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EXPERIMENTAL INVESTIGATION ON THE PROPERTIES OF CONCRETE REPLACING CEMENT WITH METAKAOLIN, FLY-ASH & BRICK POWDER

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ABSTRACT

The use of cement supplementary materials in structural concrete is widely accepted by the construction industry for technical, economical and environmental reasons firstly this study aimed to investigate crushed clay brick, originated from demolished masonry was ground in the laboratory and used as a partial replacement of cement. Three replacement levels 10%, 20%, 30% were compared with control concrete. Addition of brick powder in concrete decreases the strength. At 10% replacement level 28 days compressive strength will be approximate to control concrete. The best replacement level 10% will be taken as a reference and another two supplementary cementitious materials were metakaolin and fly ash. The replacement levels of metakaolin and fly ash are: 5%, 10%, 15%, 20% These will be blended with 10%level of brick powder and cement separately ([C+10%B.P+M.K], [C+10%B.P+F.A]). The optimal replacement of the cement, brick powder and metakaolin based mixtures [C+10%B.P+15%M.K]. The optimal replacement of cement, brick powder and fly ash based mixtures is [C+10%B.P+15%F.A].

Key Words: Metakaolin, Fly Ash, Brick Powder, Mechanical Properties, Control Concrete.

I INTRODUCTION

Concrete is probably the most extensively used construction material in the world. It is only second to water as the most heavily consumed substance [1]. With current technology, producing 1 ton of cement consumes 1.7 ton raw material and approximately 7000 MJ of electrical power and fuel energy [2] Partially replacing cement with other materials without compromising the properties of concrete is one of the effective ways to make concrete more sustainable. Current researches demonstrate that concrete could be produced with cement partially substituted by clay-brick powder (CBP) [3-5]. In recent years, metakaolin (MK) has been studied because of its high pozzolanic properties [6]. Unlike other pozzolans, it is a primary product, not a secondary product or by-product, which is formed by the dehydroxylation of kaolin precursor upon heating in the temperature range of 700–800 ^{0}C. The raw material input in the manufacture of metakaolin (Al2Si2O7) is kaolin [7]. The term fly ash was first used in the electrical power industry ca. 1930; the first comprehensive data on its use in concrete in North America were reported in 1937 by Davis et al. [8].

II EXPERIMENTAL PROGRAMME

MATERIALS

Concrete was made of ordinary Portland cement 53 grade, Fine aggregate(natural river sand), Coarse aggregate, Potable water, brick powder, fly ash and metakaolin is used as mineral admixtures and Super plasticizer conplast SP-430 is used as chemical admixture.

CEMENT

Specific gravity of cement -3.11

Table-1 Test Results on Cement (IS 12269-1987)

Properties	Results obtained	Range
Setting time Initial Final	 63 min 355 min	 >30 min <600 min
Soundness of Cement	0.2	<10 mm
Fineness	2%	<10%
Standard Consistency	31%	-

FINE AGGREGATE: Locally available sand having specific gravity of 2.64 conforming to IS: 383-1970.

Table-2 Test Results on Fine aggregate (IS 383-1970)

Properties	Results obtained	Range
Specific Gravity	2.62	2.5-3.0
Fineness Modulus Test	2.74	2.6-3.2
Bulking Of sand	4%	-

COARSE AGGREGATE: Locally available crushed stones graded of nominal size of 12.5-20mm as per IS: 383-1970.

WATER

Mixing water should be clean, fresh and potable. Water should be free from impurities like clay, loam, oils and soluble salts which lead to deterioration in properties of concrete. Potable water is fit for mixing and curing of concrete.

FLY ASH:

Finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electro-static precipitator.

Class-F fly ash confined as per **IS 3812:2000**.

Table-3 Chemical Properties of Fly Ash

Properties	**Test results**	**Chemical requirement as per IS 3812-1:2003**
Moisture	0.20%	-
Loss on ignition	4.00%	5.0 Max
Sio2+Al2o3+Fe2o3	89.82%	70.0 Min
Silicon dioxide(sio2)	60.70%	35.0 Min
Reactive silica	52.35%	20.0 Min
Magnesium Oxide(Mgo)	0.64%	5.0 Max
Total Sulphur as Sulphur Trioxide(So3)	0.18%	3.0 Max
Available Alkalis as Sodium Oxide(Na2o)	0.34%	1.5 Max
Total Chlorides	<0.01%	0.05 Max
Specific gravity	2.2	-

