International Journal of Advanced Research Methodology in Engineering & Technology, ISSN 2456-6446
Volume 2, Issue 1, January 2018

Influence of Mineral and Chemical Admixtures in Portland Pozzolona Cement Mortar Using River and Standard Sand

M.Yasvardhan Reddy[1], P.Eliyaz Khan[2] , S Mohammad Hasham[3], C.V.S Nagendra[4]

[1,2,3]B.Tech III Year Student, Civil Engineering Dept, SVCET – Chittoor , A.P, India

[4] Assistant Professor Civil Engg Dept, SVCET ,Chittoor,A.P, India

[4]chintalanagendra25@gmail.com [1]yasvardhanmopuri@gmail.com

Abstract— To fulfil the demands of cement and reduce the production of cement. In the present research,the supplementary cementious materials (SCMs) or mineral admixtures like fly ash, silica fume, metakaolin and ground granulated blast furnace slag(GGBS) are used in cement composite by partial replacement of cement about 20% and studied the properties of cement composite using river and standard sand. By adding this type of SCMs in cement the performance with regard to water requirement for consistency, setting time and preparation of cement mortar with and without addition of superplasticizer(SP)may demand less or more water as compared to cement alone. The present study gives the requirement of water at different stages of consistency and also the mechanical and durability properties of cement mortar are studied by preparation of mortar cubes.

I. Introduction

Every year the production of cement is increasing with increasing demand in construction industries. In the process of manufacture of cement large amount of CO_2 is released. While the demand of cement increases the rate of production also increases and it causes many environmental problems like greenhouse effect. Suppose if one ton of cement is manufactured then equal amount of CO_2 is released. Therefore, it is necessary to replace the cement by some cementious materials or by using activation of pozzolanic materials like fly ash, silica fume and rice husk etc.

From the past decade, the addition of admixtures in mortar or concrete has become common in practice. Besides its economic advantages, the partial replacement of Portland Pozzolana Cement by some supplementary cementious materials in cement mortar is known to have a beneficial effect on several properties like durability. Generally, Portland-Pozzolana Cement can be either by grinding together Portland cement clinker and Pozzolana with addition of gypsum or calcium sulphate,or by intimately and uniformly blending Portland cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than normal Portland cement. Moreover,it reduces the leaching of calcium hydroxide liberated during the setting and hydration of cement.it is particularly useful in marine and hydraulic construction and other mass concrete structures. Portland-Pozzolana cement can generally be used wherever 33 grade ordinary Portland cement is usable under normal conditions and in the present study PPC is used to determine the change in properties by addition of admixtures.

In general, most expensive most expensive ingredient among construction materials is undoubtedly cement both economically and environmentally. Normally cement contains many ingredients like oxides of calcium(ca0),silica(sio2),aluminium(alo3),iron(fe20), magnesium(MgO) and alkali's like Na2O and K20 and the main products of hydration of cement are calcium silicate hydrates(C-S-H).calcium hydroxides(CH),and calcium aluminate hydrates(C-A-H).The changes in addition of admixtures to cement affects the rate, quantity and quality of hydration products which eventually results in changes in the demand of water requirement, strength and durability property of the cement paste.

A. Admixtures

A material other than water, aggregate, cement, used as an ingredient of concrete or mortar added to the batch immediately before or during mixing is called admixture. These are also called as supplementary cementitious materials. There are two kinds of admixtures they are chemical and mineral admixtures. Mineral admixtures are of different types i.e. pozzolanic, cementitious, both pozzolanic and cementitious, natural materials (volcanic ash) and by product material.

B. Fly ash

Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. The dust collection system removes the fly ash as a fine particulate residue from the combustion of gases before they are discharged in atmosphere. Generally fly ash is used as admixtures in cement paste. When it is partially replaced there will be a change in the physical properties of cement paste like setting time, consistency and the mechanical properties like strength and also the durability property (Kumar et al,2004).

C. Ground Granulated blast furnace slag(GGBS)

GGBS means ground granulated blast furnace slag. It is a non-metallic product consisting of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form glassy sand like granulated material and then this material is ground to less than 45 microns. The chemical composition of blast furnace slag is similar to that of cement clinker.

