RESEARCH ON MECHANICAL AND DURABILITY PROPERTIES OF CONCRETE BY REPLACEMENT OF NATURAL ZEOLITE AND FLY ASH

K.LOKESH[1], M.MALLIKARJUNA[2]

[1]Post Graduate Student, [2]Assistant professor
Department of Civil Engineering,
SVR Engineering College, Nandyal, Kurnool (DT)

***Abstract*: In conventional concrete we want to gain more strength with the optimum materials. That's why here we are using zeolite and Fly ash in concrete for the replacement of cement which might absorbing CO_2. Due to rapid change in metrology, deep minimizing emission will be required in coming decades. Global warming is controlled by the process of reducing greenhouse gases like CO_2, HFC and Sulphur-di-oxide in atmosphere. Zeolite powder is good agent to absorb harmful gases. Natural zeolites form where volcanic rocks and ash layers react with alkaline groundwater. Zeolites also crystallize in post-depositional environments over periods ranging from thousands to millions of years in shallow marine basins. Concrete with zeolite as partial replacement material with mean ratio it absorbs harmful gases and gives high compressive strength, hence it is ecofriendly.**

In this project, concrete made with cement is partially replaced with zeolite and Fly ash then compared with normal concrete. Here cement in concrete is partially replaced with the zeolite in the respective proportions such as 5%, 15%, 20%, and 25% and Fly ash proportions are 5%, 10%, 15%, 20% & 25% the specimens were casted and tested for their mechanical and durability properties.

***Keywords*: Zeolite, Fly Ash, compressive strength, split tensile, Young's Modulus, Flexure Test, Rapid Chloride Permeability test, water permeability test.**

I.INTRODUCTION

Concrete is a composite material made out of coarse aggregate bonded together with a liquid cement that solidifies after some time. Most cements utilized are lime-based cements, for example, Portland cement concrete or cements made with other pressure driven concrete, for example, bond found. Be that as it may, black-top solid which is every now and again utilized for street surface, is likewise a kind of solid, where the bond material is bitumen, and polymer cements are now and again utilized where the establishing material is a polymer. At the point when aggregate is combined with dry Portland cement and water, the mixture frames liquid slurry that is effectively poured and formed into shape. The cement responds artificially with the water and different fixings to shape a hard network that binds the materials together into a strong stone-like material that has many employments. Regularly, added substances, (for example, pozzolons or super plastisizer) are incorporated into the blend to enhance the physical properties of the wet blend or the completed material. Most concrete is poured with reinforcing materials implanted to give rigidity, yielding reinforced concrete.

Zeolites happen actually but at the same time are created modernly on a substantial scale. As of September 2016, 232 one of a kind zeolite systems have been famed, and more than 40 normally happening zeolite structures are known. Each new zeolite structure that is gotten must be endorsed by the International Zeolite Association Structure Commission and gets a three letter assignment. Common zeolites frame where volcanic shakes and fiery debris layers respond with antacid groundwater. Zeolites additionally take shape in post-depositional conditions over periods extending from thousands to a large number of years in shallow marine bowls. Normally happening zeolites are once in a while immaculate and are sullied to changing degrees by different minerals, metals, quartz, or different zeolites. Thus, normally happening zeolites are rejected from numerous imperative business applications where consistency and immaculateness are fundamental.

Fly ash, one of the most widely utilized by-product in the construction industry resembling the Portland cement. It is a non-combustible, inorganic, finely divided residues which are collected or precipitated from exhaust gases of any industrial furnace. It is produced from the modern power stations in India of high quality as it consists of very low un burnt carbon and low sulphur i.e. less loss on ignition. In order to utilize fly ash for various applications, most of the thermal power stations had established a dry fly ash evacuation and storage system. In this system fly ash from Electrostatic Precipitators (ESP) is evacuated through pneumatic system and stored in silos. From silos, it can be loaded in open truck/ closed tankers or can be bagged through suitable bagging machine, the ESP systems has 6 to 8 fields (rows) depending on the design of ESP. the field at the chimney end is called the last field. Coarse particles of the fly ash are collected in the first fields of ESP. fineness of fly ash particles increases in subsequent fields of Electrostatic Precipitators.

