A RESEARCH ON BEHAVIOR OF HIGH STRENGTH CONCRETE WITH USE OF CALCINED KAOLIN ALONG WITH ZEOLITE POWDER

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ABSTRACT

The rapid increase in construction work coupled with a renewal of interest in wide range of concrete performance has created more challenges in the construction industry. These challenges cannot be met by designing mix proportions based on existing codes and methods of concrete mix design. Several methods and codes are available to serve as guide for mix design of NSC, HPC. It needs of concrete market and the economic and ecological needs, several researchers, all over the world, studied the beneficial effect of different types of SCM which reduce the use of cement and decrease the emission of CO2 and also cost effective.
In this research we use eco-friendly and cost effective material Calcined kaolin and zeolite replace individual and combined as cement replacement material with constant silica fume content by weight of cement and understand the effect of material in high strength concrete of grade M60,M70 and M80 with use of high range water reducers by weight of water. We perform the test of fresh and hard property of concrete then perform durability test and find optimum amount for M60, M70 and M80.

Keyword: *High strength concrete, calcined kaolin,zeolite*

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1 Introduction

The premature deterioration of concrete structures in aggressive environment has led to the development of high performance concrete in many fields such as, runway in airport, railway sleepers, nuclear reactor, prestressed concrete bridges, high-rise buildings, offshore platforms, chimneys, and silos etc. In this regard concrete with low permeability (or) higher impermeability is considered as durable concrete. This in turn improves the resistance of concrete against the penetration of harmful substances such as chloride ions, sulphate ions, carbon dioxide, water and oxygen.
The rapid increase in construction work coupled with a renewal of interest in wide range of concrete performance has created more challenges in the construction industry. Concrete with several properties may be desired such as high workability, medium workability, high strength, lightweight, insulation etc. These challenges cannot be met by designing mix proportions based on existing codes and methods of concrete mix design. Several methods and codes are available to serve as guide for mix design of NSC, HPC and lightweight concrete. However, these are just guide to arrive at first trial mix. Optimum mix proportions are obtained through testing of trial mixes and making adjustment accordingly. This is because these codes were developed based on experience with materials in certain parts of the world and may not be applicable to mix design in other parts of the world. Also, these codes do not address all issues regarding concrete mix design such as admixtures, transportation, and temperature effect

Supplementary Cementitious Materials

High performance concrete can be made, using Portland cement alone as a cementitious material. However, a partial substitution of Portland cement by one or combination of supplementary cementitious materials can be advantageous, not only from an economic point of view but also from a rheological and sometimes strength point of view.

Most supplementary cementitious materials have one feature in common: they contain reactive silica which in the presence of water, can combine with lime at room temperature, to form calcium silicate hydrate of the same type as that formed during the hydration of Portland cement. Basically, a pozzolanic reaction can be written in the following manner. This reaction is generally slow and takes several months for completion at the room temperature. However, the finer pozzolan reaction with lime was faster.

Pozzolan + lime + water = Calcium silicate hydrate

ROLE OF MINERAL ADMIXTURES

The presence of silica fume (SF) in the concrete mix improves workability and makes the mix more mobile, yet cohesive. This is the consequence of a better dispersion of the cementitious particles and due to the surface characteristics of the silica fume particles, which are smooth and absorb little water during mixing. The workability of concrete containing silica fume is more sensitive to variations in the water content of the mix than ordinary mix, as the fineness of silica fume reduces bleeding of concrete. The mix containing silica fume has very low penetrability and good resistance to penetration by chloride ions and thereby reduces freeze and thaw effect

The incorporation of metakaolin improves strength of concrete significantly. The research conducted on metakaolin indicated that the optimum level of replacement lies somewhere between 5% and 10%. Research studies have confirmed the partial replacement of cement by metakaolin contributes to the strength of concrete due to the filler effect, and the acceleration of hydration of cement due to its pozzolanic reaction. Moreover, metakaolin concrete have exhibited strength, slightly greater than silica fume concrete mixes at the same levels of cement replacement by the pozzolans

