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Comparison of compressive strength of cement mortars using an industrial product obtained from three different regions of India

Moulshree Dubey [1, *], S. V. Deo [2], G. D. Ramtekkar [3]

[1] Department of Civil Engineering, Research Scholar, National Institute of Technology, Raipur 492 010, India
[2] Department of Civil Engineering, Associate Professor, National Institute of Technology, Raipur, 492 010, India
[3] Department of Civil Engineering, Professor, National Institute of Technology, Raipur, 492 010, India,

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Abstract

The quest to realize initial strength and develop high strength concrete has increased considerably in recent times. Cement is one among the main sources of environmental impacts of concrete use. it's therefore recognized because the most practical solution to scale back the environmental impacts of concrete, the shortage of cement content. this will be achieved by replacing some of cement with an industrial product like metakaolin. Metakaolin is that the material obtained by calcination of kaolinite at 500 and 800 degrees. Metakaolin (MK), in its applications partial replacement of cement, features a particularly growing role worldwide for technological enhancement thanks to its pozzolanic activity and mainly to realize strength. This paper portrays the results of an investigation on the utilization of metakaolin (MK) as a complementary cement material. Four metakaolin substitution levels were employed in experimental studies of mortar mixes: 5% 10% 15% and 20% by weight of hydraulic cement. The concise strength of mortar cubes with different levels of metakaolin with different chemical properties obtained from three different regions of India, namely Maharashtra, Gujarat and Tamil Nadu, was compared. The chemical composition of varied metakaolin was obtained by conducting X-ray deflection analysis. Mortar cubes are cast with varying w / b ratios, i.e. 5% to twenty substitution by metakaolin with replacement of cement at 0.30, 0.35, 0.40 and 0.45 w / b ratios. The results depicted that, overall, 20% substitution of metakaolin from Maharashtra, Gujarat and Tamil Nadu significantly increased the compressive strength. At a ratio of 0.45 w / b, Metakaolin from Tamil Nadu achieved initial strength upon 10% replacement of cement by metakaolin.

Keywords: Metakaolin, Mortar, Compressive Strength, Mix Design, X-Ray Diffraction, Pozzolana.

1. Introduction

Concrete is a "man-made" material in which bonds are reinforced simultaneously when it is mixed with water. With the innovation and expanding field of use of cement and mortar, the quality, utility, strength, and various characteristics of common cement can be justified for a situation. For this, bonds, water, coarse aggregate, fine aggregate, mineral mixture and synthetic mixture are needed separately. Metakaolin is a mineral mixture that can be used as a partial replacement. Further CH is also formed in the hydration process of cement CSH which does not make a very large commitment to quality and can be harmful to solid solubility.

The utilization of calcined earth as metakaolin (MK) as a pozzolanic extension to mortar and cement has gained significant impetus for late years. A lot of this intrigue has been centered around the extraction of CH, which is formed by hydration of bonds and which is related to inferior strength. CH deficiency makes solids and mortars resistant to deliberate sulfate attack which reduces the effect of the soluble base - silica reaction. This gives the superior quality that is obtained from the additional cementite phases produced by the reaction of CH with MH. MK is controlled by high-immaturity kaolin earth by calcination at moderate temperatures up to 800 degrees Celsius. Alumina and silica in MK react sufficiently with CH.

The main purpose behind the use of clay-based pozzolan in mortar and cement has been due to the improvement in accessibility and strength of the material. In addition to that it also depends on the calcining temperature and the category of sludge. It is likewise conceivable to obtain upgrades in quality, especially among restorative quality. In all cases the initial quality upgrade is due to a mixture of

*Corresponding author. Tel: +917712254200; E-mail address: smastmouly@gmail.com

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filler effects and accelerating concrete hydration. Thus, the pozzolanic reaction between hydration of bonds between MK and CH improves these effects.

In this way the MK is an extremely powerful pozzolana and results in improved quality that is not burdened with long run quality. MK bonding changes the pore structure in glue, mortar and cement and makes the blends resistant to the spread of destructive particles and water infiltration that cause dissection of the frame. The addition of metakaolin to concrete also increases its durability. The applications of metakaolin as cementitious material is being growing owing to the benefits it offers especially in the building industry. Metakaolin provides accelerated early age compressive strength which in turn facilitates faster production times. Its application in housing schemes, flyovers and other projects is scaling up. The pozzolanic reaction greatly depends on the quality and raw materials used in the production of metakaolin.