BRICK POWDER

Table-4Chemical composition of Brick Powder

Sl.no	Constituent	Percent by wt
1	Silica(SiO2)	89.04
2	Iron oxide(Fe2O3)	1.50
3	Alumina(Al2O3)	4.30
4	Calcium oxide(CaO)	1.10
5	Magnesium oxide(MgO)	0.90
6	Alkalis	0.50
7	Loss on ignition	2.38

METAKAOLIN

Physical Form: powder

Color: Off white

Table-5Chemical composition of Metakaolin

Sl.no	Constituent	Percent by wt
1	SiO_2	52. 86%
2	CaO	0. 28%
3	MgO	0. 20%
4	Fe_2O_3	0. 45%
5	Al_2O_3	44.10%
6	loss on ignition	0. 85%
7	Na_2O	0. 25%
8	K_2O	0. 20%
9	TiO_2	0. 36%

MIX PROPORTIONS

Design grade of concrete: M40 (as per IS: 10262-2009 and IS 456-2000)

Water : Cement : Fine Aggregate : coarse aggregate : Super plasticizer - 0.38 :1 : 1.68 : 2.95 : 0.015

Table-6 CONCRETE MIXTURE PROPORTIONS FOR 1 M^3 OF CONCRETE (M40 GRADE)

Material mixture (in %)	Gravel(KG)	sand(KG)	cement(KG)	B.P	Sp
Control	1180	672	400	-	0.015
CBP10	1062	604.8	360	10%	0.015
CBP20	944	537.6	320	20%	0.015
CBP30	826	470.4	280	30%	0.015

Table-7 CONCRETE MIXTURE PROPORTIONS FOR 1 M^3 OF CONCRETE (M40 GRADE)

Material mixture (in %)	Gravel(Kg)	sand(Kg)	cement(Kg)	B.P	M.K	W/C	Sp
Control	1180	672	400	-	-	0.38	0.015
M.K 5	1003	571.2	340	10%	5%	0.38	0.015
M.K10	944	537.6	320	10%	10%	0.38	0.015
M.K15	885	504	300	10%	15%	0.38	0.015
M.K20	826	470.4	280	10%	20%	0.38	0.015

Table-8 CONCRETE MIXTURE PROPORTIONS FOR 1 M^3 OF CONCRETE (M40 GRADE)

Material mixture (in %)	Gravel(Kg)	sand(Kg)	cement(Kg)	B.P	F.A	W/C	Sp
Control	1180	672	400	-	-	0.38	0.015
F.A5	1003	571.2	340	10%	5%	0.38	0.015
F.A10	944	537.6	320	10%	10%	0.38	0.015
F.A15	885	504	300	10%	15%	0.38	0.015
F.A20	826	470.4	280	10%	20%	0.38	0.015

III TEST METHODS

The compressive strength, tensile strength and flexural strengths of various concrete mixtures were determined on $150mm^3$ cubes, 150x300mm cylinders and 100x100x500mm beams respectively.

Table -9 COMPRESSIVE STRENGTH OF THE CONCRETE MIXTURES(C+BP)

Cement+B.P (in %)	7 days CS	28 days CS	60 days CS	90 days CS
control mix	42.45	49.36	52.23	56.27
10	38.30	49.02	53.89	55.71
20	35.76	45.29	47.62	52.58
30	31.91	39.97	42.58	47.31

Table -10 COMPRESSIVE STRENGTH OF THE CONCRETE(C+BP+MK):

Cement+B.P+M.K (in %)	7 days CS	28 days CS	60 days CS	90 days CS
Control mix	42.45	49.36	52.23	56.67
10%+5%	38	50.5	54.04	55.12
10%+10%	42	51.10	53.10	57.97
10%+15%	44	53.84	54.49	56.12
10%+20%	40.20	48.24	49.68	51.38