The influence of zeolite on the properties of fresh concrete depends upon the shape of the zeolite particles. A concrete mix containing zeolite is cohesive and has a reduced bleeding capacity. The action of zeolite is similar to that of superplasticizer with respect to water demand. The zeolite disperses and absorbs the particles of portland cement. Zeolite in the mix has a retarding effect, typically of about 1 hour, caused by the release of sulphur trioxide ions present at the surface of the zeolite particles. Because of this retarding effect, only initial setting is delayed, the time interval between setting and final setting being unaffected. It is proved that the addition of zeolite improves the dispersion of the portland cement particles, improving their reactivity. The reaction took place within the pores of the cement paste and on the surface of zeolite particles. Using zeolite in concrete will increase the setting time compared with an equivalent grade of normal concrete.

2. Material and Specimen details

R. NO.	PROPERTIE NAME	SILICA FUME	KAOLINITE	ZEOLITE
1	Specific gravity	2.9	2.4	2.2
2	Mean grain size(μm)	<1	2.5 to 4.5	2 to 200
3	Specific surface area(m2/kg)	20,000	10000	320
4	Silicon dioxide(SiO2)	92%	59%	70%
5	Aluminum oxide(Al2O3)	1%	43%	14%
6	Iron oxide (Fe2O3)	0.5%	1%	1%
7	Calcium oxide(Cao)	-	0.15%	1.5%
8	Magnesium oxide(Mgo)	1.6%	0.15%	0.15%
9	Sulphite (SO3)	0.05%	-	0.5%
10	Sodium oxide (Na2O)	-	0.01%	1.3%
11	Potassium oxide (K2O)	-	0.10%	10%
12	LOI	1%	1%	1.5%

Materials Detail:

The cement used in all mixture was normal OPC (53grade) conforming to IS:12269.Commercially available calcined kaolin, zeolite and silica fume was used as mineral additive. Their chemical composition is specified in given table (A).Good quality aggregates have been procured for this experiments Crushed granite with nominal grain size of 20 mm and well-graded river sand of maximum size 4.75 mm were used as coarse and fine aggregates, respectively.The coarse aggregates with 20, 10 mm fractions had specific gravities of 2.81 and 2.71, whereas the fine aggregate had specific gravity of 2.70, respectively. Commercially available Gallium SKY 8233 - High-performance super plasticizer based on PCE (polycarboxylic ether) was used in all the concrete mixtures. The market price of MK in the country is about 3–4 times that of cement. Therefore the use of calcined kaoiln proves economical over that of silica fume.

Mixture Proportions:

Trials mixtures were prepared to obtain target strength of M60,M70 and M80 grade of the control mixture at 28 days and the water/binder ratio same for M70 and M80 and it's change for M60.The details of the mixtures for the study are Normal,K5,K10,K15,Z5,Z10,K5Z5,K5Z10,K10Z5,K10Z10,K15Z5,K15Z10 were employed to examine the influence of low water to binder ratio on concretes containing calcined kaolin,zeolite and combination of it on themechanical and durability properties.Trial mixtures were conducted to determine the optimum dosage of SP for each of the mixtures in order to achieve the target slump of 50 to 75 mm.
Silica fume content is replaced in 5% by weight of cement for all mix proportions. For normal mix batch "binder" include cement and silica fume.

Mixing and Casting Details:

The materials were fed into the mixer in the order of coarse aggregate, cement, MK,zeolite and silica fume and sand. The materials were mixed dry for 1.5 min. Subsequently three-quarters of the water was added, followed by the SP and the remaining water while mixing continued for a further 5 min in order to obtain a homogenous mixture. Upon discharging from the mixer, the slump test was conducted on the fresh properties for each mixture. The fresh concrete was placed into the steel cube moulds and compacted on a vibrating table. Finally, surface finishing was done carefully to obtain a uniform smooth surface.

Specimens and Curing:

The following specimens were cast from each mixture

- Three 150 * 150 * 150 mm cubes for the compressive strength for 7days and 28 days curing time.
- 150*150 *700 mm beams castfor 28 days curing then flexural test of concrete conducted by third point loading method.
- Three 150 * 150 * 150 mm cubes for the water penetration test for 28 days curing time.

