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A QUALIFIED STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN ADMIXTURE

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ABSTRACT

In the gift investigation a shot is formed to search out varied compressive strengths supported the experimental results, mathematical models were elaborate to predict the strength of mortar cubes V-J Day replacement of cement by varied differing kinds of mineral admixture. The strength of cubes with differing kinds of cement (OPC) an 3,7 and 28 with the time of natural action and therefore the kind of cement on the compressive strength and ultra-pulse velocity changes. The take a look at results of designated properties of binders and hardened mortar cube with admixture also are enclosed. The analysis showed that mortar cube with admixture is characterised by advantageous applicable qualities. The investigation discovered that use of waste material like Metakoalin that area unit otherwise risky to the atmosphere could also be used as a partial replacement of cement, that results in economy and additionally by utilizing the commercial wastes within the helpful manner the atmosphere pollution conjointly reduced to nice extent.

Keywords: Metakaolin, Compressive Strength, Ultra Pulse Velocity, Initial and Final Setting Times, Consistency, Water Immersed Curing, Application of Heat, Memberane Curing,etc.,

I. INTRODUCTION

The best challenge before the event trade is to serve the two pressing desires of human society specifically the protection of the surroundings and meeting the infrastructure demand of our growing population and consequentially desires of manufacture and urbanization within the past. The concrete trade has met these desires fine. but for a range of reasons, the case has been changed now. The cement and concrete industries due to their large size are unquestionably feasible scope for economic and safe disposal of millions of tonnes of industrial by products such as fly ash, micro silica, Meta Kaolin. Due to their properties, by- products can be used in certain amount such as cement replacement material than in the practice today. In fact, these mixes replaced by 15% of by-products have shown high strength and durability at relatively early ages. This development has removed one of the strong objections to the use of high volume of by products in mortar cubes. Therefore, it should be obvious that certain scale cement replacement with industrial by products is highly advantageous from the stand point of price, economy, energy potency, sturdiness and overall ecological and environmental benefits.The advantageous in concrete technology method of construction and type of construction have paved the thanks to build the simplest use of regionally accessible materials by considered

combine proportioning and proper workmanship so as to result in a construction industry satisfying the performance requirements. High performance does not necessarily require high strength. it is proportioning of mixes, which has low permeability, as possible for particular use that determines the long-term high strength performance behavior of a structure.

1.1. Admixtures

According to the reference No.3 Admixtures are additionally provides steering on the circumstances once it should be necessary to specify an admixture to a concrete producer. Some admixtures have been in use for a awfully long term, like salt to supply a cold-weather setting concrete. Others are more modern and signify an area of expanding potential for increased performance. Not all admixtures area unit economical to use on a selected project. Also, a few characteristics of concrete, such as low amalgamation can be achieved simply by constantly adhering to high quality concrete in practice. Admixtures are now widely accepted as materials that contribute to the production of durable and cost-effective concrete structures. The contributions include improving the handling properties of fresh concrete making placing and compaction easier, reducing the permeability of hardened concrete, and providing freeze or thaw resistance.

Admixtures vary widely in chemical composition, and many perform more than one function. Two basic types of admixtures are available:

1. Mineral admixtures.
2. Chemical admixtures.

1.1.1. Mineral Admixtures: Mineral admixtures (fly ash, compound fume [SF], and Metakaolin) or typically extra to concrete in larger amounts to reinforce the workability of contemporary concrete; to enhance resistance of concrete to thermal cracking, alkali-aggregate enlargement, and salt attack; and to change a discount in cement content.

- ash
- silicon oxide Fume
- Meta kaoline

1.1.2. Chemical Admixtures: Chemical admixtures square measure extra to concrete in terribly tiny amounts chiefly for the entrainment of air, reduction of water or cement content, plasticization of latest concrete mixtures, or management of setting time. Seven varieties of chemical admixtures square measure laid out in ASTM C 494, and AASHTO M 194 [06], looking on their purpose or functions in PCC. Air entraining admixtures square measure laid out in ASTM C 260 and AASHTO M 154[05]. General and physical needs for every style of admixture square measure enclosed within the specifications.

- Air-Entrainment agents.
- Water-Reducers.
- Set-Retarders.
- Accelerators.
- Super plasticizers.

