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Hardened Properties of Concrete by Incorporating Brick Powder & Metakaolin by Partial Replacement of Cement

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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 conventional 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 supplementary cementitious material was metakaolin. The replacement levels of metakaolin are: 5%, 10%, 15%, 20% these will be blended with 10%level of brick powder and cement separately ([C+10%B.P+M.K].The optimal replacement of the cement, brick powder and metakaolin based mixtures [C+10%B.P+15%M.K]. The use of cement supplementary materials in structural concrete is widely accepted by the construction industry for technical, economic 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 conventional 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 supplementary cementitious material was metakaolin. The replacement levels of metakaolin are: 5%, 10%, 15%, 20% these will be blended with 10%level of brick powder and cement separately ([C+10%B.P+M.K].The optimal replacement of the cement, brick powder and metakaolin based mixtures [C+10%B.P+15%M.K].

KEYWORDS: *Cement, Brick Powder, Metakaloin*

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. With current technology, producing 1 ton of cement consumes 1.7 ton raw material and approximately 7000 MJ of electrical power and fuel energy. 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).In recent years, metakaolin (MK) has been studied because of its high pozzolanic properties. 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 0C. The raw material input in the manufacture of metakaolin (Al2Si2O7) is kaolin.

II. EXPERIMENTAL PROGRAAMME

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

A. CEMENT

In this work cement of OPC53 grade was used for all concrete mixes. The cement was of uniform color i.e., grey with a light greenish shade and was free from any solid lumps. The various tests conducted on cement are fineness, standard or normal consistency, initial setting time, final setting time, specific gravity and compressive strength etc. testing of cement was done as per IS: 12269-1987. Various test results conducted on cement are reported in Table 1.

Table 1 Physical Properties of Cement

Properties	Observed	As per IS code 12269 -1987
Initial setting time	42 min	Not be less than 30 min
Final setting time	310 min	Not be greater than 600 min
Fineness (%)	2mm	Not be greater than 10
Specific gravity	3.11	-
Compressive strength	55.7MPa	Not be less than 53 N/mm^2

B. FINE AGGREGATE

The natural sand used for the experimental programme was locally procured and conformed to grading zone II as per IS: 383-1970. The sand which is passed on 4.75 mm sieve and retained on 150μ sieve is used.

Table 2 Physical Properties of Fine Aggregates

Properties	Value
Type	Uncrushed(natural)
Specificgravity	2.62
Fineness modulus	2.74
Gradingzone	ZoneII

C. COARSE AGGREGATE

Locally available coarse aggregate having the maximum size of the 20mm were used in the present work. Testing on coarse aggregate was done as per IS: 383-1970. They were then washed to remove dust and dirt and were dried to surface dry condition. The results of various tests conducted on coarse aggregate are given in table 3.

Table 3 Physical Properties of Coarse Aggregate

Properties	Value
Type	Crushed
Maximum size	20 mm
Specific gravity(20 mm)	2.66
Fineness modulus (20 mm)	7.87

D. WATER

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

E. WASTE BRICK POWDER

Bricks are a widely used construction and building material around the world. In developing countries bricks are still one of the most popular construction materials. India is the second largest producer of fired clay bricks after china. Bricks are a widely used construction and building material around the world. Waste brick powder is used as a cement substitute.

Table 4 Physical Properties of the Brick Powder

Properties	Results
Color	Brick red
Specificgravity	2.45
Bulk density (kg/m^3)	1810

F. METAKAOLIN

Metakaolin is brought from ASTHRA Chemicals Chennai having 50-55% of SiO_2 and Specific gravity 2.5 and finer than Cement.

Table 5 physical properties of the Metakaolin

Properties	Results
Color	White
Specific gravity	2.5
Bulk density (kg/m^3)	1810

III. MIX PROPORTIONS

Design grade of concrete: M35 (as per IS: 10262-2009 and IS 456-2000)

Water: Cement: Fine Aggregate: coarse aggregate: Super plasticizer - 0.38:1: 1.87: 3.15: 0.015

Table 6 Concrete Mixture Proportions for 1 m^3 of Concrete (Cement + Brick Powder + Metakaolin)

Dosage of BP &MK	Gravel(Kg)	sand(Kg)	cement (Kg)	BP	MK	W/C	SP
Conventional	1204	715	382	-	-	0.38	-
MK 5%	1204	715	324.7	10 %	5 %	0.38	0.015
MK10%	1204	715	305.6	10 %	10 %	0.38	0.015
MK15%	1204	715	286.5	10 %	15 %	0.38	0.015
MK20%	1204	715	267.4	10 %	20 %	0.38	0.015

IV. TEST METHODS

A. SPECIMENS FOR CASTING

CUBES: The moulds used for the concrete cubes are made up of cast iron with dimensions of 150 mm X 150 mm X 150 mm for Compressive Strength studies.