- 150* 150 * 150 mm cubes casted for rapid chloride penetrability test and samples of 100*52 mm were prepared from these cubes by core cutting in lab.

Mix Design per m3 of concrete

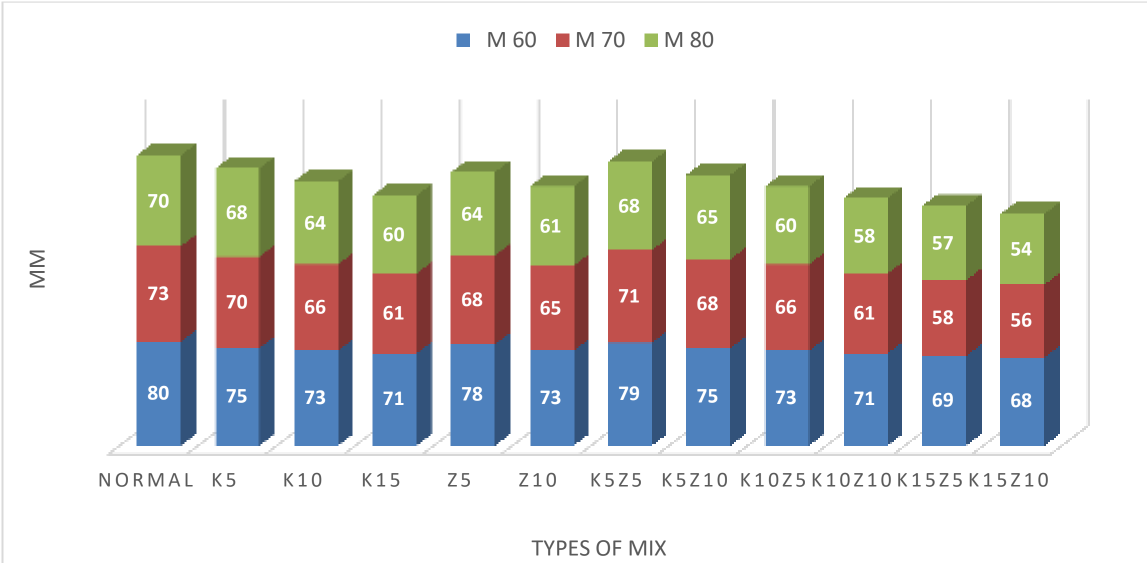
SR NO.	NAME OF INGREDIANT	M 60	M 70	M 80
1	BINDER (cement +silica fume)	441.2 kg	446 kg	510.3 kg
2	WATER	145.6 kg	146.1 kg	153.3 kg
3	FINE AGGREGATE	745 kg	729.3 kg	694.5 kg
4	COARSE AGGREGATE	1218 kg	1192.6 kg	1192.6 kg
5	ADMIXTURE	2.1 kg	2.1 kg	3.06 kg
6	DENSITY	2550 kg	2555 kg	2551 kg
7	W/C RATIO	0.33	0.30	0.33

RESULTS AND DISCUSSIONS

1.) **FRESH PROPERTIES :**

SLUMP TEST RESULTS

Mix Proportion	Slump Value (mm) M-60	Slump Value (mm) M-70	Slump Value (mm) M-80
Normal	80	73	70
K5	75	70	68
K10	73	66	64
K15	71	61	60
Z5	78	68	64
Z10	73	65	61
K5Z5	79	71	68
K5Z10	75	68	65
K10Z5	73	66	60
K10Z10	71	61	58
K15Z5	69	58	57
K15Z10	68	56	54