1.2. Functions: In ACI 212-3R [01], the explanations for the utilization of admixtures square measure printed by the subsequent functions that they perform:

- Increase workability while not increasing or decrease the water content at an equivalent workability.
- Retard or accelerate time of initial setting.
- Reduce or stop shrinkage or produce slight enlargement
- Modify the speed or capability for hurt
- Reduce segregation
- Improve pump ability
- Reduce rate of slump loss
- Retard or scale back heat evolution throughout early hardening
- Accelerate the speed of strength development at early ages
- Increase strength (compressive, tensile, or flexural)
- Increase sturdiness or resistance to severe conditions of exposure, as well as application of deicing salts.
- Decrease porousness of concrete
- Control enlargement caused by the reaction of alkalis with doubtless reactive mixture constituents
- Increase bond of concrete to steel reinforcement
- Increase bond between existing and new concrete

- Improve impact and abrasion resistance
- Inhibit corrosion of embedded metal and turn out colored concrete or mortar

The construction industry is now slowly becoming aware of the environmental issues and other sustainable development issues for cement and concrete industries. It is looking for the ways and means to develop building products, which will increase the life span and quality. it is in this regard that merit of using MetaKaolin have been well recognized by the construction industry. Addition of these material was found to have enhanced the basic properties including strength and durability both in fresh and hardened state. There have been subtle changes in the way aggregates are used. Proportioning between different sizes is now much more flexible is designed for specific purpose in response to intended specific performance criteria. There has also been development in the optimum use of locally available materials with the consideration of economy.

II. MATERIALS FOR TESTING

Within the gift chapter, the physico-chemical properties of cement, sand and water employed in the investigation were analyzed supported and additionally the quality procedure arranged down among the commonplace codes, like IS, ASTM and SB codes. These commonplace experimental procedures were adopted for the determination of traditional consistency, initial and final setting times, and soundness of cement and compressive strength of cement mortar cubes. In establishing these necessities, careful thought of properties of domestically obtainable materials needs to be accounted for.

2.1. Materials: The materials employed in the experimental investigation include:

1. standard Portland cement (OPC)
2. MetaKaolin
3. Fine Aggregate
4. Water

The properties of those materials square measure given within the following sub-sections

2.1.1. Cement: There square measure many varieties of cement within the market to suit each want. Out of them some square measure enclosed within the initial experiments like initial setting time, final setting time, compressive strength and soundness take a look at on mortar cubes were conducted on varied grades of cement.

2.1.1.1. Ordinary Portland cement (OPC)

Even supposing solely standard:Portland cement is hierarchal consistent with strength, the opposite cements too need to gain a selected strength. 33, forty three and fifty three grade in OPC indicates the compressive strength of cement once twenty eight days once tested as per IS: 4031-1988[25], eg, thirty three Grade implies that twenty eight days of compressive strength isn't but thirty three N/mm2 (MPa) . equally for forty three grade and fifty three grade the twenty eight days compressive strength mustn't be but forty three and fifty three MPa severally. forty three and fifty three grade also are being introduced in PPC and PSC shortly by the Bureau of Indian Standards (BIS). The compressive strength of cement once tested as per IS code shall be minimum forty three MPa. Cement employed in this investigation is forty three Grade. The physical and chemical properties of this cement square measure given within the table no.2.1 below.

Table 2.1: The Physical and Chemical properties of OPC

PHYSICAL CHARACTERISTICS OF 43 GRADE OPC									
IS CODE	Fineness (Sq,m/Kg) Min	Soundness by		Setting Time		Compressive Strength in MPa			
		Lechatlier	Auto clave	Initial	Final	3Day	7Day	28 Day	90 Day
		(mm)	Max (%)	(min)	(min)	MPa	MPa	MPa	MPa
(IS 8112-1989)	225	0.92	0.8	105	200	23	33.5	43.5	44.1

CHEMICAL CHARACTERISTICS OF 43 GRADE OPC						
IS CODE	Lime Saturation Factor	Alumina Ratio	Insoluble Residue (%)	MgO	Sulphuric anhydride	Loss on Ignation (%)
		Min.	Max	(%)		
(IS 12269-1987)	0.8 Min 1.02 Max	0.66	3	6	2.5% Max when C3A is 5 or less 3% Max when C3A is greater than 5	5

2.1.2. MetaKaolin

Metakaolin may be a pozzolan, in all probability the foremost effective pozzolanic material to be used in concrete. it's a product that's factory-made to be used instead of a by-product and is created once kaoline, the mineral terra alba, is heated to a temperature between 600 and 800ºC. Its quality is controlled throughout manufacture, leading to a far less variable material than industrial pozzolansthat ar by-products. 1st employed in the Sixties for the development of variety of enormous dams in Brazil, metakaolin was with success incorporated into the concrete with the first intention of suppressing any injury thanks to alkali-silica reaction.When accustomed replace cement at levels of five to 100% by weight, the concrete made is usually a lot of cohesive and fewer probably to bleed. As a result pumping and finishing processes need less effort. The compressive strength of hardened concrete is additionally increased at this level of replacement.Slightly higher replacement levels (up to 20%) turn out a cement matrix that has low porousness and porosity. This ends up in enhancements to resistance of the hardened concrete to attack by sulfates, chloride ions and alternative aggressive substances, like mineral and organic acids. Freeze/ thaw resistance is improved and also the risk of injury ensuing from the results of impact or abrasion is reduced for metakaolin concrete that has been finished and cured properly. The physical and chemical properties of this cement are given in the table no.2.2 below.