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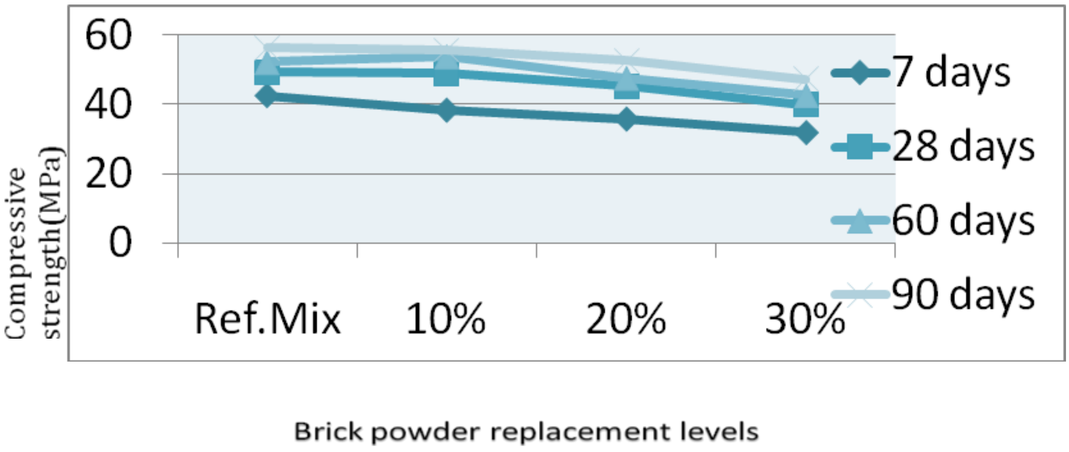
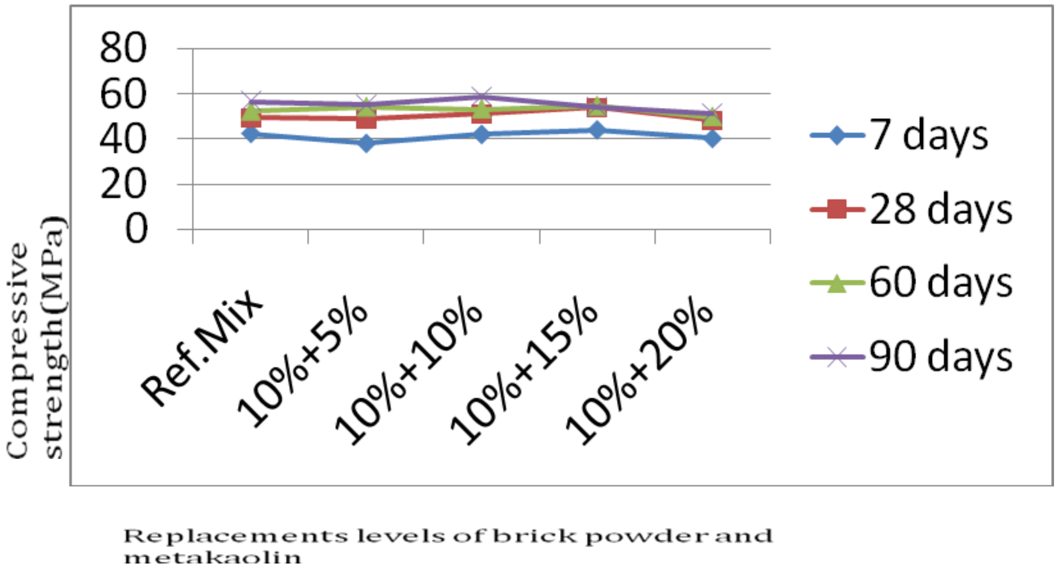
Table- 11COMPRESSIVE STRENGTH OF THE CONCRETE(C+BP+FA)

Cement+B.P+F.A (in %)	7 days	28 days	60 days	90 days
control mix	42.45	49.36	52.23	56.27
10%+5%	38	44.12	48.00	51.25
10%+10%	39.76	46.39	48.92	52.58
10%+15%	41.38	53.57	55.65	56.31
10%+20%	42.24	48.57	49.20	51.33

Graph for table -9



Graph for table-10



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Graph for table-10

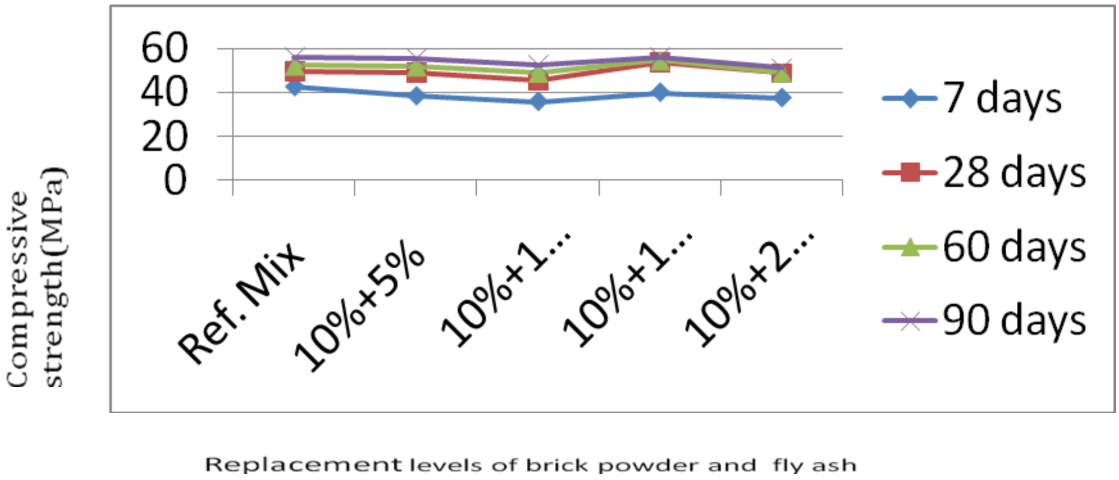

Table- 12 SPLIT TENSILE STRENGTH OF THE CONCRETE(C+BP)