- **DISCUSSIONS :**

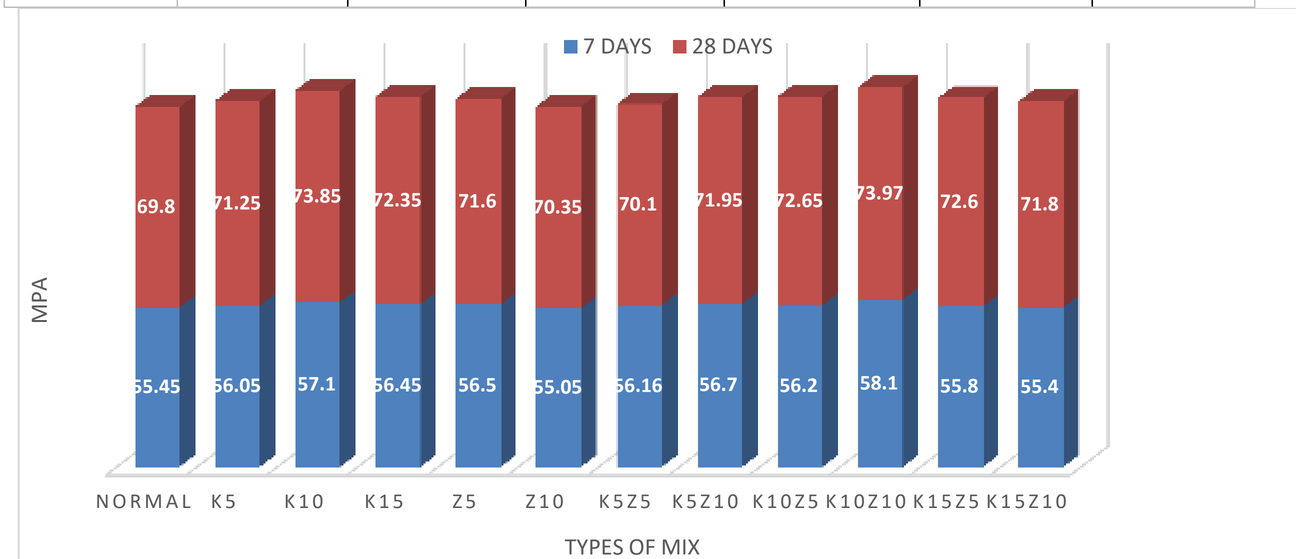
➢ Two different super-plasticizer dosages were added to the different mixtures in order to obtain the workability in terms of target slump.Workability decreased with increase in the replacements of material for all cases because super-plasticizer dosages are fix for each grade of concrete. main causes for cement particles electrostatic attraction between cement and pozzolan particlesbecomes dominant due to the increase in the wettable surface area. Therefore, as the percentage replacement increase super-plasticizer demand also increase but here super-plasticizer demand is constant so the surface of cement grains, particles repulse each other because of the dispersion of agglomerated cement particles and remain separate thus decreased the workability of concrete.

2.) MECHANICAL PROPERTIES :

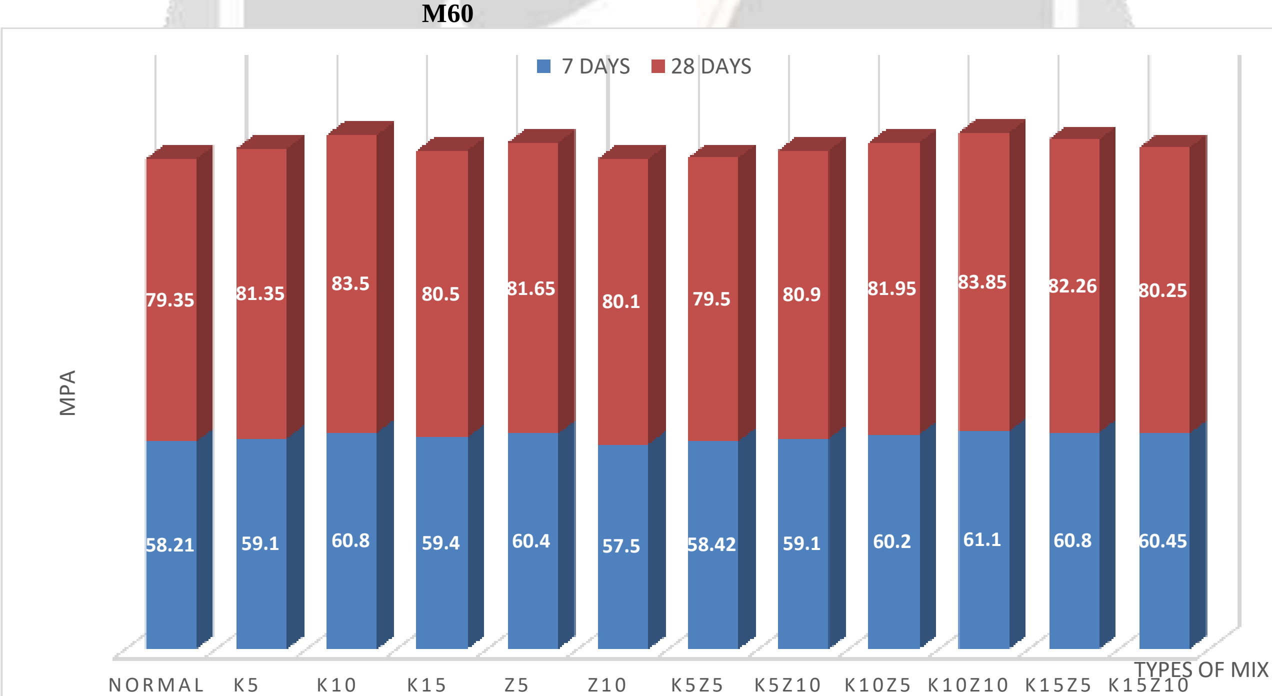
COMPRESSIVE STRENGTH RESULTS (MPa)