2. Literature Review

Moises Fraiset al. (2000) The founders have demonstrated the results of experiments focused on the effects of metakaolin (MK) on the formation of mixed flakes in MK. Glue containing 0% - 25% MK at different intervals was developed in a 0.55 water / folio consistency and returned to 200 C for a hydration period of 1 to 360 days. They observed a complete gel uptake and a gel agent with a set time and analyzed the level of hydration in the typical Portland bonds and metakaolin glues. The level of hydration is determined by the ratio of the Ca (OH) 2 present in the glue and the information derived from the probe gram (DTA) thermogrametry (TG) variant. A positive relationship has been established between porous and hydration levels. All pores are reduced to 28-56 days after release. You have noticed that in all combinations, the time from 28 to 56 days of pores release is the same. Pores of all metakaolin compounds expanded over the past 56 days when heterogenible and OPC mixtures were made. The best evidence of the effect of MK on polluting the pore structure was expressed in the pores with a little sweep compared to 100 0A. Within 7,090 days, the MK gel filtrate increases, while the OPC mixture remains consistent with the goals and objectives. The results indicate the need to achieve significant improvements in the normal pore width and reduction of gel porosity. The rated content of lime indicates overall consumption of MK (10% - 15%) during the 90-day hydration period. A positive correlation between hydration levels and pores levels has been found.

Jamal M. et al. (2003) in their experiments, water retention (WA) by total lubrication and a reduction in cement containing Metakaolin (MK) is observed. Bond partially replaced Metakaolin and in the latter case. Privacy is brought about by the state of precise and balanced Metakaolin particles. They think that shear thickening is represented by water which is a folio ratio, a measure of Metakaolin and its light. The saturated properties can be determined by looking at the plate like and renish state of the elements of MK particles and SF.

Gruber et al. (2001) Examinations completed by the above creators found that the temperature climbed to MK-PC mortar (above 5% Metakaolin and 15% MK at any rate) is more prominent than that of proportional PC mortar (except for the exception MK level). Due to the expansion in heat progression between long segments of hydration, accelerated Portland concrete hydration and the consolidated effect of the pozzolanic reaction came about. The ascent temperature in FA-PC mortars is not the same as in similar PC mortars, it is attributed to the dilution of PCs by FA, combined with its insignificant pozzolanic reaction, between reactions, Both the rate of heat development and absolute heat advanced.

Xia Oquian et al. (2001) Considered the stress – strain connection of cement from 0% - 15% of metakaolin at a constant rate of 5%. They argued that the addition of metakaolin up to 15% enhanced the elastic and compressive quality, and in addition the crest strain was expanded at a rate of up to 15% of replacement of cement by metakaolin. The fuse of metakaolin has enlarged the compressive versatility modulus to some extent.

Poon et al. (2001) Reported the rate of pozzolanic reaction of meta kaolin in superior bond mortar. They investigated the hydrology advancement of metakaolin as far as its compressed quality, holes and the ability to measure perforation. They argued that high pozzolanic reactivity results in high rates of quality improvement and refinement of its pore structure to solid glues in earlier stages.

W. Aquino et al. (2001) The creators made an attempt to demonstrate the effect of silica fume and high efficiency metakaolin on the material science of alkali silica reaction. They found that ASR reduced silica smoke diffusion and a greater reaction than metakaolin. In addition, they found that the calcium content of ASR substances increased over time in all cases except mineral compounds, and tests containing mineral compounds distinguished calcium levels. In addition, a small X-beam test shows that the calcium content in ASR materials increases over time. As the ASR reaction increases, the calcium changes according to the exact pattern of reaction of the silica in the reactor. From the results, it was indicated that the calcium-containing substances in the gel were not at all prone to growth.

3. Materials and Methodology

The following materials were used for the study:

- The cement that is used in all mixture was normal OPC (43 grade) conforming to IS: 12269 (BIS 1987).
- Commercially available sand was used in all the mixtures.
- The chemical composition of different metakaolin is specified in Table 2, 3, 4. The spectrum diffraction (SEM) pattern of the MK utilized in the study is depicted in Fig. 9, 10, 11. Metakaolin from different regions of India Maharashtra, Gujarat and Tamil Nadu were obtained.