D. Metakaolin

Metakaolin is a natural pozzolanic material manufactured under a carefully controlled process by thermally activating purified kaolinite clay within a specified temperature range of 650-700^0.To increase the resistance of sulphate attack it is necessary to reduce the permeability of concrete. This can be achieved by using mineral admixtures like metakaolin in concrete. (Chisu Mereena Joy et al,2007)

E. Silica fume

Silica fume is a pozzolanic amorphous material. A by-product of the production of elemental silicon or Ferro silicon alloys in electric arc furnaces consisting of ultra-fineparticle (0.01 m). It is difficult to handle so, it is necessary to use (high range) water reducing admixtures. When it is partially replaced in cement paste the mechanical property like strength increases compared to conventional mix and it also provides good bond between cement and aggregates. When silica fumes of about 6% is blended with OPC of about 94% the durability increases and strength increases with w/c ratio 0.4 compared with cement / (fly ash) ratio. (Malhotra et.al 1992)

II MATERIALS

A. Cement

The Cement used throughout the test program was Portland Pozzolana Cement (PPC) Ultratech cement conforming to IS 1489:1991. The physical properties of cement are tabulated below.

Table 1 Properties of cement

S. No	Physical Properties	Cement (PPC)	Fine Aggregate (River Sand)
1	Consistency (% of water)	34	
2	Initial setting time(min)	175	
3	Final setting time(min)	430	
4	Fineness modulus		2.9

B. Fly ash

The fly ash used in this study is obtained from Rayalaseema Thermal Power Plant (RTPP), Middalur, Kadapa (Dist) which is grey in colour.

Table 2 Composition of Fly ash

Constituents	Percentage(%)
SiO_2	52.2
Al_2O_3	32.63
Fe_2O_3	6.16
CaO	ND
MgO	ND
SO_3	4.95
Na_2O	0.02
K_2O	0.11

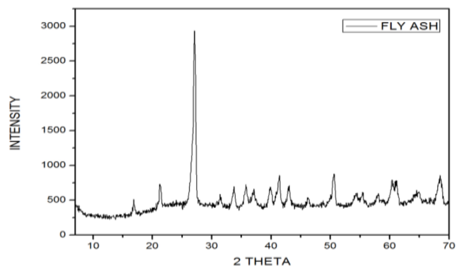

Fig 1 XRD for Fly ash

C. Metakaolin

Metakaolin used in this study is obtained from Astrra chemicals, Chennai.

Table 3 Composition of Metakaolin

Constituents	Percentage(%)
SiO_2	52-54
Al_2O_3	44-46
Fe_2O_3	0.6-1.2
CaO	0.09
MgO	0.03
Na_2O	0.1
K_2O	0.03

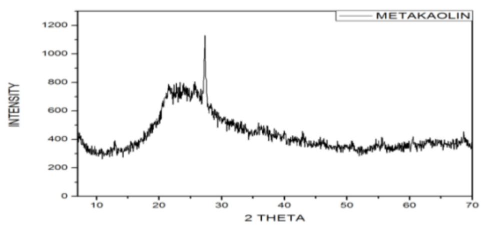

Fig 2 XRD for Metakaolin

D. GGBS

GGBS used in this study is obtained from Astrra chemicals, Chennai.

Table 4 Composition of GGBS

Constituents	Percentage(%)
SiO_2	35
Al_2O_3	12
Fe_2O_3	1
CaO	40
SO_3	9
Na_2O	0.3
K_2O	0.4

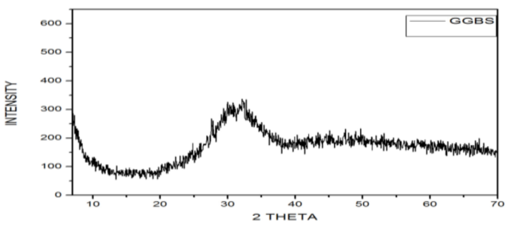

Fig 3 XRD for GGBS

E. Silica Fume

Silica Fume used in this study is obtained from Astrra chemicals, Chennai.