Mix Proportion	**M 60**		**M 70**		**M 80**	
CURING	**DAYS**	**DAYS**	**DAYS**	**DAYS**	**DAYS**	**DAYS**
Normal	55.45	69.80	58.21	79.35	55.80	90.10
K5	56.05	71.25	59.10	81.35	56.10	91.95
K10	57.10	73.85	60.80	83.50	56.75	93.85
K15	56.45	72.35	59.40	80.50	57.45	95.25
Z5	56.50	71.60	60.40	81.65	55.25	90.25
Z10	55.05	70.35	57.50	80.10	56.80	92.25
K5Z5	56.16	70.10	58.42	79.50	55.91	92.85

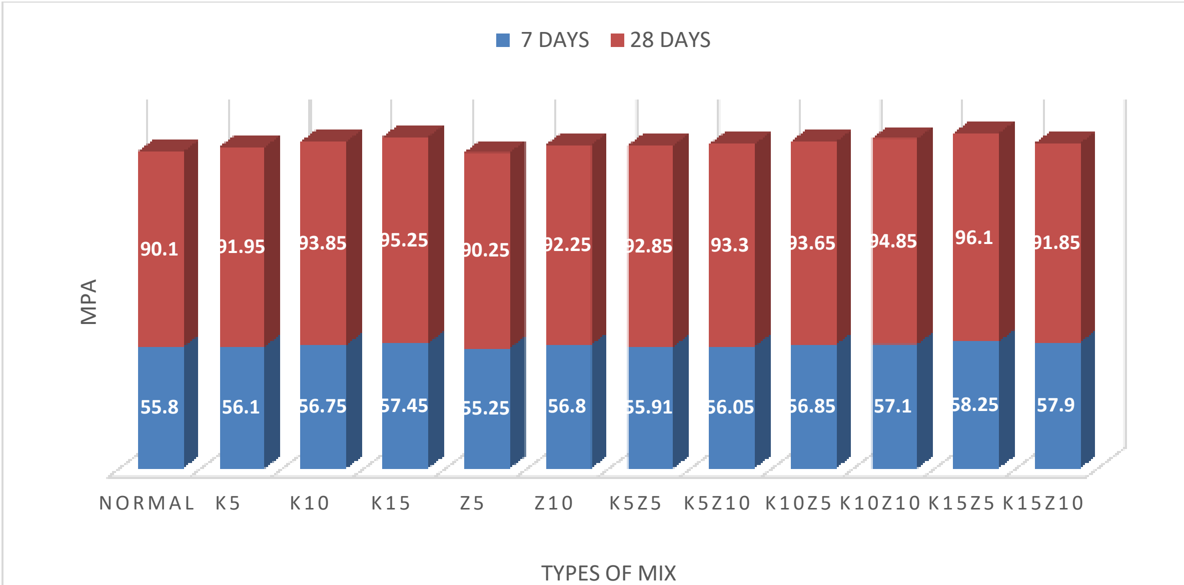
K5Z10	56.70	71.95	59.10	80.90	56.05	93.30
K10Z5	56.20	72.65	60.20	81.95	56.85	93.65
K10Z10	58.10	73.97	61.10	83.85	57.10	94.85
K15Z5	55.80	72.60	60.80	82.26	58.25	95.85
K15Z10	55.40	71.80	60.45	80.25	57.90	91.85



