An Experimental Investigation on Meta Kaolin Modified Concrete Paver Blocks

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ABSTRACT

Concrete paver blocks are special pre-cast pieces of concrete blocks of non-interlocking or interlocking types, commonly used in exterior landscaping pavement applications. Properly designed and constructed paver blocks give excellent performance at locations where conventional pavement systems have lower service life due to a number of environmental, geological constraints. But with the use of high-performance concrete, they can be designed to sustain light, medium, heavy and very heavy traffic conditions under any constraints. Modern concrete can be modified with addition of mineral admixtures which refine the microstructures of the concrete and enhance its physical properties and durability. Meta kaolin, produced by controlled thermal treatment of kaolin, can be used as a concrete constituent, since it has pozzolanic properties. It is a highly efficient Pozzolana and react rapidly with the excess calcium hydroxide resulting from OPC hydration by a pozzolanic reaction, to produce calcium silicate hydrate and calcium alumina silicate hydrates.

INTRODUCTION

Concrete is a product attained artificially by hardening the mixture of cement, sand, gravel and water in suitable quantities. As we know concrete is a composite material which is mostly used in construction industry all over the world. It is artificially attained by mixing the cementitious materials, aggregates and water in predetermined quantities. The word"concrete"is originated from the Latin word"concrete" which has the meaning to grow together to harden. The strength properties for the concrete depend upon the properties for constituent of material used and their combined action.

In the manufacturing process of cement CO_2gas emission is high, which results in damaging the natural environment and climatic conditions. To reduce the utilization of cement, partial standby of cement with some additional cementitious materials like Meta kaolin (MK), bottom ash, rice husk ash, GGBS and silica fume etc., are used in concrete production. Meta kaolin is a de hydroxylated form of the Kaolin clay mineral. Stones having the high percentage of kaolinite are called as the china clay (kaolin) was traditionally used as the manufacturing of the porcelain ceramic material. Meta kaolin reacts with Ca $(OH)_2$which is oneofthe by-product of hydration reaction of cement and its forms the C-S-H gel. This gel formation results in increasing strength and durability of the concrete. By replacing cement with MK increases the strength and durability and reduces the porosity in the concrete and reduces the permeability also.

Paver blocks

Concrete paver blocks were first used in Holland as substitution of paver blocks. These blocks were rectangular in shape and had almost the same size as the bricks. Since last fifty years the block shapes of paving blocks had been modified depending on the applications. Initially they were designed as non-interlocking or partially inter locking, then modified to fully interlocking shape types. These paver blocks are precast concrete units which are laid on thin compacted bedding over a profiled base course to construct a pavement.

If non-interlocking or partially-interlocking paver blocks are used, then it is called Concrete Block Pavement (CBP) and if interlocking paver blocks are used the pavement is called 'Interlocking Concrete Block Pavement (ICBP).

Materials

Cement

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction. It is used as a basic ingredient of concrete. Ordinary Portland cement is classified as OPC-53, OPC-43, OPC-33 grades. The 43 grade OPC is the most popular general-purpose cement in India.

The four basic chemical compounds of OPC are tricalcium silicate (3CaO.SiO2), dicalcium silicate (2CaO.SiO2), tricalcium aluminate (3CaO.Al2O3) and tetra calcium alumino ferrite (4CaO. Al2O3.Fe2O3). Their relative percentage in cement derive the essential properties in the cement concrete mix. The chemical composition of OPC is shown in Table 1.2

Table1.2ChemicalCompositionofCement

Chemicals	**Mass(%)**
CaO	60-67
SiO2	17-25
Al2O3	3-8
Fe2O3	0.5-6
MgO	0.1-4

Metakaolin

Meta kaolin is a highly reactive Pozzolana for use in concrete. It is not a by-product but a product that is manufactured for use by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Its quality is controlled during manufacture, resulting in a much less variable material than industrial Pozzolana that are by- products. First used in the 1960s for the construction of a number of large dams in Brazil, Meta kaolin was successfully incorporated into the concrete with the original intention of suppressing any damage due to alkali-silica reaction.

When used to replacecement at levels of5 to10%by weight ,the concrete produced is generally more cohesive and less likely to bleed. As a result, pumping and finishing processes require less effort. The compressive strength of hardened concrete is also increased at this level of replacement.