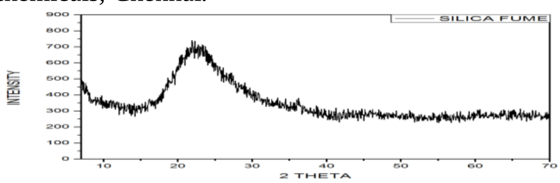

Fig 4 XRD for Silica fume

Table 5 Composition of Silica fume

Constituents	Percentage(%)
SiO_2	90
Al_2O_3	0.4
Fe_2O_3	0.4
CaO	1.6
SO_3	0.4
Na_2O	0.5
K_2O	2.2

F. Water

Ordinary water available in the laboratory was used for the experimental investigations and for curing purpose. Water is an important ingredient of concrete reaction with cement. Tap water available in a college premises is used for mixing and curing.

G. Super plasticizer

Super plasticizer was used during investigation to improve the workability of concrete. As per Indian Standards, the dosage of super plasticizer should not exceed 2% by weight of cement. A higher dosage of super plasticizer may delay the hardening process. After trails, the optimal dosage of super plasticizer was found to be 0.6%. Glenium B233 having specific gravity 1.08 at 30^0 C at no calcium chloride content and having 1 to 4 hours retardation depending on dosage and climatic conditions used in this experimental work.

III Details of mixes

The details of mixes for to determine the mechanical and durability properties of cement mortar specimens using river sand and standard sand with SP and without SP in the ratio 1:3 is given as shown below table 6.

Table 6 Details of Mixes

Mix designation	Mix constituents	Super plasticizer Dosage (% of Binder)
CM	Cement+sand	-
CMF	Cement+flyash+sand	-
CMM	Cement+metakaolin+ sand	-
CMG	Cement+GGBS+sand	-
CMS	Cement+silicafume+s and	-
CM-S	Cement+sand	0.6
CMF-S	Cement+flyash+sand	0.6
CMM-S	Cement+metakaolin+ sand	0.6
CMG-S	Cement+GGBS+sand	0.6
CMS-S	Cement+silicafume+s and	0.6

IV Results and Discussions

A.Consistency

The standard consistency test was carried out for each of the different mixes as described below table 7.

Table 7 Standard consistency of cement with SCM''s

MATERIAL	% OF WATER WITHOUT SP	% OF WATER WITH SP	% OF REDUCTION
CEMENT	34	26	23.5
CEMENT + FLYASH	36	28	23.5
CEMENT + METAKAOLIN	39	31	23.5
CEMENT +GGBS	34	26	23.5
CEMENT + SILICA FUME	33	25	23.5

Consistency test is conducted for all mixes i.e. with and without mineral admixtures. The percentage of water required for consistency of cement alone and mix with GGBS is same of about 34% and for the mix with silica fume the percentage of water is less compared to all mixes i.e. about 33% and clearly indicates that the water required for consistency of cement is 34% and by addition of mineral admixtures except silica fume and GGBS. all other mixes consumed more water for consistency particularly metakaolin is about 39%. The mixes with silica fume and GGBS consumed 33% and 34% water for consistency respectively. Consistency is also conducted for all the mixes i.e. with and without mineral admixtures with the addition of SP. It is observed that by addition of chemical admixture (super plasticizer) there is a reduction of water consumption for consistency compared to mixes without SP of about 23.50%.Among that the cement alone and the mix with GGBS consumed same percentage of water of about 26% and the mix with silica fume consumed less percentage of water compared to all other mixes.