Table 2.2: The Physical and Chemical properties of Meta Kaolin

S. No.	Physical Characteristics	Properties of Meta Kaolin
1	Specific gravity	2.49
2	Fineness m^2/kg	450
3	Nitrogen Absorption, m^2/gm	16.7
4	Bulk density Kg/m^3	890
5	Colour	white

S. No.	Compound	Properties of Meta Kaolin
1	Silicon dioxide, SiO_2	60-65
2	Aluminum oxide, Al_2O_3	30-34
3	Ferric oxide, Fe_2O_3	1.00
4	Calcium oxide, CaO	0.2-0.8
5	Magnesium oxide (MgO)	0.2-0.8
6	Sodium oxide (Na_2O)& Potassium oxide (K_2O)	0.5-1.2
7	Loss on ignition	<1.4

2.1.3.Sand: The sand used throughout the experimental work was obtained from the watercourse avatar close to Amaravathi, Guntur district, province. this sort of sand was employed by the various of researchers as AN ingredient in cement mortar. in line with IS 650:1966[24], the sand employed in cement mortar ought to adjust to the subsequent specifications.

- Sand shall be of quartz, lightweight grey or whitish selection.
- It shall be free from silt.
- The grains shall be angular. the {form} of grains shall approximate to spherical form, enlarged and planar grains shall be gift solely in negligible quantities.
- Grading:
  - Passing through a pair of millimeter IS Sieve 100%

- maintained on ninety µ IS Sieve100 the troubles
- Particle size larger than one mm33.33 %
- Particle size smaller than one millimeter And larger than five hundred µ33.33 %
- Particle size smaller than five hundred µ thirty three.33 %

- Sand shall be free from organic impurities. Loss of weight on interaction with acid shall not exceed zero.25 %.

The precise particle size composition of the sand was ready as per the IS 650:1966[24] and IS 383:1970 [21]. Sand was completely washed with water to get rid of impurities like decayed matter, humus, organic matter and harmful materials like clay, fine silt and fine mud and was household appliance dried for 24 hours and cooled to temperature. This sand was used for the experimental work. injurious substances area unit seemingly to interfere with the method of association, forestall the effective bond between the fine mixture and matrix (Hooton, 1993 [18]). These impurities most likely cut back the strength and sturdiness of the cement mortar. The organic matter can interfere with the setting action of cement and conjointly interfere with the bond characteristics with the fine aggregates. The presence of organic matter also will lead to entrainment of air voids within the mortar and reduces its strength. At an equivalent time excessive silt or clay contained within the fine or course mixture could lead to accrued shrinkage or accrued permeableness additionally to poor bond characteristics (Komar, 1987[33] and Duggal, 1997[12]).

The properties of sand were analysed in accordance with the procedures arranged down in IS 2386 (Part I and half II): 1963 and were conferred in Table 2.3

Table 2.3:The Properties of Sand

Sl. No.	Properties	Unit	Results
1	Specific gravity	-	2.62
2	Bulk density	kN/m^3	15.49
3	Fineness modulus before sieving	-	2.68
4	Particle size variation	mm	0.15 to 2.0

2.1.4. Water: The characteristics of water, to which various chemical and biological substances were spiked, are presented in the Table 2.4 and the characteristics of water were analyzed according to the standard methods for the examination of water.

Table 2.4: Characteristics of water (All values in mg/L except pH)

Sl. No.	Parameter	Units	Concentration
1	pH	-	6.75
2	Total dissolved soilds	mg/l	400
3	Alkalinity	mg/l	125
4	Acidity	mg/l	12.5
5	Hardness	mg/l	140
6	Sulphates	mg/l	25
7	Chlorides	mg/l	70

III. EXPERIMENTAL PROGRAMME

3.1. Take a look at Programme: The main points of the mineral and chemical admixtures employed in the experimental work ar given in Table four.3.1 & 4.3.2 .a complete of sixty samples of normal mould employed in Vicat's equipment were forged and tested for initial and final setting times experiments. identical variety of samples of normal mould was employed in Le-chatelier's instrumentality to check for soundness. a complete of 60 mortar cubes of fifty sq-cm cross-sectional space were tested at completely different ages (3, 7, twenty eight days) for compressive strength and Ulatra Pulse Speed.

Table 3.1: Details of Test Programme

Sl. No.	Constituent	No. of specimens for setting times test	Total
1	OPC	3	3
2	OPC + 15% Meta Kaolin	3	3

Table 3.1.2: Details of Test Programme

Sl. No.	Constituent	No. of specimens for compression test	No. of Specimens for UPV Test	Total
1	OPC	3 ×3 × 3	3	30
4	OPC + 15% Meta Kaolin	3 ×3 × 3	3	30

Note: SP = Super plasticizer, OPC = Ordinary Portland Cement , Rep. = Replacement

3.2. Process

Traditional consistency, initial and final setting times are determined by Vicat's equipment, that live the resistance of cement paste of ordinary consistency to the penetration of the needle below total load of 300gms.


