ISSN: 2321-8169
263 – 267

Feasibility of Local Materials as Ingredient of Masonry Cement.

Tushar G Shende[1st]
Department of Civil Engineering,
ITM COE,Kamptee
Nagpur,India
tushar_shende@rediffmaail.com

Dr.S.R.Choudhari[2nd]
Principal
JD College of Engineering,
Nagpur,India
subhash9_sr@yahoo.com

Abstract**—** This paper presents the experimental investigation on derived cement . Various laboratory tests were conducted to explore the possibilities of feasibility of local materials as ingredient of masonry cement on local materials by referring various Indian standard codes. Test conducted include physical and chemical composition of ingredients, test results confirm the requirement of Indian standard. Total 18 mixes were prepared. First 6 mix proportion of masonry cement were prepared by doing variation in OPC & Hydrated lime on volume basis. OPC was replaced by hydrated lime at 0%, 30%, 40%, 50%, 60% & 70% respectively. Similarly in addition to 6 mixes, fly ash & cupola furnace slag 50% of total (OPC & Hydrated lime) kept constant. For identifying the feasibility of local materials only compressive strength of masonry cement was conducted. Total one hundred and eight (108) standard 50mm cube cast for the various mixes, and cured for 7 days & 28 days. Test results indicated that masonry cement mixture proposed in the investigation met the IS 3466:1988 requirement for compressive strength. The result shows that potential of local materials as ingredient of masonry cement.

Keywords*- Masonry cement; OPC; Hydrated Lime; Fly ash; Cupola furnace slag.*

*****

I. INTRODUCTION

All In the late 1920s, portland cement manufacturers began formulating special combinations of Portland cement and plasticizers for use in the masonry industry. Premixed and packaged in bags, these cements came to be called masonry cements.[1,2]

Lime mortars are relatively weaker in strength and slower setting and they sometimes bleed under pressure. Ordinary cement mortars, although fast setting and capable of high strength development, are harsh, non-plastic and non-cohesive with the result that they cannot take up the shrinkage and temperature movements in the masonry and are liable to result in comparatively wide cracks passing right through the bricks or building blocks as compared to a number of evenly distributed hair cracks in the joints which occur when weaker mortars containing lime are used.[3]

Properly proportioned and gauged lime-cement mortars can be made to possess the desired properties of a good masonry mortar but the preparation of lime-cement mortars is time consuming and also unslaked lime and magnesia, when present in such mortars, can cause delayed expansion and consequently defects in the masonry and plaster work. In order to avoid the necessity for mixing cement and lime, and in order to minimize the risk of trouble from expansion due to the presence of small quantities of unslaked lime, the use of masonry cement is quite popular in a number of countries abroad and its use should be encouraged in this country also. [3]

Masonry cement is chiefly intended for use in masonry mortars for brick, stone and concrete block masonry, and for rendering and plastering work. Because of its property of producing a smooth, plastic, cohesive and strong, yet workable, mortar when mixed with fine aggregates, masonry cement is considered superior to lime mortar, lime-cement mortar or cement mortar.[3]

Masonry cement is a cement mill formulation of materials that was developed to fill the need for a volume-stable mortar. Masonry cement is combined with sand and water at the jobsite to produce a workable, durable, and economical mortar that meets the strength and present-day construction requirements for use with all types of masonry units. [4]

II. LIETRATURE REVIEW

A. ORDINARY PORTLAND CEMENT

Ordinary Portland cement is manufactured by intimately mixing together calcareous and argillaceous and/or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resultant clinker so as to produce a cement capable of complying IS specification. In market three types of grade cement are available i.e.OPC 33 grade, OPC43 grade and OPC 53 grade cement. Mainly OPC cement is used for structural element due to its high strength. Cement with lime is quite popular for masonry work.

B. HYDRATED LIME

There are two types of lime, Non-hydraulic lime and Hydraulic lime. The former is made from high purity calcium carbonate (limestone or chalk). The calcium carbonate ($CaCO_3$) is heated to approximately 900 to 1200 degrees Celsius in a kiln to produce calcium oxide (CaO), also known as quicklime. When water is added to quicklime, known as slaking, it releases large amount of heat, causing the water to boil and 'pit'. The resulting product is calcium hydroxide $Ca(OH)_2$, or 'hydrated lime', or 'slaked lime' or 'lime putty'.