B. Initial and Final Setting Time

The initial and final setting time values of cement with different SCM's are shown below in Fig 5

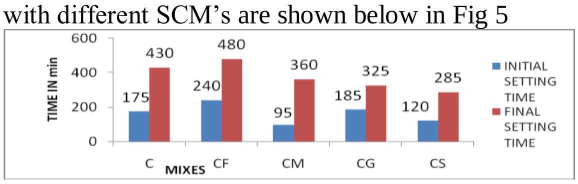

Fig 5 Initial and Final setting Time

Initial and final setting time test conducted on all mixes i.e. with and without mineral admixtures and it is observed that the initial setting time for cement alone is about 175 minutes and final setting time is about 430 minutes. The mix with flyash consumed more time to set both initial and final setting of about 240 and 480 minutes and the mix with metakaolin and mix with silica fume consumed less time to set but compared to all mixes the metakaolin mix consumed less time to set in both initial and final of about 95 and360 minutes.Initial and final setting time test is also conducted on all mixes i.e. with and without mineral admixtures with the addition of SP and it is observed that the initial and final setting time is decreased with the addition of SP. cement alone with SP consumed initial setting time of about 170 minutes and final setting time is about 400 minutes. The mix with fly ash consumed more time to set in both initial and final setting of about 230 and 465 minutes and the mix with metakaolin and mix with silica fume consumed less time to set but compared to all mixes the metakaolin mix consumed less time to set in both initial and final of about 60 and 325 minutes.

C. Compressive strength test

The cement is always tested for strength at the laboratory before it is used for important works. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkages and subsequent cracking of neat cement. Strength of cement is found on a cube cast using cement mortar, sand in specific proportions. The fine aggregate as river sand and standard sand are used in this study for preparation cement mortar specimens. A total of 70.6x70.6x70.6 mm size mortar cubes are casted and are tested at different ages (3,7,28 and56 days) for compressive strength and results are shown in Table8.

Table8 Compressive strength of Specimens using river sand (N/mm^2)

MATERIAL	3 DAYS	7 DAYS	28 DAYS	56 DAYS
CM	19.35	26.76	37.489	41.3
CMF	17.28	20.98	31.744	36.77
CMM	15.47	23.82	38.51	40.0
CMS	17.0	25.7	30.47	40.0
CMG	16.52	23.35	37.26	40.6
CM-S	33.9	37.4	47.08	58.37
CMF-S	23.48	26.15	39.82	49.0

CMM-S	21.86	28.04	40.71	47.16
CMS-S	27.29	31.54	41.18	51.85
CMG-S	23.67	28.8	39.28	52.57

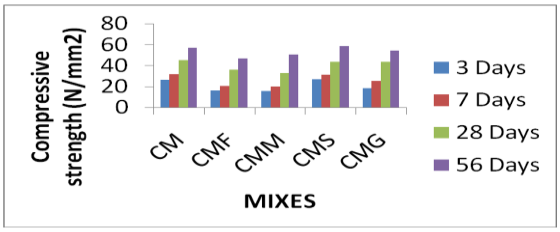

Fig 6 Compressive strength results using Ennore sand

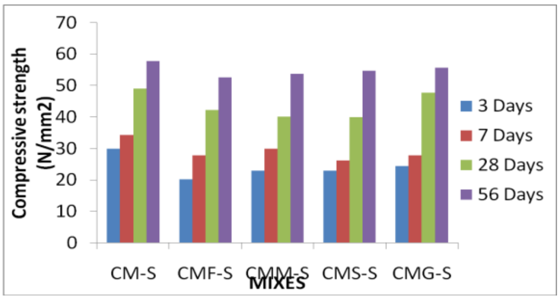

Fig 7 Compressive strength results using Ennore sand with SP

Compression strength test is conducted on the cement composite specimens cast using river sand and without addition of SP which gave almost better results in the same range shown in Table 8. All mixes gave strength in the same range for 28 days it is observed that every mix gave strength in the same range except the mix with Fly ash of about 16% less compared to higher strength and same thing is followed at 56 days. The compressive strength at 3,7,28 and 56 days for the mortar cubes casted using river sand without SP is almost more or less in the same range for all mixes except Fly ash. The compressive strength of cement composite specimens prepared using standard sand without SP at 3,7,28 and 56 days is almost more or less in the same range for all mixes except Fly ash but among that mix with silica fume got higher strength compared to conventional mix which is shown in Fig 6. The mix cement with silica fume gave higher strength about 58.8 MPa. It is also conducted on the cement composite specimens cast using standard sand and with addition of SP shown in Fig 7 and for 28 days it is observed that every mix gave strength in the same range and the cement alone, mix with GGBS and mix with silica fume gave higher strengths in the same range and among that cement alone and mix with GGBS gave higher strengths of about 49.11 MPa and 47.80 MPa. The remaining are in the same range of about 18.5 % less compared to higher strength but at 56 days.