Vicat's equipment confirming to IS 5513-1976 [27] consists of a frame to that a movable rod having AN indicator is connected which supplies the depth of penetration. The rod weights 300gms and has diameter and length of 10mm and 50mm severally. Vicat's mould is within the kind of a cylinder and it will be split into 2 halves. Vicat's equipment includes 3 attachments – plunger for crucial traditional consistency, sq. needle for initial setting time, and needle with circular collar for final setting time. elaborated experimental procedures adopted within the investigation ar given within the following sub-sections.

3.2.1. Consistency

Traditional consistency is that the initial parameter of cement for crucial different properties of cement. the traditional consistency of a cement paste is outlined as that consistency which can allow a Vicat plunger having 10mm diameter and 50mm length to penetrate to a depth of 33-35mm from high of the mould. the method is employed to search out out the proportion of water needed to provide a paste of ordinary consistency. concerning 400g of cement with ab initio mixed with twenty eight share of blending water. The paste ready within the normal manner and stuffed into the Vicat mould among three to five minutes. The surface of the mould was ironed, levelled and shaked to expel the air. a customary plunger, 10mm diameter, 50mm long, is connected and down gently to the touch the surface of the paste within the take a look at block and quickly discharged to sink into the paste by its own weight. The reading is noted by taking the depth of penetration of the plunger. The experiment was performed fastidiously removed from vibrations and different disturbances. The take a look at procedure was perennial by increasing the proportion of blending water at a hundred and twenty fifth increment till the reading was five to 7mm from the lowest of the mould. once the condition is consummated, the quantity of water further was taken because the share of water for traditional consistency. the complete take a look at was completed among three {to fiveto five} minutes and if the time taken exceeds 5 minutes, the sample should be rejected and contemporary sample should be taken.

3.2.2. Initial and Final Setting Time

Initial setting time is regarded at time march on between the instant that the water is further to the cement, to the time that the paste starts losing its malleability. Final setting time is that the time march on between the instant the water is further to the cement, and also the time once the paste has fully lost its malleability and has earned spare firmness to resist bound definite pressure. concerning 300gms of cement was taken and mixed with zero.85 times of applicable mixture water needed to provide cement paste of ordinary consistency. The stopo watch was started at the moment the blending water was further to the cement. The paste was stuffed into the Vicat mould within the specific manner among three to five minutes. The take a look at was conducted at a space temperature of twenty seven □ 20C at a ratio of hour. The mould was placed within the Vicat's equipment and also the needle (1mm square) was gently down to form contact with the take a look at block and was then quickly discharged. ab initio the needle can fully elicited into the take a look at block. however once the paste starts losing its malleability, the needle penetrates solely to a depth of 5mm from bottom. The stopo watch was then stopped and also the time march on is noted because the initial setting time. The needle was replaced by

another needle with circular collar. The cement are thought of as finally set once, upon lowering the attachment gently, the middle needle makes a control, whereas the innovative of the attachment fails to try to therefore now is noted because the final setting time.

3.2.3. Compressive Strength

The compressive strength of hardened cement is that the most vital of all the properties. Moulds for the cube specimens of 50cm2 face space square measure taken. The mould shall be sufficiently thick to forestall spreading and distortion. The moulds square measure bolt created in such a way as facilitate the removal of the moulded specimen while not harm. The moulds once assembled ought to adjust to the subsequent specifications.

The interior dimensions of the mould shall be seventy.6 mm (3-D). The angle between the adjacent interior faces, prime and bottom planes of the mould shall be 900. The inside faces of the moulds shall be plane. The peak of the mould and therefore the distance between opposite faces shall be seventy.6mm. The angle between the adjacent interior faces and prime and bottom planes of the mould shall be 900. The inside faces of the mould shall be plane surfaces with a permissible variation of zero.15mm. The bottom plate is of such dimensions on support the mould throughout filling while not outflow. Whereas collecting the mould, the joints between the halves of the mould were lined with a skinny film of jelly and the same coating of jelly shall be applied between the contact surface of very cheap of the mould and its base plate so as to confirm that no water escapes throughout vibration. The inside faces of the mould were treated with a skinny coating of mould oil. The assembled mould has got to place on the table.

A mix of cement and sand within the proportion 1:3 by weight was mixed dry. Admixture was applied employing a mechanical mixer reminiscent of IS specifications IS 4031 (Part 6) 1968[25]. The constituents were initial poured into the mixer and mixed in dry condition until uniform color was obtained. Then spiked water of the calculated quantity was value-added to that and admixture was continued until homogenized a standardized an identicalthe samea regularan even} and homogenous paste was obtained. The quantities of cement, customary sand and admixture water for every cube square measure 200gms, 600gms and (P/4 + three.0) % of combined weight of cement and sand severally. Wherever P is that the proportion of water needed to supply a paste of ordinary consistency. Instantly when admixture the mortar, it absolutely was placed within the cube moulds and damped with the rod. The mortar was damped twenty times in concerning eight seconds to confirm elimination of honey combs. The mould was then placed on the vibration table. The amount of vibration was maintained for 2 minutes at the required speed of 12000 ±400 vibrations per minute (Kaushik et.al 1998). At the endthe primethe tipof vibration the mould beside the bottom plate was aloof from the machine and therefore the top surface of the cube was finished sleek with a trowel. The compacted cubes within the moulds were maintained at controlled temperature of twenty seven ± 2^0C and at ninetieth ratio for twenty-four hours by keeping the moulds beneath wet sacking baggage. When twenty four hours, the cubes were aloof from the moulds then immersed within the corresponding admixture water till taken out for testing.