 ISSN: 2321-8169
263 – 267

The lime putty of non-hydraulic lime hardens extremely slowly by drying and by a process named as carbonation in which the lime putty reacts with carbon dioxide in the air to convert it to calcium carbonate [6].

Hydraulic lime is made in a very similar process as given above. Quite often the limestone used for the source of calcium carbonate contains impurities, such as small amount of silt or clay. Along with the calcium oxide formed while being burned in the kiln, the silt and/or clay form calcium silicates and aluminates. These compounds will react with water to set and harden regardless of the presence of air. Only enough water is added in hydraulic lime to produce calcium hydroxide in a powder form, not excess to set the calcium silicates and aluminates. This dry material, known as hydrated lime, is mixed with water to produce a mortar that will set very quickly as compared to non-hydraulic lime [6].

Lime content shows a significant effect on the strength development and pozzolanic reaction rate of natural pozzolans. The increase of lime content over a critical value results in an increase in water requirement and initial porosity. At the same time, the remaining unreacted Ca(OH)2 weakens the hardened paste. Thus, the strength of the lime-pozzolan pastes decreases if the lime content is higher than the critical value.[8]

C. FLY ASH

Thermal power stations use pulverized coal as fuel. They produce enormous quantities of coal ash as a by-product of combustion. This calls for the development of strategies to encourage and establish technological concepts which will ensure increase in consumption of fly ash in bulk. Among the various uses of fly ash, its major utilization is possible to manufacture alternative cementing material. This necessitates characterization of the fly ash with reference to Lime-fly ash mixture for construction activities.[6]

The use of pozzolans in the preparation of mortar and concrete is a common practice because they improve the mechanical properties and increase their durability in environments with aggressive agents. These improvements are attributed to two processes: i) the formation of additional hydrated products due to reaction of pozzolan with calcium hydroxide resulting from hydration of cement, and ii) reduction of permeability by the effect of filling the pores with the products formed in the pozzolanic reaction.[7]

Fly ash reacts with lime produced from the hydration of cement and produces useful calcium silicate hydrates (C-S-H), which in turn reduces the leaching problem. There are three features of the pozzolonic reaction. First the reaction is slow; therefore the rates of heat liberation slow. Second the reaction is lime consuming instead of lime producing, which has an important bearing on the durability of the hydrated paste to acidic to environment. Third pore size distribution studies of hydrated cement have shown that the reaction products are very efficient in filling up large capillary space thus improving the strength and impermeability of the system.[9]

The fluidity of mortars results indicates that the workability of mortars will be enhanced due to the incorporating fly ash, especially incorporating ultra-fine fly ash [10]

D. CUPOLA FURNACE SLAG

The slag cements demand less water than the reference pure cement and the slag addition improves the mortar workability. On the contrary, the blended cements showed longer setting times than the pure one. The addition of steel slag slows down the hydration of the blended cements. This phenomenon was mainly attributed to the crystal size and structure of the C2S contained in slag.[17]

III. MATERIAL AND TESTING

A. ORDINARY PORTLAND CEMENT

As per IS 3466:1988 Ordinary Portland Cement,(OPC) 33 grade is require as main ingredient but not availability of 33 grade cement in the market, 43 grade cement was used. The name of cement company is ACC. Various chemical testing was carried out on OPC as per IS 4032:1985 and satisfy the requirements of IS 8112:1989.Test values are shown in Table 1

Table No.1: Chemical requirement of OPC 43 Grade (As per IS: 8112:1989)

SN.	Characteristic	Requirement	Test Value
i	Ratio of percentage of lime to percentages of silica, alumina and iron oxide, when calculated by the formula $\frac{CaO - 7\,SO_3}{2.8\,SiO_2+1*2\,AL_2O_3+0*65\,Fe_2O_3}$	Not greater than 1.02 and not less than 0.66	0.89
ii	Ratio of percentage of alumina to that of iron oxide	Not less than 0.66	0.72
iii	Insoluble residue, percent by mass	Not more than 4 percent	1.3
iv	Magnesia, percent by mass	Not more than 6 percent	0.70
v	Total sulphur content calculated as sulphuric anhydride(SO_2), percent by mass	Not more than 2.5 and 3.0	2.3
vi	Total loss on ignition	Not more than 5 percent	2.8