3.1 Cement

Conventional Portland concrete accessible in nearby market of certain brand was made use of in the examination. Care

Table 1. Chemical analysis of cement utilized OPC 43 grade conforming to IS 8112:2013

Chemical Analysis (%)	Cement
Ratio of percentage of lime to percentage of silica, alumina and iron oxide when calculated by the formula: Cao–0.7SO3/(2.8Sio2+1.2Al2O3+0.65Fe2O3)	0.66-1.02
Ratio of percentage of alumina to that of iron oxide	0.66
Percentage of insoluble residue by mass	4
Alkali content	0.05
Chloride content by mass	0.1
Magnesia percentage by mass	6
SO3 by mass	3.5
Loss on ignition (LOI)	5

has been taken to see that the acquirement produced using a solitary bunch and is put away in hermetically sealed compartments to avoid it is being influenced by barometrical, storm dampness and mugginess. Chemical Properties of 43 Grade commercial cement mentioned in Table below.

3.2 Metakaolin

Different qualities of metakaolin with variation in their chemical composition are depicted in table below:

Table 2. Properties of Metakaolin-I

Element	Weight %	Atomic %
Mg	0.35	0.42
Al	30.74	32.66
Si	59.47	60.69
K	1.94	1.42
Ca	4.18	2.99
Total	100.00	

Table 3. Properties of Metakaolin-II

Element	Weight %	Atomic %
Mg	0.25	0.29
Al	35.57	36.80
Si	61.98	61.60
Ca	0.23	0.16
Ti	1.96	1.14
Total	100.00	

Table 4. Properties of Metakaolin-III

Element	Weight %	Atomic %
O	61.48	73.43
Mg	0.05	0.04
Al	17.55	12.43
Si	20.46	13.92
Ca	0.15	0.07
Fe	0.32	0.11

4. Results and Discussions

The results obtained are as following:

4.1 Compressive Strength

Mortar mixes with varying water binder ratios partially replaced cement with metakaolin of three different regions were prepared. The mortar mixes experimented for compressive strength tests gave an average of 10.77% increase at 28-day strength results. The mortar mix containing metakaolin from Maharashtra and Gujarat gave maximum compressive strength results on 20% replacement of cement. Whereas, mortar mixes made using metakaolin from Tamil Nadu gave maximum compressive strength results on 15% replacement of cement by metakaolin. At 0.30 w/b ratio the mortar mixes showed early strength gain up to 35.11% approx at 7-day strength for all m1, m2, m3. At 0.30 w/b ratio the mortar mixes made using metakaolin from Gujarat gave maximum early strength gain at 15% replacement of cement by metakaolin with cost of metakaolin being 1.5-2 times the cost of cement. Hence, we aim to produce high strength concrete with early age strength using metakaolin from Gujarat as it is more economical compared to metakaolin from Maharashtra and Tamil Nadu. The accelerated curing results of the concrete mix showed 3-times the strength gain at 15% replacement of cement by metakaolin (m2- Gujarat).