CYLINDERS: Cast Iron moulds are used of size 150 mm diameter X 300 mm height for Split Tensile Strength.

All the specimens were prepares in accordance with Indian standard specification IS: 516-1959.

B. COMPRESSIVE STRENGTH TEST

This test is performed on 150 mm size cube specimens to determine compressive strength of concrete after 7, 28, 60, 90days curing.

Apparatus used: Compressive Testing Machine (CTM)

Compressive Strength of Concrete is calculated from the following formulae:

$$C = \frac{P}{A}$$

Were **P** is the maximum load at failure in N

A is the area of Cube specimen in mm

Table 7 Compressive strength of concrete mixtures (Cement + Brick Powder + Metakaolin)

Mix Designation	ConventionalMix	C+10%BP+5%MK	C+10% BP+10% MK	C+10%BP+15% MK	C+10%BP+20% MK
7 days	37.14	38.59	40.39	43.1	36.69
28 days	43.9	44.23	45.42	47.13	42.49
60 days	45.7	46.41	46.59	47.68	43.47
90 days	49.23	49.98	50.72	51.38	46.97

C. SPLIT TENSILE STRENGTH TEST

The Cylindrical specimens were tested at the age of 7, 28, 60, 90 days in compression testing machine.

Apparatus used: Compressive Testing Machine (CTM)

Split Tensile Strength of Concrete is calculated from the following formulae:

$$S = \frac{2P}{\pi DL}$$

Where **P** is maximum load at failure in N

D and **L** are the diameter and length of the cylindrical specimen in mm

Table 8 Split Tensile Strength of concrete mixtures (Cement + Brick Powder + Metakaolin)

Mix Designation	Conventional Mix	C+10%BP+5%MK	C+10% BP+10 %MK	C+10% BP+15 %MK	C+10%BP+20%MK
7 days	3.67	3.93	4.16	4.31	3.55
28 days	4.34	4.51	4.67	4.78	4.14
90 days	4.83	5.17	5.22	5.37	4.67

D. ULTRASONIC PULSE VELOCITY TEST

It is a non-destructive testing technique (NDT). The method consists of measuring the ultrasonic pulse velocity through the concrete with a generator and a receiver. This test can be performed on samples in the laboratory or on-site. The results are affected by a number of factors such as the surface and the maturity of concrete, the travel distance of the wave, the presence of reinforcement, mixture proportion, aggregate type and size, age of concrete, moisture content, etc., furthermore some factors significantly affecting UPV might have little influence on concrete strength. Table 15 shows the quality of concrete for different values of pulse velocity.

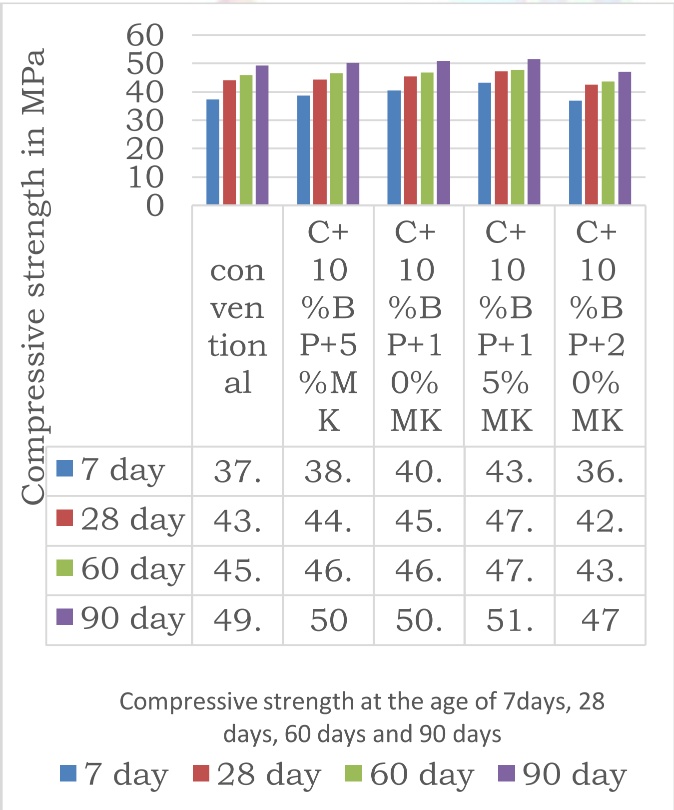
Table 9 Criteria for quality of concrete