Slightly higher replacement levels (up to 20%) produce a cement matrix that has low porosity and permeability. This results in improvements to resistance of the hardened concrete to attack by sulfates, chloride ions and other aggressive substances, such as mineral and organic acids. Freeze/thaw resistance is improved and the risk of damage resulting from the effects of impactor abrasion is reduced for Meta kaolin concrete that has been finished and cured properly.

LITERATURE REVIEW

Satyendra Dubey et al. (2015) aimed to study effect of Meta kaolin on compressive strength of concrete. For M25grade of concrete by replacing cement with 0, 5, 10, 15% MK. The results to showed that 10% MK is the optimum %replacement and the other % of MK suchas5 and 15% also showed that considerable increase in strength characteristics of the concrete when compared with conventional concrete.

Nikhil Kand Ajay A.H (2015) studied the valuation of Strength of Plain Cement Concrete with Partial substitute of Cement by MK. In this study they observed replacement of cement with MK and fly ash at 0%, 5%, 10% and 15% for 7days and 28 days for M20and M25. And these results compared with the conventional concrete. Finally, they concluded that up to 15% replacement cement with MK and flyash strength is increasing, beyond strength was decreased. Therefore, it is always better to use 10% for good results.

Nazeer M et al. (2014)aimed to study the assessment of Strength Studies on Metakaolin Blended with High-Volume Concrete. Generally, the addition of Pozzolana to concrete will improve some properties like Workability, Later age strength and Resistance to sulfate and Chloride attacks. In their research work 50% of cement was replaced with

Class-F MK and 0%, 5%, 10%, 15% and 20% of Metakaolin is also replaced in place of cement for M_{30} grade concrete mix. From this research study they concluded as addition of MK and SF in concrete reduces the Workability. Mechanical properties for example compressive strength, split tensile strength and modulus of elasticity shows diminishing trend with the increasing of MK. The declined in workability of high-volume MK concrete changed with the addition of MK shall be expressed as a function of MK content in the mix.

Nova John (2013) studied the Strength Properties of MK Admixed Concrete. In this study they studied the strength properties for M_{30}concrete at 0%, 5%, 10%, 15%, 20%. Finally, they concluded that MK gives faster early age strength and mix with 15% is superior to all other mixes. Theusage of supplementary cementitious material like MK concrete can compensate for environmental and economic issues caused by cement industry.

EXPERIMENTAL PROGRAMME

The process to select the mixing materials and their appropriate quantities is done through mix design. There are ways to find the concrete mix design. The methods which are using in India are in accordance with the BIS. The main objective of the concrete mix design is to find the appropriate proportion in which the concrete ingredients like cement, water, fine aggregate and coarse aggregate should be mixed to provide the specified strength, durability and workability and possibly meet other requirements according to IS: 456-2000. IS: 10262-2009 code which gives the guidelines for the nominal concrete mix designs.

This chapter deals with the properties of the material used and methodology for evolving concrete mixes with Metakaolin in varying percentages. The main objective of this research study was the assessment of the mechanical properties in terms of compressive strength, flexural strength and water absorption of concrete. The materials used for this research work and experiments performed on concrete specimens have been discussed in this chapter.

Natural Fine Aggregate
Locally available river coarse sand is used as a fine aggregate. The sieve analysis and physical properties of fine aggregate have been shown in the table below. Fine aggregate(sand) conforms to Grading Zone-III as per **IS: 383-1970**.
Wight of Sample Taken=1000gms.

Table3.5Sieveanalysisoffineaggregate

S.No	ieve Size (mm)	ιetained Weight (gms)	%Weight Retained	mulative% Retained	%finer
1	4.75	16	1.6	1.6	98.4
2	2.36	28	2.8	4.4	95.6
3	1.18	97	9.7	14.1	85.6
4	0.6	282	28.2	42.3	57.7
5	0.3	221	22.1	64.4	35.6
6	0.15	331	33.1	99.5	0.5
7	Pan	20	0.2	99.7	0.3

Concrete Mix Design
Mix Design
Mix design is done for the present study. Generally, for the manufacture of precast concrete paver blocks needs dry,low slump mixes. Mix design was done for control mix ofM40 grade of concrete by using the IS code 10262: 2009 and specification given in the IS code15658: 2006

Manufacturing of paver block

Cement, sand, coarse aggregate, water and super plasticisers were mixed thoroughly in the concrete mixer. Then it was filled in the rubber paver mould of different shapes and different thickness. All the filled paver moulds were vibrated using table vibrator. After casting all the specimens were completed with a steel trowel and it was kept for 24 hours. After 24 hours they were remoulded from the paver moulds and kept in the water tank for water curing. The same procedure was done for 5%,10% and15% replacement of cement with metakaolin. To know the effect of standby of cement with metakaolin, compressive strength, flexural strength, were done on the paver block.