D. Water absorption test

MATERIAL	DRY WEIGHT(gm)	WET WEIGHT(gm)	WEIGHT LOSS (gm)	WATER ABSORPTION (%)
CM	705.9	750.1	44.2	5.89
CMF	712.2	758.4	46.2	6.09
CMS	763.0	795.2	32.2	4.04
CMG	772.3	796.3	24	6.78
CMM	764.7	786.3	21.6	2.74
CM-S	786.3	812.0	25.7	3.16
CMF-S	781.2	811.9	30.7	3.78
CMM-S	784.2	804.2	20	2.48
CMG-S	796.5	820.2	23.7	2.88
CMS-S	783	810.8	27.8	3.42

Table 9 Water absorption for cement mortar cubes using river sand

This test was conducted after 28 days curing of mortar cubes size 70.6mmx70.6mmx70. 6mm.The cubes were placed in an oven for 48 hours at 70^0C temperature as in fig. After that the weight of the specimen is noted and is termed as dry weight (W2) and for 24 hours the specimens are kept in water curing after the weight of the specimen is noted and is termed as wet weight (W1). The difference in loss of weight was ensured by periodic weighing. Once the constant weight was observed, then the sample weight was considered for water absorption. The loss of weight of the cubes after oven drying was expressed as a percentage of the original weight of the cube. This value is called water absorption of the

sample. Water absorption is determined by the formula given below.
Water absorption= [(W1-W2)/W2]x100
Where,
W1=wet weight of sample

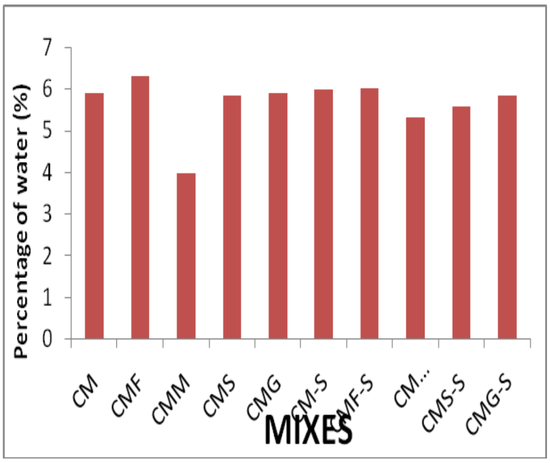

Fig 8 Water Absorption for Cement Composite Specimens after 28 days Curing (Standard Sand)

Water absorption test is conducted on cement composite specimens of with and without SP using river sand as shown in table 9. All the mixes showed better results but the mixes without SP. Among the mixes without SP the mix with GGBS absorbed more percentage of water of about 6.78% and for fly ash it is about 6.09% and the cement alone mix without SP absorbed water of about 5.89% which is less compared to fly ash and GGBS mix. The mix with metakaolin absorbed less percentage of water compared to all other mixes without SP of about absorbed less percentage of water compared to all other mixes without SP of about 2.74%.Among the mixes with SP the fly ash mix absorbed more percentage of water of about 3.78% and the mix with silica fume and cement alone are in the same range i.e. about 3.42% and 3.16%.The mixes such as metakaolin and GGBS absorbed less amount percentage of water in both cases with and without SP and also from the clearly indicates that the water absorption values for different mixes casted using river sand shows that the mix with metakaolin absorbs less percentage of water compare to all other mixes in both with and without super plasticizer. Among the mixes without SP, cement alone, cement with fly ash and cement with GGBS absorbed more percentage of water and among the mixes with SP, cement with fly ash and cement with silica fume absorbed more water. Therefore, it concludes that mix with metakaolin absorbs less water both with and without SP using River sand and ennore sand as shown in Fig 8.