The cubes were tested for compressive strength, each time, within the forty weight unit universal testing machine at 3-day, 7-day, 14-day, 28-day, and 90-day. These periods square measure from date of casting of cubes. The cubes square measure tested on their sides with none packing between the cube and steel plates of testing machine. One among the platens is carried on a base and is self-adjusting and therefore the load was steady and uniformly applied, ranging from zero at the speed of 350 kg/cm2/min

3.2.4. Ultra Pulse Speed: This check is completed to assess the quality of concrete by supersonic pulse speed methodology as per IS: 13311 (Part 1) – 1992. The underlying principle of this check is –The method consists of activity the time of travel of associate supersonic pulse passing through the concrete being tested. Comparatively higher speed

is obtained once concrete quality is good in terms of density, uniformity, homogeneity etc.

Procedure to figure out strength of hardened concrete by supersonic Pulse speed:

i) getting ready for use: Before shift on the 'V' meter, the transducers got to be connected to the sockets marked "TRAN" and " REC".

The 'V' meter may even be operated with either:

- the inner battery,
- associate external battery or
- The A.C line.

ii) Set reference: A reference bar is provided to look at the instrument zero. Thecenter beat time for the bar is carven on that. Apply a smear of grease to the device faces before inserting it on the opposite ends of the bar. alter the 'SET REF' management until the reference bar transit time is obtained on the instrument read-out.

iii) vary selection: for liquid ecstasy accuracy, it's recommended that the zero.1 unit of time vary be chosen for path length upto 400mm.

iv) Pulse velocity: Having determined the foremost acceptable take a glance at points on the material to be tested, produce careful live of the path length 'L'. Apply couplant to the surfaces of the transducers and press it backbreaking onto the surface of the material. Do not move the transducers whereas a reading is being taken, as this could generate noise signals and errors in measurements. Continue holding the transducers onto the surface of the material until an equivalent reading appears on the show, that's that the time in unit of time for the breathed pulse to travel the area 'L'. the common of the show readings got to be taken once the units digit hunts between a pair of values.

Pulse velocity=(Path length/Travel time)

v) Separation of device leads: it's considered to forestall the two device leads from returning into shut contact with each other once the transit time measurements unit of measurement being taken. If this will be not done, the receiver lead might pick-up unwanted signals from the transmitter lead Associate in Nursingd this would possibly cause AN incorrect show of the transit time.

IV-TEST RESULTS AND DISCUSSIONS

4.1. General: The results of the current investigation ar bestowed each in tabular and graphical forms. so as to facilitate the analysis, interpretation of the results is distributed at every section of the experimental work. This interpretation of the results obtained is predicated on the present information on the market within the literature further as on the character of result obtained. the importance of the result's assessed with relation to the standards such that by the relevant I S codes.

- The averages of each the initial and final setting times of 3 cement samples ready with admixture water containing typical chemical or biological element of varied concentrations into account ar compared with those of the cement specimens ready with deionised water. If the distinction is a smaller amount than half-hour, the modification is taken into account to be negligible or insignificant and if it's quite half-hour, the modification is taken into account to be vital.
- The average compressive strength of a minimum of 3 cubes ready with water into account is compared thereupon of 3 similar cubes ready with deionised water. If the distinction within the strength is a smaller amount than 100%, it's thought of to be insignificant and if it's bigger than 100%, it's thought of to be vital.
- The average soundness check results of 3 samples ready with admixture water take into accentuation into account into consideration} ar quite ten metric linear unit supported the results of Le-Chatelier's check than the sampler is consider as condition.
- Test results of initial and final setting times, soundness and proportion modification in compressive strengths and sturdiness tests relating to compressive strength of various varieties of cement mortar cubes with

replacement of mineral and chemical admixtures ar according within the Tables five.1 to 5.6.

- Though all the samples created with of cement (i.e.OPC) by replacement of chemical and mineral admixtures either accelerate or retard considerably the setting method. the boundaries for significance criteria in setting times of all these samples below thought ar inside the vary of standards per IS 8112:1989[29]. The IS code specifies initial setting time mustn't be but thirty minutes and final setting time mustn't be quite 600 minutes.