M60



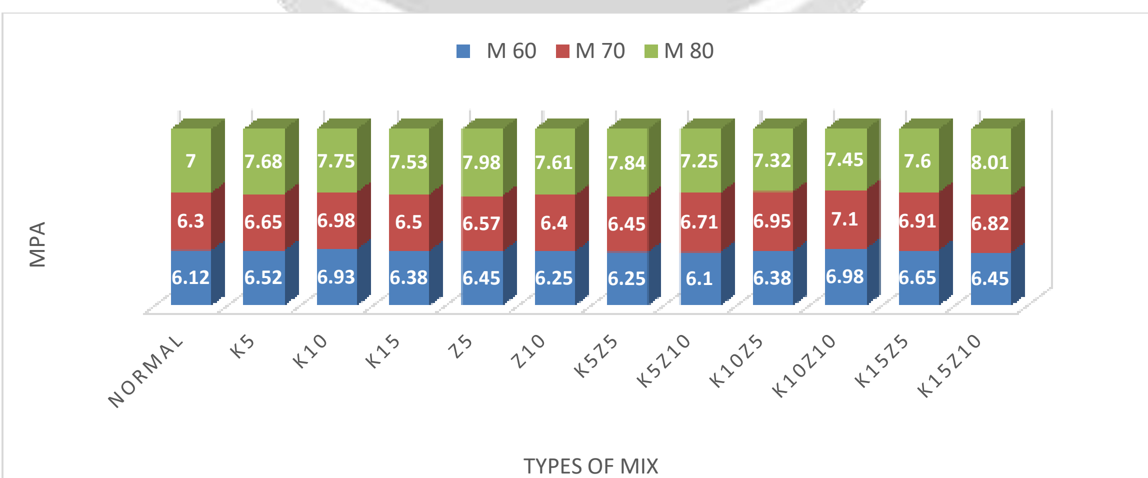
M70



M80

<u>FLEXTURE STRENGTH RESULTS (MPa)</u>

Mix Proportion	Flexture strength M-60	Flexture strength M-70	Flexture strength M-80
Normal	6.12	6.30	7.68
K5	6.52	6.65	7.75
K10	6.93	6.98	7.53
K15	6.38	6.50	7.98
Z5	6.45	6.57	7.61
Z10	6.25	6.40	7.84
K5Z5	6.25	6.45	7.25
K5Z10	6.10	6.71	7.32
K10Z5	6.38	6.95	7.45
K10Z10	6.98	7.10	7.60
K15Z5	6.65	6.91	8.01
K15Z10	6.45	6.82	7.60