Various physical testing was carried out on OPC as per IS 4032:1985 and satisfy the requirements of IS 8112:1989.Test values are shown in Table 2

Table No.2 Physical requirement of OPC 43 Grade (As per IS:8112:1989)

SN.	Characteristic	Requirement	Test Value	Method As per IS
i	Fineness	Specific surface should not less than 260m^2/Kg	327 m^2/Kg	IS 4031 (Part-II)
Ii	Soundness	Should not expand 10% By autoclave 0.8%	1.5 0.06%	IS 4031(Part-III)
Iii	Setting Time	Initial setting Time (>30Min) Final setting Time (<600Min)	45 Min 290Min	IS 4031 (Part-V)
Iv	Compressive strength	3 days < 23 MPa 7 days < 33 MPa 28 days< 43 MPa	27 MPa 33.87 MPa 43.50 MPa	IS 4031 (Part-VI)

B. HYDRATED LIME

Yavatmal District of Vidarbha region is popular as lime belt. After doing standard procedure lime is converted in to hydrated lime. Various chemical testing was carried out on lime as per IS 6932:1973 & IS 1514:1990.Used lime satisfies the chemical requirements as per IS 712:1984. Test values are shown in Table 3

Table No.3 Chemical requirement for hydrated lime (As per IS 712:1984)

S N .	Characteristic	Requirement		Test Value	Method As per IS
		Clas s A	Clas s B		
1	Calcium and magnesium oxide percent (Min)	60	70	76.18%	IS 6932 (Part-I)
2	Magnesium oxides percent (Max)	6	6	5.6%	IS 6932 (Part-I)
3	Silica,Alumina and ferric oxide percent(Min)	20	10	12.56%	IS 6932 (Part-I)
4	Unhydrated magnesium oxide percent (Max)	--	--	6.70%	IS 6932 (Part-V)
5	Insoluble residue in dilute acid and alkali percent(Max)	15	10	8.14%	IS 6932 (Part-I)
6	Carbon dioxide percent (Max)	5	5	3.71%	IS 6932 (Part-II)
7	Free moisture content (Max)	2	2	1.83%	IS 1514 (Part-I)
8	Available lime as CaO(Min)	--	--	72.5%	IS 1514 (Part-I)

Various physical testing was carried out on lime as per IS 6932:1973 & IS 1514:1990.Used lime satisfies the physical requirements as per IS 712:1984. Test values are shown in Table 4

Table No.4 Physical requirement for hydrated lime (As per Is 712:1984)

SN.	Characteristic	Requirement		Test Value	Method As per IS
		Class A	Clas s B		
i	Fineness Residue on 2.36mm IS Sieve ,percent (Max) Residue on 300 micron IS Sieve, percent (Max) Residue on 212 micron IS Sieve, percent (Max)	Nil 5 --	Nil 5 --	-- 4.5 7	IS 6932 (Part-IV) :1973
ii	Setting Time a. Initial setting time Hrs,(Min) b. Final setting time, Hrs(Max)	2Hrs 48Hrs	-- --	4 Hrs 32 Min 26 Hrs 18 Min	IS 6932 (Part-XI) :1973
iii	Compressive Strength a. At 14 days ,MPa,(Min) b. At 28 days,Mpa, (Min)	1.75 2.8	1.25 1.75	1.35 1.85	IS 6932 (Part-VII) :1973
iv	Transverse strength teat at 28 days,MPa,(Min)	1	0.7	0.80	IS 6932 (Part-VII)
v	Soundness, Le chatlier expansion,Min	5	5	Nil	IS 6932 (Part-IX)
vi	Popping &pitting	Free from pop and pits	Free from pop and pits	Free from pop and pits	IS 6932 (Part-X):1973

C. FLY ASH

Fly ash samples were collected from Khaprkheda Thermal Power Station,MAHAGENECO. The detailed analysis was carried out and it was observed that low calcium and siliceous fly ash.Test values satisfy the requirement of IS 3812:2003(PartI).Test values of chemical and physical test shown in table no.5 &6 respectively.