E. Sorptivity test

In unsaturated cement mortar specimens, the rate of water or other liquids is largely controlled by absorption caused by capillary rise. The performance of cement mortar cubes subjected to aggressive environments mainly depends on the pore system. For this study the cylinders of size 100*200mm were casted with and without admixtures using river and standard sand cured for 28days. After 28days of curing those cylinders were removed from water and cut into specimens of size 100*50mm disc as shown in Fig 9. After drying in oven for 100+10^{0}C for 24hours, the specimens were drawn from oven and cooled to room temperature then drying weight of specimens were taken. After that, the specimens were immersed in water up to depth not exceeding 5mm from the base of specimen as shown in fig. The quantity of water absorbed in time period of 30 minutes was measured by weighing the specimen such that surface water on the specimen was wiped off with a dampened tissue. This procedure will be repeated for every half an hour once and continued up to 3hours. Sorptivity is calculated by the formula given below.

$S= (W_X-W_Y)/ (ADT^{1/2})$

Where,

S = Sorptivity (mm)/ (min) $^{1/2}$;

W_X-W_Y =Weight after 60 min-Weight after 30 min (increase in weight for every 30 min (gm));

A = surface area of specimen through which water penetrates, mm^2;

D = density of water, gm/mm^3;

T = Elapsed time, min.

Fig 9 cubes under sorptivity test

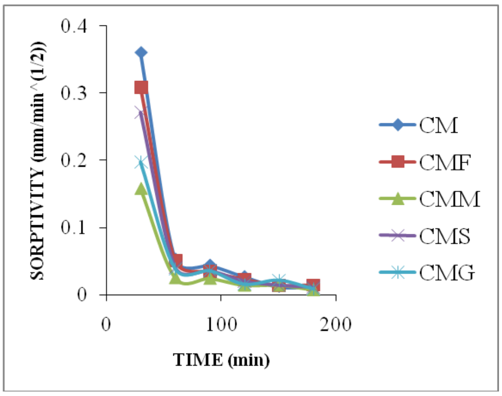

Fig 10 Sorptivity (without SP) – River Sand

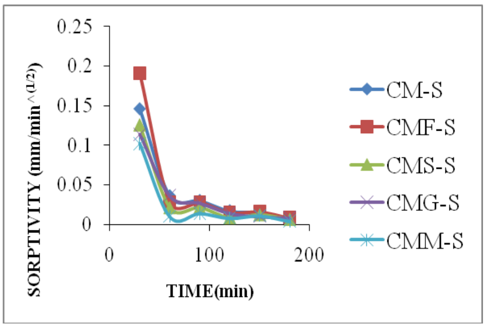

Fig 11 Sorptivity (with SP) – River Sand

Table 10 sorptivity Test results using standard sand

Material			Sorptivity (mm/(min)1/2)			
	30(min)	60(min)	90(min)	120(min)	150(min)	180(min)
CM	0.151	0.064	0.031	0.023	0.016	0.006
CMF	0.214	0.084	0.047	0.029	0.019	0.008
CMM	0.121	0.045	0.03	0.02	0.012	0.005
CMS	0.135	0.067	0.039	0.023	0.016	0.007
CMG	0.163	0.053	0.031	0.022	0.011	0.009
CM-S	0.146	0.051	0.034	0.020	0.012	0.006
CMF-S	0.177	0.062	0.035	0.021	0.012	0.006
CMS-S	0.063	0.054	0.023	0.017	0.009	0.002
CMG-S	0.112	0.039	0.026	0.014	0.008	0.003
CMM-S	0.102	0.03	0.014	0.01	0.007	0.001

The mix with metakaolin absorbed less water compare to all other mixes with a sorptivity value of 0.158 and when compared to cement alone mix the sorptivity for metakaolin mix is 56 % less and when the period of interval is increasing it is observed that the water absorption rate for all the mixes is same. But the water absorption by capillary action to the mix with metakaolin is less compare to the all other mixes. The Sorptivity test results within a period of 30 to 60 minutes for the cement composite specimens cast using river sand with addition of SP are shown in Fig 10 & 11. During a period of 30 to 60 minutes, the metakaolin and GGBS specimens absorbed equal amount of water.