Testing of Paver block

Compressive strength

As per IS 15658: 2006, compressive strength of paver block was determined at 7 and 28 day using universal testing machine (UTM). Minimum 3 samples were tested for 7- and 28-day strength. The average strength of 3 samples at 28 days were taken as compressive strength of paver block. The apparent compressive strength of paver block was multiplied with correction factor as it is mentioned in IS 15658: 2006 of table 5 Annex D to get corrected compressive strength of paver block.

RESULTS AND DISCUSSION

The results obtained from experiments conducted on concrete paving blocks have been discussed in this chapter. A comparison of results has been made to evaluate the effect of the partial replacement of the cement by Meta kaolin in concrete mixes to determine the mechanical properties at the age of 7 days and 28 days.

One reference mix M0 of M40 grade was prepared without addition of Meta kaolin and three more mixes M1, M2 and M3 were prepared with Meta kaolin of varying amounts 5%,10% and 15%usedas partial replacement of cement respectively. Three different shapes of paver blocks, Zigzag, I shaped, and Dumbel shaped were adopted for the study. Eight specimens of each type of paver blocks were cast and cured for 7daysand 28 days.

Compressive strength

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EDS Analysis

EDS is energy dispersive X-ray spectroscopy. It isa characterization technique that provides elemental composition of various constituent elements in a material. The abscissa of the EDX spectrum indicates the ionization energy and ordinate indicates the counts. Higher the counts of a particular element, higher will be its presence at that point or area of interest.

Table4.7EDSanalysisofdifferentmixes

Mix	**Si(%wt)**	**Ca(%wt)**
M0	1.60	13.98
M1	8.02	8.75
M2	6.48	8.01
M3	11.18	2.84

- EDS analysis of control mix with OPC M0 gave higher count of Ca (13.98%) and less count of Si (1.60%) indicating higher percentage of CSH gel.
- The mix with5%MetakaolinM1 showed increase in Si count(8.02%)due to addition of Metakaolin and reduction in Ca count (8.75%) due to consumption of CH in forming secondary CSH gel.
- The Mix with10% Metakaolin M2 exhibited further reduction in Si count(6.48%) which may be due to higher consumption of Si to form more secondary CSH gel forming more compact microstructure and thereby providing more strength.
- The mix with 15% M3 showed smaller count of Ca (2.84%) which may be due to consumption of higher CH in

pozzolanic reaction and gave higher count of Si (11.18%) which may be due to addition of higher quantity of Metakaolin and presence of un hydrated Metakaolin particles owing to non-availability of enough CH for further hydration.

CONCLUSION

The aim of the present research work is to determine the mechanical properties of concrete with MK as the admixture for M_{40}grade of concrete Paver blocks. On the basis of experimental investigation of the present research study, the following conclusions have been drawn.

It is observed that compressive strength of paver block for all the shape and thickness at7 and 28 days are increased as percentage of cement replacement with MK increases up to 10%. . 7 days compressive strength of paver block for all the shapes are more than required target strength up to 15% cement replacement. The maximum compressive strength for all the shapes are more at 10% of replacement. The maximum compressive strength of Dumbel (60mm) thickness at 10% replacement is 74.26 MPa which is about 23% more than that of control concrete.

Flexural strength is increasing as cement replacement increases up to 10% after that for 15% cement replacement it is more than control concrete and also more than 5% replacement. 7-dayand 28-dayflexural strength is increases up to 10 %replacement after that it decreases as percentage of replacement increases. Even though there is decrease in flexural strengthat28 daysafter10%replacement of cement the flexural strengthat15% replacement also morethan4.5MPa for all the shapes which is required strength for rigid concrete pavement.

1. Use of Metakaolin as partial replacement of cement increases mechanical properties like compressive strength, flexural strength of concrete.
2. Concrete with Metakaolin also exhibited better durability in terms of water absorption.
3. It was observed that10 percent Metakaolin used as partial replacement of cement improve overall properties of concrete paver blocks.

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