II. Literature Review

Jonie Tanijaya(2008) Direct use of natural zeolites as partial replacement for ordinary Portland cement in concrete up to 10% by mass did not improve the concrete compressive strength. In fact, the compressive strength decreased with the increase of natural zeolites content. The incorporation of natural zeolites in concrete tends to reduce the slump value of fresh concrete due to its cubical particle shape and rough surface. Due to smaller specific gravity of natural zeolites compared to ordinary Portland cement, the specific gravity of concrete incorporating zeolites slightly reduced As in the case of concrete without natural zeolites, the tensile splitting strength and the modulus of elasticity of concrete with zeolites are function of its compressive strength. Thus, concrete with zeolites possesses lower tensile splitting strength and modulus elasticity.

E.Vejmelkoval (2012) Experimental results presented in this paper showed that natural zeolite can be considered an environmental friendly binder with a potential to replace a part of Portland cement in concrete in building industry. However, although it would be desirable from both environmental and economical points of view to use its highest possible amounts in concrete production, the extent of Portland cement replacement which could be chosen in preparation of high performance concrete mixes was found to have relatively strict limitations. The resistance against de-icing salts appeared as the main limiting parameter; even the mix with the lowest zeolite content of 10% did not meet the criteria of the ČSN 731326/Z1:1984 standard. Therefore, this type of concrete should not be used in such cases where de-icing salts are likely to act during its service life. The limitations related to other parameters were not so strict. The mechanical and liquid water transport parameters were satisfactory up to the 20% replacement level, the water vapour transport parameters, water storage parameters and thermal parameters were acceptable for all studied mixes. Summarizing the above results, it can be concluded that the replacement of Portland cement by natural zeolite in the amount of 20% by mass can be considered the most suitable option among the studied mixes.

Ali Akbar Ramezanianpour (2013) self-consolidating concrete with low portland cement and a minimum 28-day compressive strength of 30 MPa can be produced by partial replacement (10–25%) of portland cement with NZ and application of a dense-packing concept.

The mixtures with NZ replacement levels of 10–25% satisfiedthe flow ability, passing ability, and stability criteria ofEFNARC (2002). Therefore, by using NZ, SCC mixturescontaining total cementitious materials of 350 kg/m^3 couldbe produced. However, a SCC mixture without any NZ incorporationcould not be achieved because of substantial bleeding.The fresh test results demonstrate that using higher percentages of NZ results in higher demand for HRWRA to maintain the required flow ability.Considering the fresh test results, it was shown that using NZ leads to high viscosity, which provides the required stability and high segregation resistance needed for SCC mixtures.

Considering compressive strength results at different ages (up to 270 days), NZ replacement increases the compressive strength at ages greater than 28 days. Furthermore, the highest strength values at later ages were achieved by the Z10 mixture, which reached 60 MPa after 270 days of curing, whereas 48 MPa was measured for NC - CTRL mixture at the same age. According to ASTM C1202 and FM 5-578 (FDOT 2004), the permeability classes of all the NZ-incorporated mixtures were rated as low or very low at the age of 90 days, whereas the permeability class of the control mixture was moderate at this age. Considering RCPT and electrical resistivity test results, it can be concluded that NZ incorporation could enhance the durability performance of SCC mixtures, which is intensified at higher replacement levels.

Ali Akbar Ramezanianpour (2014) In general, the use of zeolite decreases slumps of concrete, so a super plasticizer is needed. The addition of zeolite delays the strength development during the first 28 days, after that age concretes having up to 10% zeolite provide competitive compressive strength with PC concrete. With increasing w/c ratio, the growth rate of compressive strength decrease at early ages and increase by the time. Less water absorption and water permeability was observed in the concretes containing up to 15% zeolite. The substitution of cement with 15% natural zeolite reduced the chloride penetration of concrete mixtures according to the RCPT test. The rate of reduction increase with increasing w/c ratio. The electrical resistivity of concrete samples containing zeolite increased 2 to 4 times compared to control samples. Adding higher percentages of zeolite to cement produces high electrical resistivity. The addition of zeolite up to 15 % in concretes with W/C = 0.5 delays higher electrical resistivity and lower passing charge in RCPT test , compared PC concretes with W/C = 0.35 , so the addition of zeolite is more effective than the reduction of w/c ratio. The performance of concrete with cement replacement by zeolite is considerable in RCPT and electrical resistivity test which are in many cases the most important characteristic concerning durability and corrosion prevention. The depth of carbonation increases with increasing zeolite replacement.