Soundness check results of the samples created with differing kinds of cements ar bestowed within the Tables five.5. The IS 269:1976[20] code specifies the limit for soundness as per the Le-Chatelier's check result mustn't be quite ten metric linear unit for normal Portland Cements. The Le-Chatelier's check results of soundness of various varieties of cements vary proportionately with the concentration of the cement. However this increase in variation is incredibly meager and fewer than the many worth, i.e., ten metric linear unit and thence, there's no considerable modification within the volume of the samples. Compressive strength and percent change in compressive strength of cement mortar cubes at different ages made with 15% replacement of Metakaolin as a admixtures in Ordinary Portland Cement

Table 4.1: Water Immersed Curing.

Sl. No.	Cement + Admixture	Compressive strength in MPa			% Change in compressive strength		
		3Days	7Days	28Days	3Days	7Days	28Days
1	OPC	25.23	36.73	52.16	0	0	0
2	OPC + 15% Meta Kaolin	27.38	40.3	57.48	8.51	9.73	10.2

Table 4.2: Application of Heat -31/2 hrs @100^{0}C.

Sl. No.	Cement + Admixture	Compressive strength in MPa	% Change in compressive strength
		Upto 31/2 hrs curing @100^0 C	
1	OPC	43.29	0
2	OPC + 15% Meta Kaolin	47.58	9.91

Table 4.3: Membarane Curing.

Sl. No.	Cement + Admixture	Compressive strength in MPa			% Change in compressive strength		
		3Days	7Days	28Days	3Days	7Days	28Days
1	OPC	23.7	34.51	46.94	0	0	0
2	OPC + 15% Meta Kaolin	25.56	37.59	52.15	7.79	8.92	11.1

Table 4.4: Ultra Pulse Velocity (UPV)

Sl. No.	Cement + Admixture	Ultra Pulse Velocity(m /sec)	Quality of Mix
1	OPC	3880	Good
2	OPC + 15% Meta Kaolin	3990	Good

Table 4.5: Initial and final setting times of cement at different ages made with 15% replacement Metakaolin as a admixtures with and without super plasticizer in Ordinary Portland Cement.

Sl. No.	Cement + Admixture	Initial setting time (min)	Final setting time (min)
1	OPC	105	200
2	OPC + 15% Meta Kaolin	85	175

Note: SP = Super plasticizer, OPC = Ordinary Portland Cement

Meta Kaolin as mineral admixture are used in the present work.

4.2. Effect of different admixtures on Ordinary Portland Cement

The effects of different admixtures with super plasticizers on the Ordinary Portland Cement are presented in the Tables 4.1 to 4.5. and the graphical representation is illustrated in the following Figures 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5 & 4.1.6.

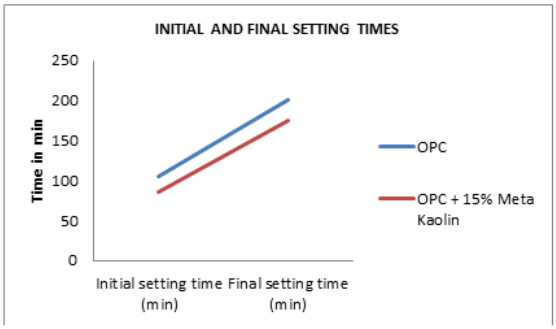

Fig.4.1.1: Variation of initial and final setting times in the Ordinary Portland Cementwith replacement of Metakaolin admixture

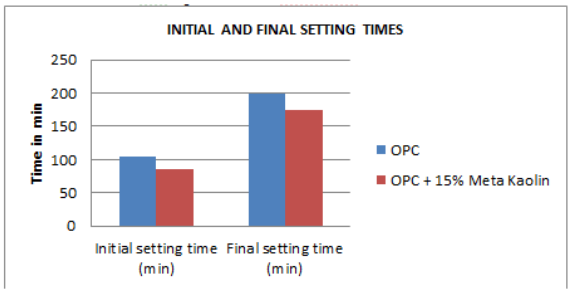

Fig.4.1.1a: Variation of initial and final setting times in the Ordinary Portland Cementwith replacement of Metakaolin admixture

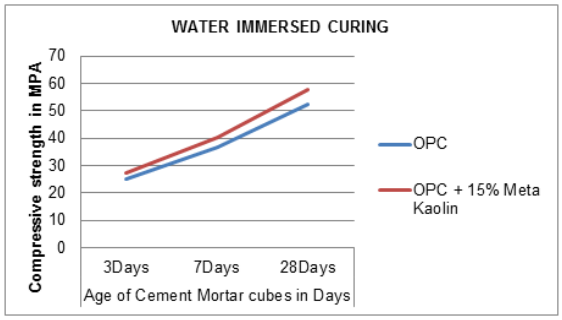

Fig. 4.1.2: Variation of compressive strength of the Ordinary Portland Cement replaced with Metakaolin admixture under WATER IMMERSED CURING.