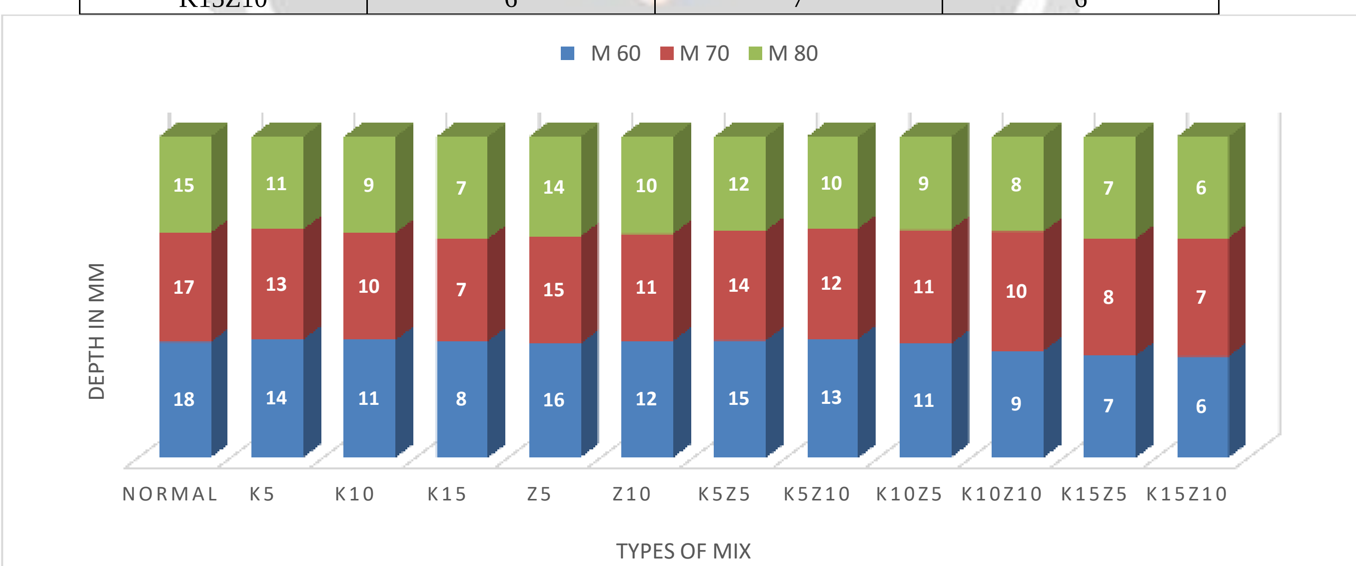
- **DISCUSSIONS:**

It can be seen that the strength was the highest for the combined mixtures of calcined kaolin and zeolite for all grade of concrete.Replacement level is also changed with respect to grade of concrete.It can be seen from results higher the grade of concrete required higher replacement amount minertal additive.The reduction in strength is explained as the result of a clinker dilution effect.The dilution effect is a result of replacing a part of cement by the equivalent quantity of mineral additive.In mineral concrete, the filler effect, pozzolanic reaction of mineral with calcium hydroxide and compounding effect (synergetic effect of mineral admixture) react opposite of the dilution effects.For this very reason, there was an optimum mineral replacement for mineral concrete.With time, the strength differences between the mineral mixtures and OPC concrete becomes smaller.This might be due to the fact that all cementitious materials reactions were close to completion, or had stopped; mainly because the reactions between mineral and OPC mixtures were slowed down with time.Replacement level of mineral is mainly depends of the fineness of material and its pozzolanic properties.

3.)DURABILITY STUDIES:

WATER PENETRATION TEST RESULT

Mix Proportion	M-60 (MM)	M-70 (MM)	M-80 (MM)
Normal	18	17	15
K5	14	13	11
K10	11	10	9
K15	8	7	7
Z5	16	15	14
Z10	12	11	10
K5Z5	15	14	12
K5Z10	13	12	10
K10Z5	11	11	9
K10Z10	9	10	8
K15Z5	7	8	7
K15Z10	6	7	6



- **DISCUSSIONS:**

- Results indicating that the penetration depth is decreasing with increasing percentage replacement of mineral .This is because the pore sizes decreased with time either by refining the voids and/or by segmenting the interconnected voids with hydration products or mineral particles. it was observed that maximum amount of replacement level exhibited the lowest depth of penetration could be due to the fact that the pores were filled by hydration products, which would result in pore refinement leading to improved performance of the concrete..

- **CONCLUSIONS**

- Using local kaolin and cement for low w/c ratio high strength concrete can be developed.
- Optimum replacement of kaolin with respect to compressive strength is 10% for M60 and M70 while it increase for M80 for 15% due to increase binder content and dilution effect of partial replacement.
- Increase the Calcined kaolin content reduced water penetration depth which is parameter of durability due to filler effect of calcined kaolin which reduced the porosity of the concrete.
- 5% of zeolite is optimum with respect to compressive strength for M60 and M70 grade, which is increase 10% for M80 grade which followed same behavior as calcined kaolin.
- Combined use of kaolin and zeolite is give beneficial effect on compressive strength then individual use.
- Durability increase with increase the mineral content which is due to micro filler effect of cementing material.

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