4.2 Compressive strength Comparison of control and metakaolin specimens from different regions of India

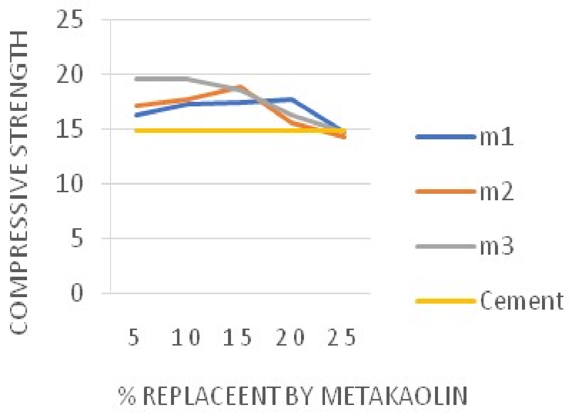

Fig 1. 7 day strength of mixes with 0.45w/b ratio

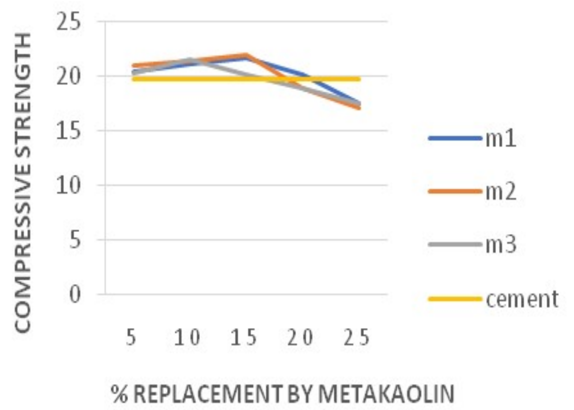

Fig 2. 28 day strength of mixes with 0.45 w/b ratio

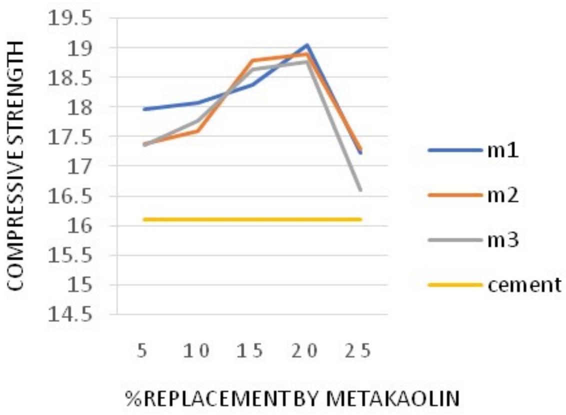

Fig 3. 7 day strength of mixes with 0.40 w/b ratio

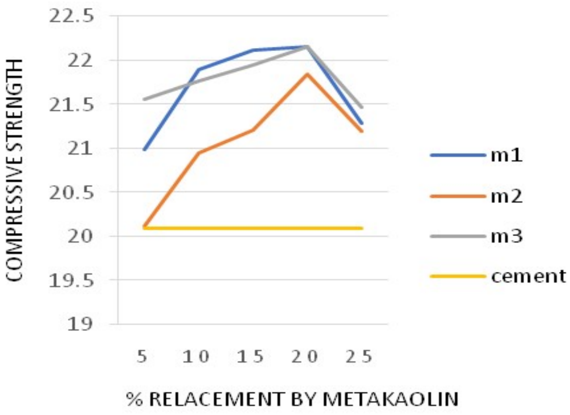

Fig 4. 28 day strength of mixes with 0.40 w/b ratio

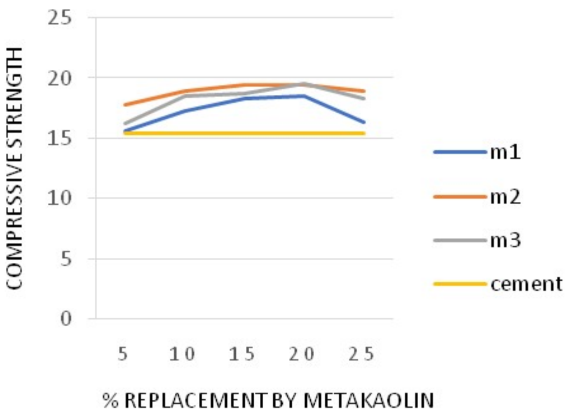

Fig 5. 7 day strength of mixes with 0.35 w/b ratio

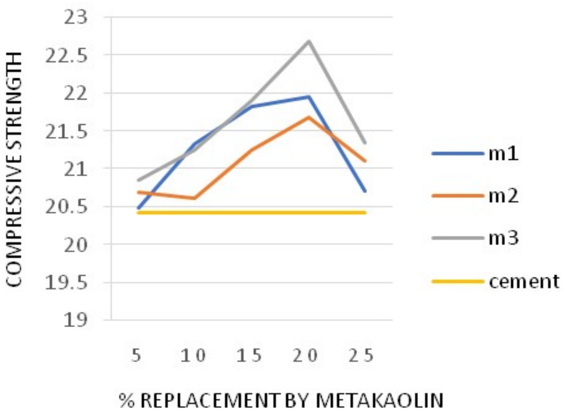

Fig 6. 28 day strength of mixes with 0.35 w/braio

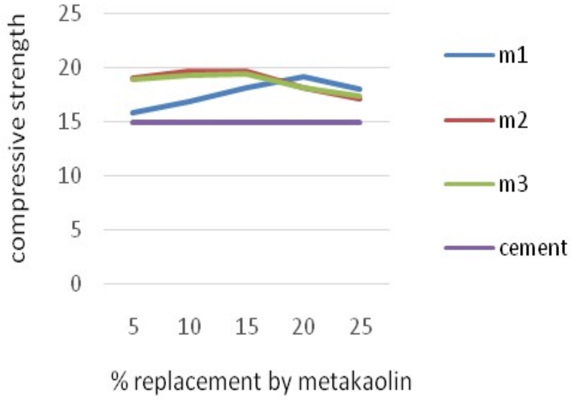

Fig 7. 7 day strength of mixes with 0.30 w/b ratio

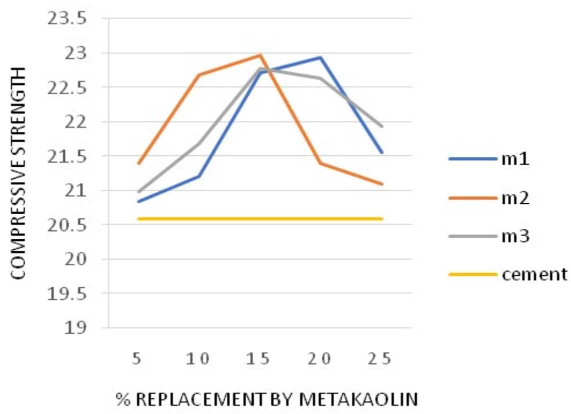

Fig 8. 28 day strength of mixes with 0.30 w/b ratio

4.2 SEM Analysis

The SEM analysis patterns of different metakaolin show that the characteristic peak of kaolinite decreases from m1 to m3. This indicates incomplete metakaoilinization in m1. There is complete metakaolinization only at higher temperatures crystallization process. Therefore, m3 shows significant effect in compressive strength of cement mortars.

Metakaolin-I