Table No.5 Chemical requirement of Fly ash (As per IS:3812:2003)

SN.	Characteristic	Requirement		Test Value	Method as per
		Sillicious Fly ash	Calcareous fly ash		
i	Silicon dioxide ($Si0_2$) plus aluminum oxide ($A1_20_3$) plus ferric oxide(Fe_2O_3) in percent by mass, *Min*	70	50	89.91	IS 1727
ii	Silicon dioxide (SiO_2) in percent by mass, *Min*	35	25	58.34	IS 1727
iii	Reactive silica in percent by mass, *Min*	20	20	25	IS 1727
iv	Magnesium oxide (MgO) in percent by mass, Max	5	5	0.43	IS 1727
v	Total sulphur as sulphur trioxide ($S0_3$) in percent by mass,Max	3	3	0.35	IS 1727
vi	Available alkalis as sodium oxide (Na_2O) in percent by mass, Max	1.5	1.5	1.05	IS 4032
vii	Total chlorides in percent by mass, Max	0.05	0.05	--	IS 12423
viii	Loss on ignition in percent by mass, Max	5	5	1.88	IS 1727

Table No.6 Physical requirement of Fly ash (As per IS:3812:2003)

SN.	Characteristic	Requirement	Test value
i	Fineness-specific surface in m^2/kg by Blaine's permeability method, *Min*	320	329
ii	Particles retained on 45 micron IS sieve (wet sieving) in percent, Max	34	15
iii	Lime reactivity — Average compressive strength in N/mm^2, *Min*	4.5	4.85
iv	Compressive strength at 28 days in N/mm^2	< 80%of cement	13.07
v	Soundness by autoclave test Expansion specimen in% percent, *Max*	0.8	0.65

D. CUPOLA FURNACE SLAG

The granulated cupola furnace slag GCFS was produced in the Kapilansh Dhatu Udyog Pvt Ltd,Nagpur. The slag is cooled slowly to form a crystallized and almost inert material, usually used as aggregate. Aggregate is converted in to fine powder.

E. SAND

Used sand was of light grey and free from silt. The sand grains was angular, the shape of the grains approximating to the spherical form; elongated and flattened grains in very negligible quantities. It confirms the requirement of IS 650:1966.

IV. TESTING OF COMPRESSIVE STRENGTH FOR FEASIBILITY

A. Mix proportion

Main focus of experimentation is to identify the feasibility of local materials as ingredient of masonry cement**.** Total 18 mixes were prepared. First 6 mix proportion of masonry cement were prepared by doing variation in OPC & Hydrated lime on volume basis. OPC was replaced by hydrated lime at 0%, 30%, 40%, 50%, 60% & 70%. Similarly in addition to 6 mixes, fly ash &GCFS 50% of total (OPC & Hydrated lime) kept constant. .Composition of masonry cement shown in table no.7 Total one hundred and eight (108) standard 50mm cube cast from the various mixes, cured for 7 days and 28 days as per IS 3466:1988 and IS 4031(Part7):1988 procedure.

ISSN: 2321-8169
263 – 267

Table No.7:Composition of masonry cements MC1 to MC18

Designation	C	L	FA	GCFS
MC1	100	0	0	0
MC2	70	30	0	0
MC3	60	40	0	0
MC4	50	50	0	0
MC5	40	60	0	0
MC6	30	70	0	0
MC7	100	0	50	0
MC8	70	30	50	0
MC9	60	40	50	0
MC10	50	50	50	0
MC11	40	60	50	0
MC12	30	70	50	0
MC13	100	0	0	50
MC14	70	30	0	50
MC15	60	40	0	50
MC16	50	50	0	50
MC17	40	60	0	50
MC18	30	70	0	50