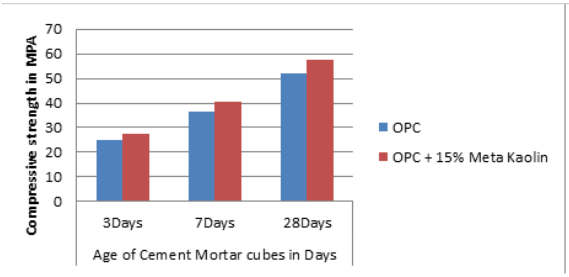

Fig. 4.1.2a: Variation of compressive strength of the Ordinary Portland Cement replaced with Metakaolin admixture under WATER IMMERSED CURING.

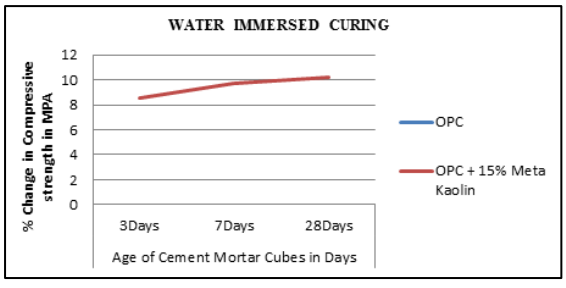

Fig. 4.1.3: Percent Variation of compressive strength of the Ordinary Portland Cement replacedWith Metakaolin admixture under WATER IMMERSED CURING.

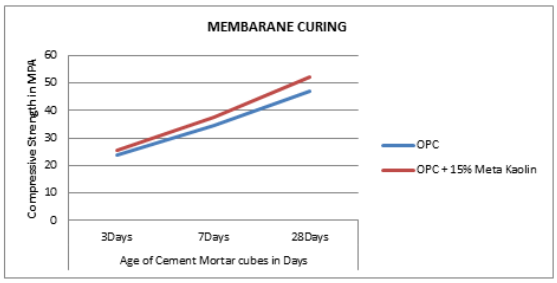

Fig. 4.1.4: Variation of compressive strength of the Ordinary Portland Cement replaced
With Metakaolin admixture under MEMBARANE CURING.

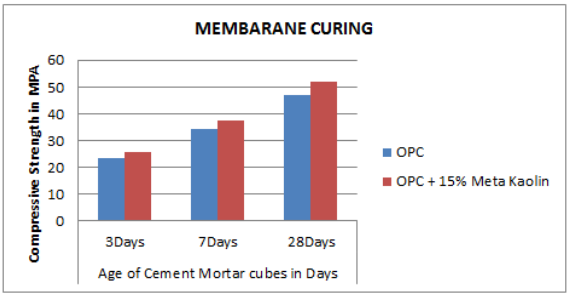

Fig. 4.1.4a: Variation of compressive strength of the Ordinary Portland Cement replaced
With Metakaolin admixture under MEMBARANE CURING

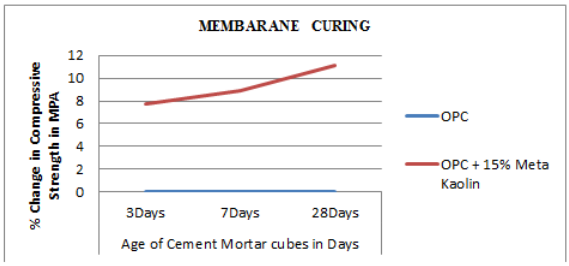

Fig. 4.1.5: Percent Variation of compressive strength of the Ordinary Portland Cement replaced
With Metakaolin admixture under MEMBARANE CURING.

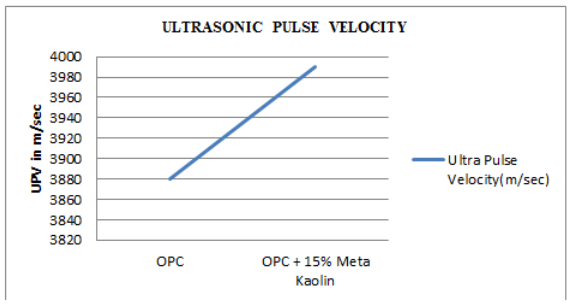

Fig. 4.1.6: Variation of Ultra Pulse Velocity (UPV) of the Ordinary Portland Cement replaced with Metakaolin admixture.

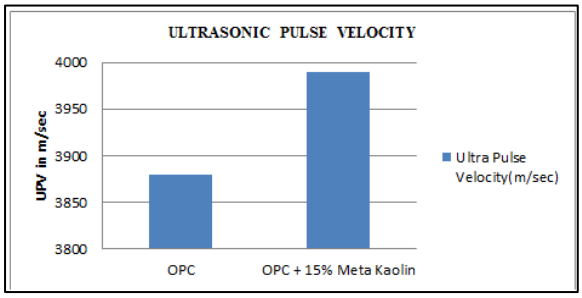

Fig. 4.1.6: Variation of Ultra Pulse Velocity (UPV) of the Ordinary Portland Cement replacedWith Metakaolin admixture.