H. Eskandaria (2015) The compressive strengths of concretes containing additives were lower than the concrete without supplementary replacement at all ages. However, the percentages of reduction were lower for high ageing times, which can be attributed to lump in transition zone. Decrease rate of tensile strength is less than compressive strength in all ages. Also effectiveness of additives on strengths for mixtures with 0.45 W/C is less than 0.4 W/C, probably because of the lack of water, strength have been decreased.

The optimized mixture for achieving high quality of durability is incorporation of 2% nano silica and 8% micro zeolite. The concrete contained 8% micro zeolite has high resistance for penetration chloride ion.

V. Praveen Kumar (2016) In zeolite mixed concrete gives the grade of M30 concrete strength in the proportion of M20 concrete mix In both substitution of 10% & 30% of zeolite in concrete brings similar compressive strength. To reduce the cost of construction to use 10 % of zeolite is preferable.

EhsanMohseni(2017) Concrete containing 15% tuff and 10% zeolite showed the highest compressive strength. Replacement of cement by zeolite substantially decreased the water absorption. However, in concrete samples with tuff as sand replacement, considerable absorption was not observed. The chloride diffusion coefficient of the control specimen diminished by up to 55% in

T15Z10 sample. Thus, it is identified that the chloride resistance of the specimens was significantly enhanced by the use of tuff and zeolite.

The compressive strength reduction of concrete samples in sulphuric acid after 236 days of immersion varied between 9.2% and 15.7% in tuff-included samples and also 13.07% and 21.4% in tuff- and zeolite-included samples, however the strength reduction of plain concrete sample was 5.01%. The highest mass loss of 4.8% was recorded for specimen 15T15Z after 180 days of exposure to hydrochloric acid.

III.Materials

Cement: Cement is a binder material, which is used to binds the other material together. Ordinary Portland Cement of 53 grade manufactured by Zuari company confirmingISO 50001:2011 is used. The main benefit is the faster rate of development of strength. The specific gravity of cement is 3.1 and fineness modulus is 225kg/m^3

Aggregates

After cement, the aggregate is the basic material used in any concrete to comprise the body of concrete for increasing the strength to the material quantity, and to minimize the consequential volume change of concrete. The fine and coarse aggregates generally occupy 60% to 75% of concrete volume and strongly influence the concrete freshly mixed and hardened properties, mixture proportions and economy.

1. Coarse aggregates:

In this research investigation crushed grained aggregate of 20mm size was used. The specific gravity of coarse aggregate is 2.74

2. Fine aggregates

The quantity of the fine aggregate important is main to fill the voids present in coarse aggregate. In this research natural sand was used as fine aggregate. The specific gravity of sand is found to be 2.63.

A. Zeolite

Generally, reactive components of pozzolanic material such the same as silica fume, fly ash and natural pozzolans are glassy or amorphous. However, natural zeolites, which are crystalline, be able to act as pozzolanic materials. It has been ascertain to natural zeolite is a commendable complementary cementitious material. The huge amount of reactive SiO_2 and Al_2O_3 in zeolite chemically combines among the calcium hydroxide formed by the hydration of cement to form additional C–S–H gel and aluminates, resulting in the expansion of microstructure of hardened cement. Like other pozzolanic materials, replacement of cement by natural zeolite can improve the mechanical properties of cement and concrete composite.