Cement+B.P	7 days S.T.S	28 days S.T.S
control mix	3.10	3.69
10%	3.19	4.02
20%	2.97	3.67
30%	2.68	3.24

Table -13 SPLIT TENSILE STRENGTH OF THE CONCRETE(C+BP+MK)

Cement+B.P+M.K	7 days STS	28 days STS
control mix	3.10	3.69
10%+5%	2.96	3.58
10%+10%	3.21	3.71
10%+15%	2.81	3.50
10%+20%	2.65	3.27

Table -14 SPLIT TENSILE STRENGTH OF THE CONCRETE(C+BP+FA)

Cement+BP+FA	7 days STS	28 days STS
control mix	3.10	3.69
10%+5%	2.84	3.58
10%+10%	3.24	3.73
10%+15%	3.62	3.90
10%+20%	2.97	3.54

Table -15 FLEXURAL STRENGTH OF THE CONCRETE(C+BP)

Cement+B.P	7 days	28 days
control mix	5.93	7.05
10%	5.65	6.86
20%	5.42	6.20
30%	5.19	5.6

Table -16 FLEXURAL STRENGTH OF THE CONCRETE(C+BP+MK)

Cement+B.P+M.K	7 days	28 days
control mix	5.93	7.05
10%+5%	5.35	6.32
10%+10%	5.25	6.00
10%+15%	4.95	5.84
10%+20%	4.52	4.72

Table -17 FLEXURAL STRENGTH OF THE CONCRETE(C+BP+FA)

Cement+B.P+FA	7 days	28 days
control mix	5.93	7.05
10%+5%	5.12	6.34
10%+10%	6.18	7.22
10%+15%	6.65	7.41
10%+20%	5.37	6.20

IV CONCLUSION

One of the effective ways to reduce the negative impacts of the cement industry is replacing the cement component of concrete with other materials like industrial wastes or by products fly ash, metakaolin and brick powder. Waste can act as a filler and reinforcement to the concrete.

1. Addition of BP into concrete strength will be decreased however, with proper mix design concrete with BP will increase the strength. As the curing age increases the compressive strength will be increased. 90 days compressive strength of concrete containing brick powder up to 20% level was over 50MPa.
2. The optimal replacement of the cement, brick powder and metakaolin based mixtures [C+10%B.P+15%M.K]
3. The optimal replacement of cement, brick powder and fly ash based mixtures is [C+10%B.P+15%F.A]

REFERENCES

[1] Sabir BB, Wild S, Bai J. Metakaolin and cacined clays as Pozzolans for concrete: a review. Cem Concr Compos 2001; 23(6):441–54

[2] Mindess S, Young JF, Darwin D. Concrete. 2nd ed. Upper Saddle River, New Jersey: Prentice Hall; 2003. p. 20–21

[3] G. Moriconi, V. Corinaldesi, and R. Antonucci, Environmentally-friendly mortars: a Way to improve bond between mortar and brick, Mater. Struct. 36 (2003) 702–708

[4] S. Wild, J.M. Khatib, B.B. Sabir, S.D. Addis, The potential of fired brick clay as a Partial cement replacement, in: R.K. Dhir, T.D. Dyer (Eds.), International Congress-Concrete in the Service of Mankind, Dundee, June 1996. Concrete for Environment Enhancement and Products, Theme 6: Waste Materials and Alternative Products, E&FN Spon, 1996. ISBN: 0-419-21450

[5] L. Zheng, Z. Ge, Mechanical properties of mortar with recycled clay-brick powder, in: ASCE Conf Proc, ICCTP 2011: Towards Sustainable Transportation Systems

[6]. Frias M, Cabrera J. Pore size distribution and degree of hydration of metakaolin–cement pastes. Cem Concr Res 2000;30(4):561–9

[7] Klimesch DS, Ray A. Autoclaved cement–quartz pastes with metakaolin additions. Adv Cem Based Mater 1998;7(3):109–18

[8] R.E. Davis, R.W. Carlson, J.W. Kelly, H.E. Davis, Properties of cements and concretes containing fly ash. J. Am. Concr. Inst. 33, 577–612 (1937)