength of concrete is 41.52 MPa which is 9.6% higher than the normal concrete for 15% replacement of concrete.
- This may be due to the fact that the CSH gel formed at this percentage is of good quality and have better composition.
- Nearly there is an increase of 16.9% in tensile strength for mix 10% dolomite and 15% zeolite when compared to the normal mix.
- It was observed that the flexural strength (at 28 days) increased about 25.54% when compared with normal concrete.
- Compressive,tensile and flexural strength values dropped for mix 10%dolomite and 15% zeolite content.
- In all mixes there is acceleration in the increase in the later stages (i.e., after 14 days) as the pozzolanic activity gains momentum with the age of concrete.
- Thus zeolite is a good alternative for replacing cement by incorporating good mechanical properties into the blended cement.
- The use of Dolomite powder and Natural zeolite combined is economic when compared to cement in concrete. Likewise saves a great deal of waste disposal problems and 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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