B. Fly Ash

The installation of super power thermal stations like RTPP, the estimated annual worldwide production of fly ash is of the order of 1000 million tons at present and it is likely to exceed 2000 million tons by early 21st century. The dumping of fly ash in open fields results in ecological and environmental problems. Fly ash confirming to the requirements of IS 1727 (1967) obtained from RTPP conforming to class F with specific gravity of 2.2 and Fineness of fly ash is 320m^2/kg was used as supplementary cementitious material in concrete mixtures

Mix Proportions

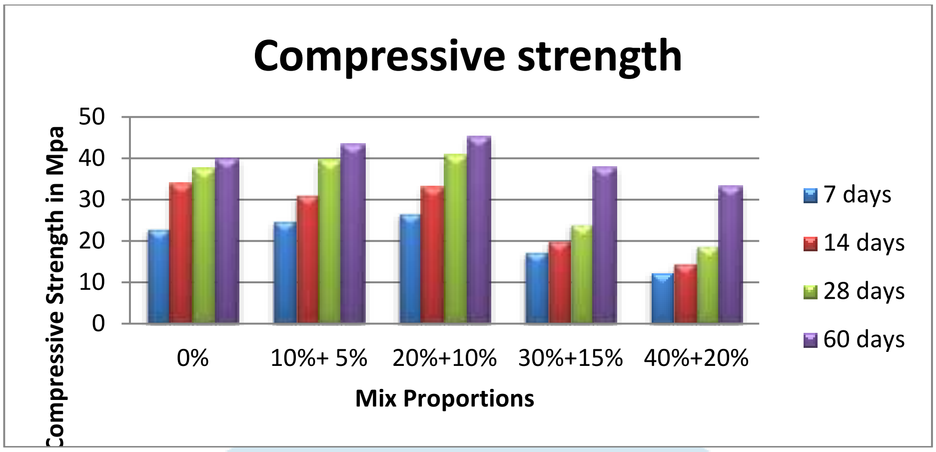
Mix Designation	Proportion of Binding Materials
A1	100% cement
A2	85%cement +10% zeolite + 5% Fly Ash
A3	70% cement + 20% zeolite + 10% Fly ash
A4	55% cement + 30% zeolite +15% Fly ash
A5	50% cement + 40% zeolite + 20% Fly Ash

IV. Experimental Results

Compressive Strength:

Results of M30 grade of OPC concrete with various proportions of Zeolite and Fly Ash tested for compressive strength as shown in below. The compressive strength of concrete mixes by replacing OPC with Zeolite Powder of 10%, 20%, 30%, 40% and Fly Ash as 5%, 10%, 15% and 20% are investigated. The results of compressive strength for these concrete mixtures tested at 7days,14 days,28 days and 60 days are presented.

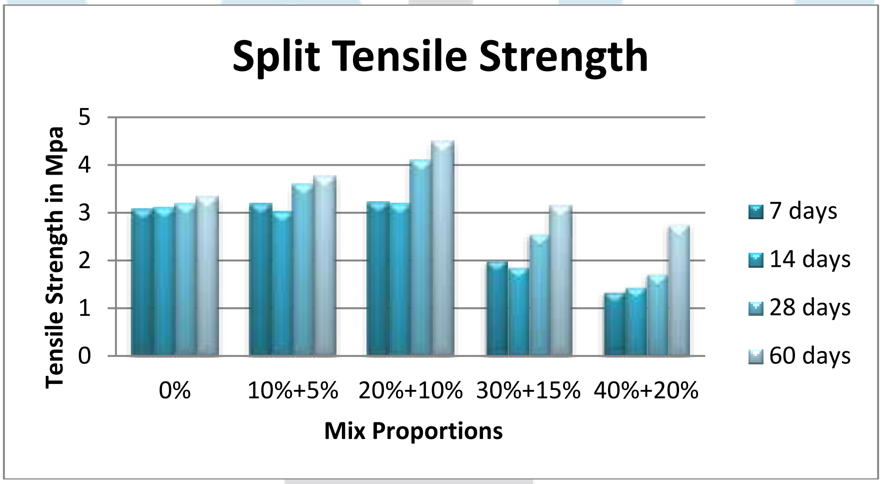
Mix Proportions	**Compressive strength N/mm^2**			
	7-Days	**14-Days**	**28-Days**	**60 –Days**
A1	22.9	34	37.5	39.96
A2	24.8	31.16	39.56	43.37
A3	26.7	33.09	41.75	45.21
A4	17.41	19.98	24	37.84
A5	12.46	14.61	18.84	33.18



Split Tensile Strength:

The Split Tensile strength of M_{30} grade of concrete by replaces in ordinary Portland cement with Natural zeolite like 10%, 20%, 30% and 40% and fly ash as 5%, 10%, 15% and 20%. The results of compressive strength of A1, A2, A3, A4, and A5 concrete mixtures tested at 7days, 14days, 28days and 60days the data are presented in the given below table and graphical presentation compressive strength.