The Sorptivity test results within a period of 30 to 60 minutes for the cement composite specimens cast using standard sand without addition of SP and with addition of SP are observed are shown in Table 10 and it concludes that metakaolin performs better compared to all other mixes.

F. Chloride penetration test

Calorimetric chlorination technique is one of the tests to find out the chlorine penetration depth in the specimens. For this study the specimens of size 100*100*100mm specimens were casted with and without admixtures using river sand and standard sand and after 28 days water curing i.e. from the period of casting are removed and are placed in water which contains sodium chloride (NaCl) about 3.5% of water as shown in a fig. After 28 days chlorine water curing, specimens are removed and are cut in to two equal pieces each. Immediately, the chemical called silver nitrate ($AgNO_3$) of 0.1M is sprayed on those specimens (broken part). Due to chemical reaction between sodium chloride and silver nitrate a white precipitate is formed on the specimens and the depth up to which it indicates white precipitate as shown in fig will provide the penetration of chlorine for that period of time.

Table 11Chlorination Penetration test results (River sand)

Specimen	Penetration depth (mm)-28	Penetration depth (mm)-44 days

	days	
CM	14	16
CMF	15	15
CMM	11	12
CMG	12	14
CMS	15	16
CM-S	12	14
CMF-S	12	13
CMM-S	11	11
CMG-S	12	14
CMS-S	11	12

Table 12 Chlorination depth results (Ennore sand)

Specimen	**Penetration depth (mm)-28 days**
CM	9
CMF	10
CMM	4
CMG	9
CMS	9
CM-S	10
CMF-S	9
CMM-S	7
CMG-S	8
CMS-S	9

It is observed for all mixes that specimens casted using river and standard sand with and without addition of SP as shown in Table 11 &12. The penetration depth of chlorine for the mix casted using metakaolin admixture is less compared to all other mixes.

G. Permeability

Permeability was carried out after 28 days water curing and cement composite specimens of size 150 x 150 x 150 mm cubes casted using river and Standard sand and with and without admixtures and the results obtained by this test is shown as below.

Table 13 Test results of permeability using River sand

Material	**Penetration depth(mm) (after 3 days)**
CM	14
CMF	15
CMM	7
CMS	10
CMG	17
CM-S	5
CMF-S	6
CMM-S	2
CMS-S	5
CMG-S	7

Table 14 Test Results of permeability Using Ennore sand

Material	**Penetration depth(mm) (after 3 days)**
CM	13
CMF	14
CMM	5
CMS	8
CMG	16
CM-S	6
CMF-S	8
CMM-S	4
CMS-S	7
CMG-S	5

Permeability test is conducted on cement composite specimen using river sand with and without addition of SP and the results are shown in Table 13. it is observed that, among the mixes without SP for the mix with GGBS the penetration of water is more compared to all other mixes with a penetration depth of 17 mm. Among the mixes with SP the fly ash mix is absorbed more amount of water with the penetration depth of about 6 mm and the mix with metakaolin absorbed less amount of water having a penetration depth of about 2 mm.

The specimens casted using standard sand with and without addition of SP are shown in Table 14 and it is observed that, among the mixes without SP the mix with GGBS absorb more amount of water with a penetration depth of about 16 mm and the mix with fly ash and cement alone absorbed almost equal amount of water with a penetration depth of about 14 and 13 mm respectively. Among the mixes with SP the fly ash mix observed less amount of water with their penetration depth of 8 mm. Among these mixes the metakaolin mix specimens observed less amount of water with a penetration depth of 4 mm.

V CONCLUSIONS

From this study, it is observed that the supplementary cementious materials used in the present investigations can be used in cement composite. The strength obtained by addition of these materials is more or less in the same range as compared to the control mix. However, with the addition of SP, maximum increment in strength was noticed with the reduction in water consumption and also the durability properties of cement composite with addition of admixtures showed better results.