PULSE VELOCITY	CONCRETE QUALITY
>4000 m/s	Excellent
3500-4000 m/s	Very Good
3000-3500 m/s	Satisfactory
<3000 m/s	Poor

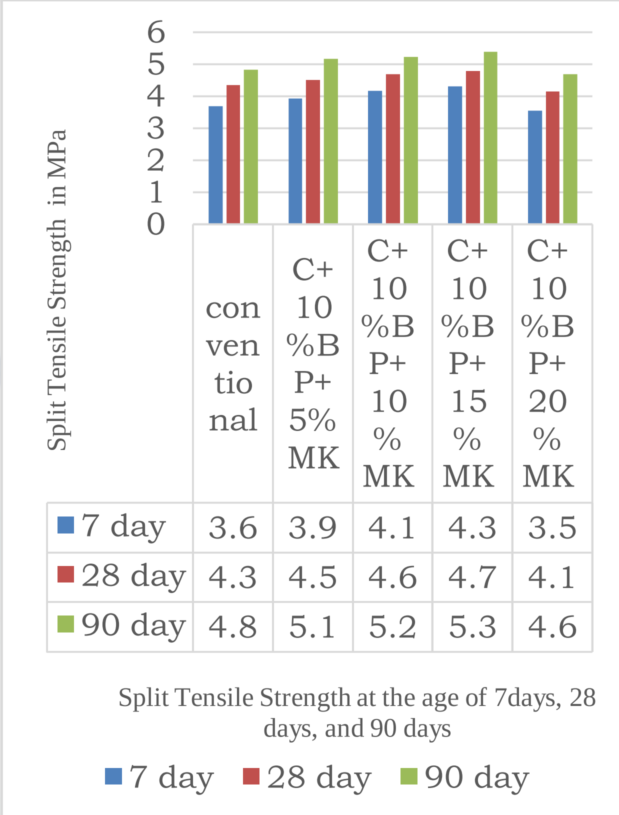
Fig 1 UPV cube testing

Table 10 Ultrasonic pulse velocity of concrete mixtures(cement + Brick powder+metakaloin)

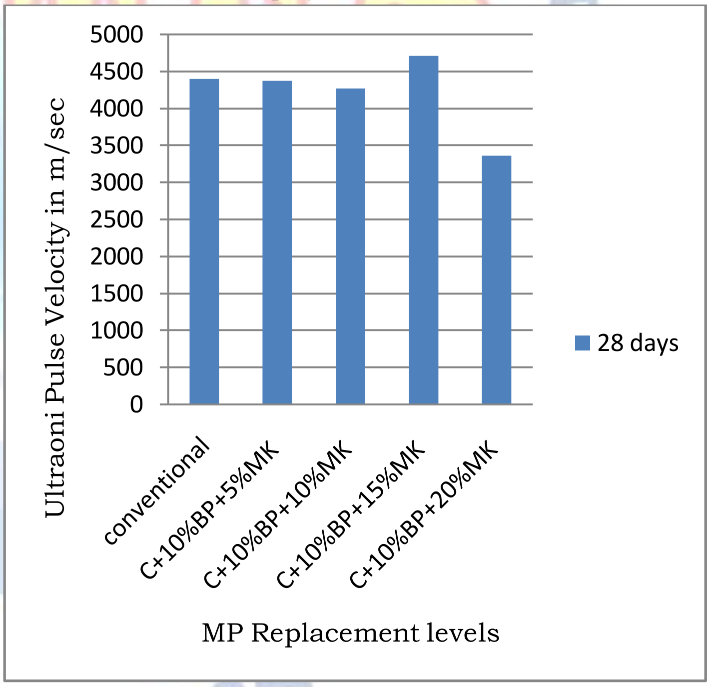
Mix Designation	ConventionalMix	C+10%BP+5%MK	C+10%BP+10%MK	C+10%BP+15%MK	C+10%BP+20%MK
28 days	4395	4372	4263	4708	3354



Graph for Table-7



Graph for Table-8



Graph for Table-10

V. CONCLUSSION

Based on the above study, the following observations are made regarding the strength properties of concrete on partial replacement of cement by mineral admixtures such as Brick Powder, Metakaolin.

[1] The optimal replacement of the cement, brick powder and metakaolin for compressive strength is [C+10%B.P+15%M.K]

[2] The optimal replacement of the cement, brick powder and metakaolin for Split tenssile strength is [C+10%B.P+15%M.K]

[3] Among all the test results it was observed that the UPV value is >4000m/sec up to a percentage of [C+10%B.P+15%M.K] the quality of concrete is excellent beyond the [C+10%B.P+20%M.K] level the quality of concrete is satisfactory.

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