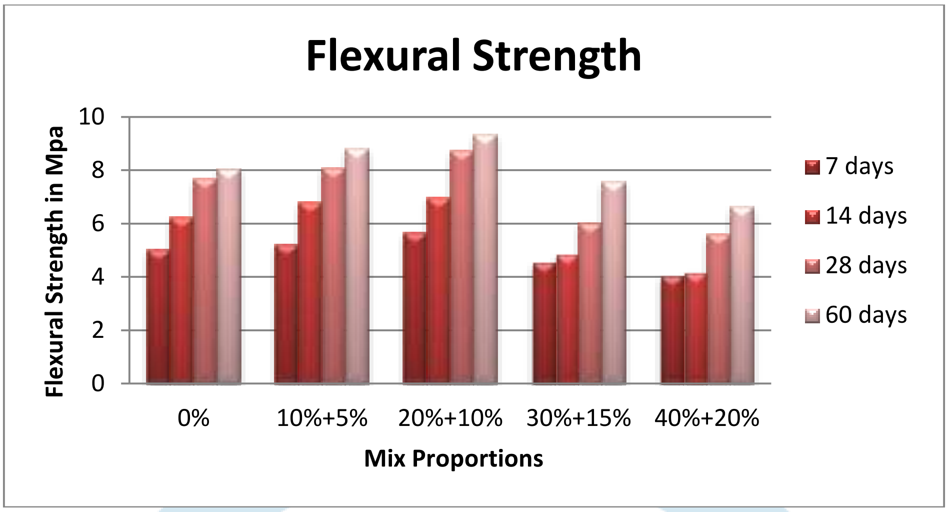
Mix Proportions	Split Tensile Strength N/mm²			
	7-Days	14-Days	28-Days	60 –Days
A1	3.07	3.10	3.18	3.33
A2	3.18	3.02	3.60	3.76
A3	3.22	3.19	4.10	4.5
A4	2.3	1.86	2.56	3.15
A5	1.34	1.45	1.72	2.76



Flexure Test

The Flexure strength of M_{30} grade of concrete by replaces in ordinary Portland cement with Natural zeolite like 10%, 20%, 30% and 40% and fly ash as 5%, 10%, 15% and 20%. The results of compressive strength of A1, A2, A3, A4, and A5 concrete mixtures tested at 7days, 14days, 28days and 60days the data are presented in the given below table and graphical presentation flexure strength.

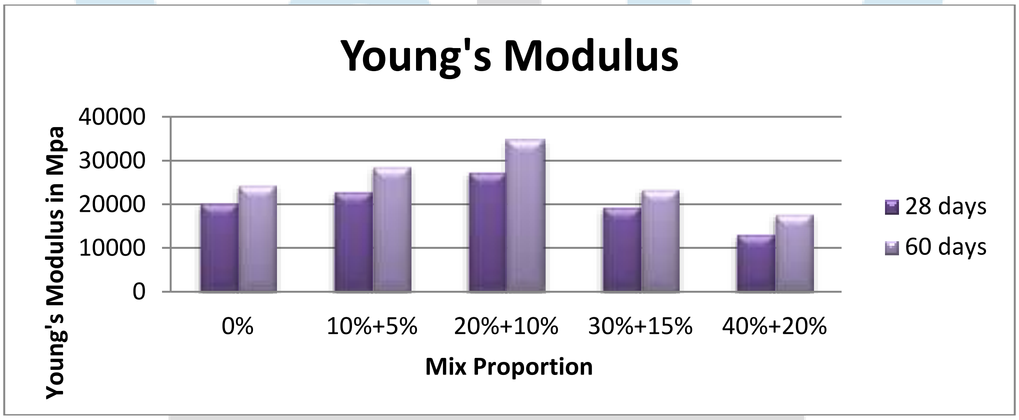
Mix Proportions	Flexure Strength N/mm²			
	7-Days	14-Days	28-Days	60 –Days
A1	5.02	6.24	7.67	8.05
A2	5.21	6.8	8.08	8.8
A3	5.65	6.98	8.74	9.34
A4	4.56	4.86	6.01	7.56
A5	4.06	4.17	5.59	6.63