The following conclusions may be drawn from this study

- Water requirements for standard consistency was enhanced by the addition of mineral admixtures.
- Metakaolin was observed to be consuming maximum water for consistency and workability.
- The use of mineral admixtures influence delay in setting time as compared to the paste with cement alone. With the addition of SP in all the mixes, the setting time is faster.
- As per LS-4031:1988(Part-6).it is observed that the water required for making mortar cubes using river sand in the study demand +1 % and using standard sand same % is maintained.
- The compressive strength at 56 days using river and standard sand indicates that all the mixes with mineral admixtures give more or less same strength except the mix with fly ash, which gives 11.20% less.
- The compressive strength for the mortar cubes with super-plasticizer and without mineral admixtures i.e. cement with sp alone gave higher strength in both conditions i.e. using river and standard sand and all other mixes are observed to be in the range of 10 to 12% less value.
- The compressive strength for the mortar cubes using standard sand without SP, the mix with cement with silica fume gave higher strength, cement alone is also in the same range but the other mixes are observed to be 10% less.
- The water absorption for the mortar cubes cast using Standard sand is more compared to cubes cast using river sand. it is also observed that the metakaolin mix observed less amount of water compare to all other mixes.
- From chlorination and porosity test, it is observed that the rate of penetration of chlorine and water respectively is high at initial stages and as the time increases the rate of penetration decreases and also it is observed that the mix with metakaolin showed better results compared to all other mixes casted with and without admixtures using river and standard sand.

The above conclusions are only related to cement mortar specimens and for the concrete it may almost differ but the compressive strength results may approximately considered with addition of admixtures but durability properties cannot be compared with concrete it is completely different.

REFERENCES

1.BIS 1489(part2):1991 Portland Pozzolona cement.
2.BIS 4031(part4):1988 for calculation of consistency of cement.
3.BIS 4031(part5):1988 for calculation of initial and final setting time of cement.
4.BIS 4031(part6):1988 for calculation compressive strength of cement mortar specimens.
5.Bremner T.W,Malhotra V.M and Caratte G.G, Fly Ash,silica fume,slag and natural Pozzolona in cement,4th international conference ,turkey,1992.
6.Erich D.Rodrigurz,Susan A. Bernal and Maria Victoria, Structure of Portland cement paste blended with sonicated silica fume,ASCE-journal of materials in civil engineering,volume-24,Oct-24,page no-1282

7.International journals on emerging trend in engineering and development Issue,volu,4(MAY2012)ISSN 2249-6149
8.Islam & Islam Concrete Research Letters Vol. 1(3) 201098 www.crl.issres.net Vol. 1(3) September 2010
9.Kameshwara Rao C.B, Rajesh Kumar and Ratish Kumar P,Proceedings of the second national conference on materials and structures (mast),14-15 December,2007,page no-1.
10.Kumar V,Nautiyal B,Chandrasekaran S, Proceedings of the second international conference on recent trends in concrete technology and structures,2004.
11.M.S Sgetty, Concrete technology 1982, admixtures,page no-125.
12.Marwan A Dayal,Brooks JJ and Neville A, creep and shrinkage of concrete as affected by admixtures and cement replacement methods 2007,page no 19.
13.Nazeer M,Suresh S and Nizad A, Proceedings of second national conference on materials and structures (mast) - durability studies on metakoalin admixed high strength concrete,2007.
14.Rajamane,Jeyalakshmi,Shyam Samarpan and Subha Sit Saha,concrete-effect of addition of nani-silica to Portland cement mortar with or without silica fume ICI journal-international conference on innovation-volume-24,14th July sep-2013.
15.Sheela.S, study on workability and strength behavior of concrete by addition of admixtures,1984,page no 156.
16.Swaroop A.H.L, Venkateswarao K ,Kodandaramarao P, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol.3,Issue 4,Jul-Aug 2013,pp.285-289
17.Yue Li,Qian-Qian Yan and Xiuli DV, Relationship between autogenous shrinkage and tensile strength of cement paste,ASCE-journal of materials in civil engineering, volume-24,oct-24 and page no-1268.