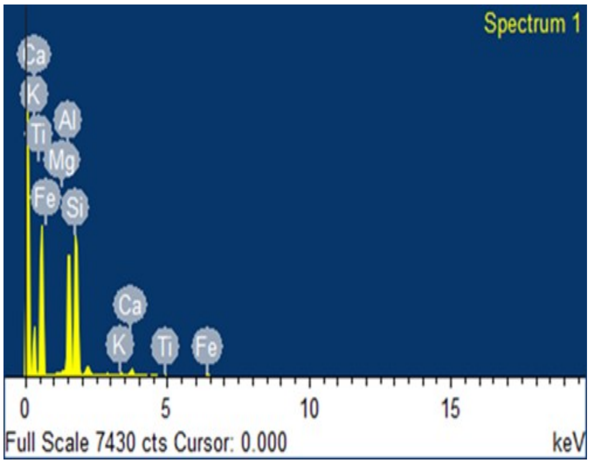

Fig 9. SEM pattern of metakaolin I

Metakaolin II

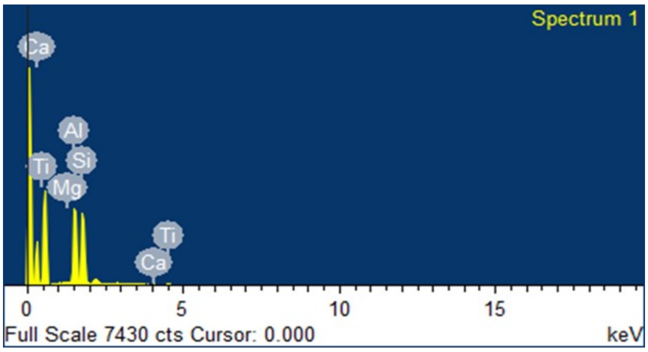

Fig 10. SEM pattern of metakaolin II

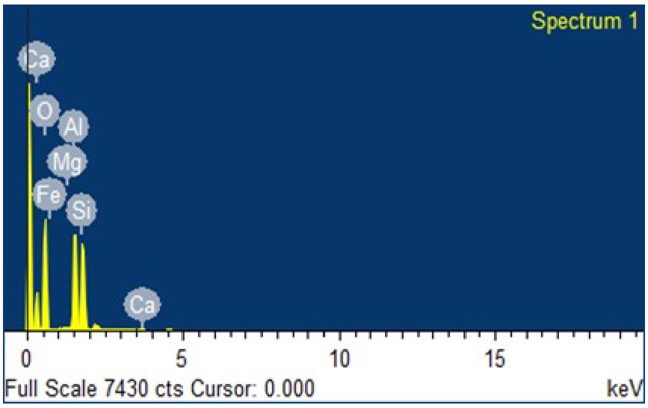

Fig 11. SEM pattern of metakaolin III

5. Conclusions

Metakaolin can be utilized as advantageous concrete material. The expansion of metakaolin to expands the compressive quality of the concrete mortar. The nature of metakaolin affected the compressive quality acquired in MK-blended concrete mortars. The higher introductory response of concrete mortar with great metakaolin for example M3 had higher compressive quality outcomes than low and mid-range quality concrete mortar. The nonattendance of superplasticizer in MK-mixed concrete glues brought about low compressive quality and a serious extent of agglomeration. Mid-range quality metakaolin concrete mortars performed well when contrasted with concrete glues with high and low properties of metakaolin. The effect of metakaolin composition on mortar strength is a vital step in enhancing their performance in order to extend their application. In recent times its application can be seen in construction industry.

Disclosures

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