Young's Modulus

The Young's Modulus of M_{30} grade of concrete by replaces in ordinary Portland cement with Natural zeolite like 10%, 20%, 30% and 40% and fly ash as 5%, 10%, 15% and 20%. The results of compressive strength of A1, A2, A3, A4, and A5 concrete mixtures tested at 7days, 14days, 28days and 60days the data are presented in the given below table and graphical presentation.

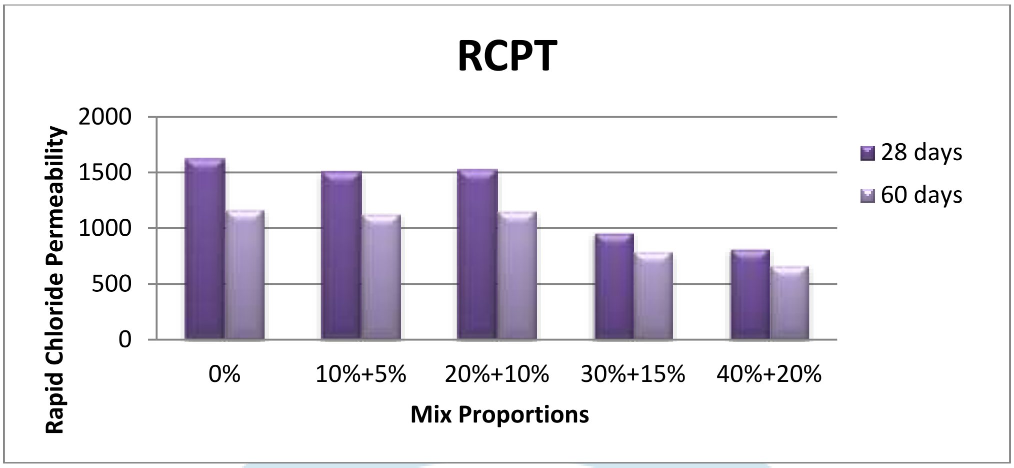
Mix Proportions	Young's Modulus at 28 days (Mpa)	Young's Modulus at 60 days (Mpa)
A1	20347.2	24416.64
A2	22986.1`	28732.62
A3	27425.4	34756.75
A4	19444.4	23468.30
A5	13194.4	17812.44



Rapid Chloride Permeability Test

The Rapid Chloride Permeability Test of M_{30} grade of concrete by replaces in ordinary Portland cement with Natural zeolite like 10%, 20%, 30% and 40% and fly ash as 5%, 10%, 15% and 20%. The results of compressive strength of A1, A2, A3, A4, and A5 concrete mixtures tested at 7days, 14days, 28days and 60days the data are presented in the given below table and graphical presentation of RCPT