C:OPC 43 grade cement,L:Hydrated lime,P:Pozolana

GCF: Granulated cupolafurnace slag

B. Compressive strength test result

After 7 days and 28 days curing the cube mould was tested on Compression Testing Machine at Concrete Technology laboratory of ITM College of Engineering, Kamptee. The minimum requirement of compressive strength for 7 days is 2.5 N/mm^2 and 5N/mm^2 for 28 days. The result graph in Fig.4.1

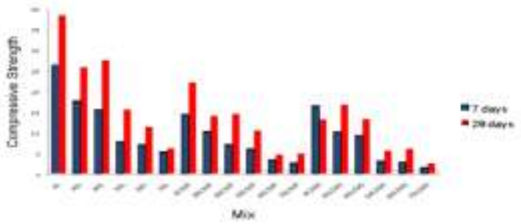

Fig.4.1

V. CONCLUSION

After experimental investigation test result shows that that hydrated lime used in testing work was of B grade as per IS 712.Test results shows fly ash used in testing was calcareous and siliceous.OPC with 30 % lime shows higher result after 7 days strength but lower result in 28 days as compare to 40% lime.OPC with 40% shows higher result after 28 days but lower after 7 days as comparison to OPC with 30%.Graph shows rate of strength gaining between 7 days strength and 28 days higher with MC9 ie 60% OPC :40% Lime :50% Flyash of (OPC+Lime) Out of eighteen mixes proportion sixteen mixes are satisfying the requirement of IS 3466:1988 for compressive strength. Local materials i.e. hydrated lime and fly ash were suitable for blending a masonry cement as ingredient .Local materials were used in testing, not require spatial process or methods .By using such type of local material as ingredient formulation of masonry cement is feasible.

ACKNOWLEDGMENT

We are thankful to management of ITM organization to provide cement and concrete laboratory for experimentation work.

REFERENCES

[1] Copeland, R. E. & E. L. Saxer, "*Tests of Structural Bond of Masonry Mortars to Concrete Block*," Journal of the American Concrete Institute, November 1964, pages 1411-52 .

[2] *"Standard Specification for Masonry Cement"*, C 91, ASTM, 1916 Race Street, Philadelphia, Pennsylvania19103.

[3] *"Indian Standard Specification for Masonry Cement"*, IS 3466, BIS, 1988 Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[4] *"Masonry Information"*, IS 181.04M, Portland Cement Association, 5420 Old Orchard Road Skokie, Illinois 60077-1083 847.966.6200

[5] *"MASONRY CEMENT An Industry view after 1930 onwards"*, Esstech, Essroc Technical notes for masonry, 3251 Bath Pike Nazareth, PA 18064

[6] Naktode P,& Choudhari S.R "*Supplementary Cementitious Materials for Rural Area*" International Journal of Computer Applications ,2012,pp37-42 .

[7] .Cruz J.M.,Paya J, Lalinde L.F,&Fita I.C., "*Evaluation of electric properties of cement mortars containing pozzolana*" Journal of material construction, Vol.61,Februwary2011,pp7-26 .

[8] .Shi Caijun., "*Studies on several factors affecting hydration and Properties of lime-pozzolan cements*" Journal of material in civil engineering, Vol.13,Novemeber 2001,pp441-445.

[9] .Bagchi S.S & Jadhav R.T, *"Blended cement using flyash for masonry and plastering workc*" The Indian Journal Environmental Protection ,July 2009,pp649-652 .

[10] Gengying Li & Xiaozhong Wu "Influence of fly ash and its mean particle size on certain engineeringproperties of cement composite mortars**"** Cement and Concrete Research 35 (2005) 1128–1134

[11] *"Indian Standard Specification for Method of Physical Test for Hydraulic Cement"*, IS 4031(Part-7), BIS, 1988 Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[12] *"Indian Standard Specification of Fly ash for use as pozzolan "*, IS 3812, BIS, 1981 Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[13] "Indian Standard Specification of standard sand for testing cement specification ", IS 650, BIS, 1991 Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[14] *"Indian Standard Specification of method of test for building lime "*, IS 6932,(All part) BIS, 1973,Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[15] *"Indian Standard Specification of method of test for Pozzolana testing "*, IS 1727, BIS, 1967,Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002

[16] *"Indian Standard Specification of lime as building material "*, IS 712, BIS, 1984,Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002