4.1.2. Effect of 15% Metakaolin

- At the Metakaolin replacement (15%), the variations of initial and final setting times are 20 and 25 minutes when compared to Ordinary Portland Cement. The change in initial and final setting times is observed to be significant.
- The effect of 15% Metakaolin replaced in the Ordinary Portland Cement on the compressive strengths under Water immersed curing, Membrane curing, Application of Heat and its percent changes at various ages is presented in Tables 4.1, 4.2 & 4.3 and depicted in Figs. 4.1.2, 4.1.3, 4.1.4 & 4.1.5. The percentage change in compressive strength for the 3-day, 7-day and 28-day is significant is observed.
- The effect of 15% Metakaolin replaced in the Ordinary Portland Cement on the Ultra Pulse Velocity(UPV) in m/sec and its percent changes is presented in Tables 4.4 and depicted in Figs. 4.1.6. The Quality of Mix is GOOD is observed.

V. CONCLUSIONS AND SCOPE FOR FURTHER STUDY

5.1. Conclusions : Based on the results obtained in the present investigation in Chapter 5, the following conclusions can be drawn.

- OPC with 15% replacement of mineral admixture like Metakaolin Accelerate initial setting time significantly.
- OPC with 15% replacement of mineral admixture like Metakaolin Accelerate Final Setting Time significantly.
- OPC with 15% replacement of mineral admixture like Metakaolin the percentage change in compressive strength is increased 3day, 7day and 28day significantly.
- OPC with 15% replacement of mineral admixture like Metakaolin the change in Pulse Velocity(UPV) in m/sec is insignificant is observed and the Quality of mix will be GOOD Property.

5.2. Scope for Further Study: The following aspects can be taken up for further investigation.

- Similar studies can be carried out on admixture cement concrete to analyze the effect of various chemical and mineral admixtures on the compressive strength with a special attention on the durability of concrete beyond 2-years.
- The effect of other similar substances present in water, which are not covered in this research, on the setting properties of cement and strength of cement mortar can be investigated.
- The effect of substances located at various places containing unique compounds can be studied to develop standards and limitations on the use of such admixtures in cement construction.
- Similar studies can be carried out on other engineering properties of cement mortar like tensile strength and shear strength.

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REFERRENCES

[1]. ACI 212-3R: "Use of admixtures are outlined by the functions that they perform".

[2]. Bogue, R.H. (1995): "Chemistry of Portland Cement, Reinhold Publishers, NewYork".

[3]. This publication provides info on the kinds and functions of admixtures that have been, or are being, standardized in Europe for implementation in national standards in CEN member countries.

[4]. Duggal, S.K. (1997): "Text Book on Building Materials, Oxford and IBM Publishing Co. Pvt. Ltd., New Delhi".

[5]. F.Curcio, B.A. De Angelis, and S.Pagaliolico (1998)43 in their investigation, super-plasticized mortars containing Metakaolin (MK) as 15% replacement of cement and with a water/binder ratio of 0.33 have been characterized with four commercially available MK samples have been studied and compared to silica fume.

[6]. F.Curcio and B.A. De Angelis (1998)44 in their investigation, cement pastes containing Metakaolin have been studied with a co-axial cylinder rotational viscometer.

[7]. J.M. Kinuthia et al. (1999)46 An experimental investigation is made by the authors in studying the workability of concrete incorporating combinations of pulverized fuel ash (PFA) and Metakaolin (MK) as partial replacements for Portland cement (PC).

[8]. M.Frias, M.I.Sanchezderojas, J.Cabrera (2000)49 In their experimental work, the influence of the pozzolanic activity of the Metakaolin(MK) on the hydration heat has been studied in comparison to the behaviors of other traditional pozzolanic materials such as flyash and silica fume.

[9]. K.A.Gruber, Terry Ramlochan, AndreaBoddy, R.D.Hooton,

[10]. IS 269:1976: "Specifies the limit for soundness as per the Le-Chatelier's test result for Ordinary Portland Cements".

[11]. IS 383:1970: "The specificification for particle size composition of the sand".

[12]. IS 650:1966: "The specifications for sand used in cement mortar".

[13]. IS 4031 (Part 6) 1968: "Specifications for a combination of cement and sand in the proportion 1:3 by weight, was carried out using a mechanical mixer".

[14]. IS 4031:1988: "Ordinary Portland Cement is graded according to strength, the other cements too have to gain a particular strength. 33, 43 and 53 grade in OPC indicates the compressive strength of cement".

[15]. IS 5513:1976: "Vicat's Apparatus (First Revision), Indian Standards Institution, New Delhi".

[16]. IS 5514:1969: "Apparatus Used in Le-Chatelier Test, Indian Standards Institution, New Delhi".

[17]. IS 8112:1989: "Specifications for 43-Grade Ordinary Portland Cement, Indian Standards Institution, New Delhi".

[18]. Krishnamurthy, G.S. (1991): "Material Testing Laboratory Manual, S.V.U. College of Engineering, Tirupati, Vol. 2".

[19]. Kuhl, (1929): "Most of the standard specifications specified the percentage of constituents with the various ratios".

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