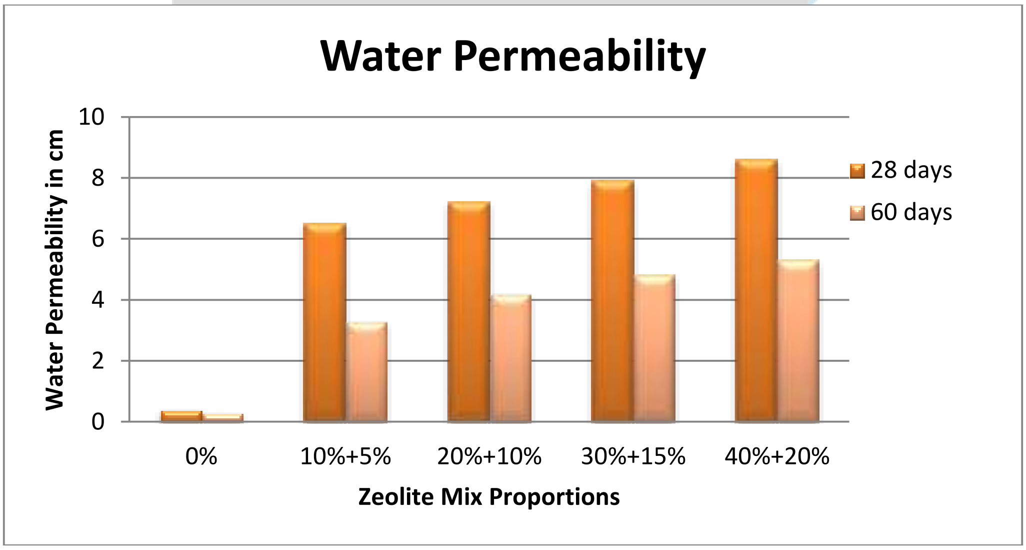
Mix Proportions	RCPT for 28 days (Mpa)	RCPT for 60 days (Mpa)
A1	1622.7	1171.8
A2	1509.5	1131.7
A3	1525.8	1158.3
A4	959.4	792
A5	815.8	669.15



Water Permeability

The Water Permeability of M_{30} grade of concrete by replaces in ordinary Portland cement with Natural zeolite like 10%, 20%, 30% and 40% and fly ash as 5%, 10%, 15% and 20%. The results of compressive strength of A1, A2, A3, A4, and A5 concrete mixtures tested at 7days, 14days, 28days and 60days the data are presented in the given below table and graphical presentation

Mix Proportion	Depth of penetration (in cm)		Coefficient of permeability (K in m/sec)	
	28 days	60 days	28 days	60 days
A1	0.4	0.3	8.94×10^{-11}	6.63×10^{-14}
A2	6.5	3.3	3.11×10^{-11}	9.88×10^{-13}
A3	7.2	4.2	5.58×10^{-12}	2.10×10^{-12}
A4	7.9	4.8	1.11×10^{-11}	3.46×10^{-12}
A5	8.6	5.3	1.61×10^{-11}	6.69×10^{-11}



V.CONCLUSION

- ❖ In this research for M30 grade of concrete it can be calculated that the cement can be replaced up to 10%, 20%, 30% and 40% of zeolite and 5%, 10%, 15%, & 20% fly ash
- ❖ In this present research work, it is concluded that the strength of the concrete by using zeolite up to 40% and 20% fly ash replaced in cement.
- ❖ In compressive strength of concrete 28 days and 60 days increases up to 20% replacement of zeolite and 10% fly ash

❖ zeolite as 28 days and 60 days decreases the strength of concrete up to 40% of zeolite and 20% fly ash replaced in concrete as compared with conventional concrete

❖ Split tensile strength of concrete 28 days strength increases the concrete replacement of zeolite up to 20% replaced as zeolite and 10% fly ash in concrete.

❖ Modulus of rupture for 28 days strength decreases the 30%+ 15% & 40%+20% replace the zeolite and fly ash in cement.

❖ Flexure test of concrete strength 28days increases strength up to 20% of zeolite & 10% fly ash and decreases the strength up to 40% of zeolite and 20% fly ash is replaced.

❖ Modulus of elasticity of concrete according to stress strain curves 28 days of strength increases up to 20% of zeolite & 10% fly ash and decreases the up to 40% of zeolite & 20% fly ash is replaced in concrete compared to normal concrete.

❖ Durability of concrete as rapid chloride permeability test s 28 days and 60 days of concrete.

❖ In rapid chloride permeability test as 28days as increased strength compared to 60days of rapid chloride test.

❖ Rcpt values of 28days and 60 days of values increased up to 20% of zeolite & 10% fly ash and decreases the up to 40% of zeolite & 20% fly ash

❖ Water permeability as 60days strength increased up to 20% of zeolite and 10% fly ash replaced in concrete and decreases the strength 30%+15% and 40%+20% of zeolite & fly ash as replaced in concrete.

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