INCORPORATION OF METAKAOLIN IN CONCRETE: A REVIEW

Umer UL Nazir
PG Student, Department of Civil Engineering,
Chandigarh University, Chandigarh, Punjab, India.

Abhishek Jandiyal
PG Student, Department of Civil Engineering,
Chandigarh University, Chandigarh, Punjab, India.

Sandeep Salhotra
Associate Professor and Head, Department of Civil Engineering,
Chandigarh University, Chandigarh, Punjab, India

Raju Sharma
Assistant Professor Department of Civil Engineering,
Chandigarh University, Chandigarh, Punjab, India

ABSTRACT
Concrete is the most well-known, prevalent and comprehensively used building material worldwide with its usage almost doubling the mutual utilization of other materials like wood, steel and plastics. From the beginning of researches in concrete, the researchers and scientists have always tried to utilize and incorporate various materials, which are industrial waste products or agricultural wastes into concrete in such a manner that it can provide an effective mean not only to dispose of such wastes but also effectively enhancing some properties and nature of concrete. Researchers many times tried to incorporate metakaolin with concrete so that the properties of concrete get enhanced. The use of metakaolin formerly provided a expedient means for its disposal rendered as waste, but it has been feasible to alter its properties, subsequent to its mutual use along with super plasticizer. They incorporate metakaolin in different amounts so that to find out at what amount the properties will enhance better. They also tried to incorporate metakaolin with other materials like fly ash, silica fume etc. By doing such experiments researchers got different results and conclusions.

Key words: Compressive strength, Flexural strength, Polypropylene fibre, Silica fume, Tensile strength.

http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=7&IType=5
1. INTRODUCTION

Metakaolin is one of the good quality substances. Metakaolin is not a byproduct. The process of manufacturing metakaolin includes calcinations of kaolinitic clay. The pure form Kaolinitic is calcined at 6500° Celsius and 8500° Celsius. So that to achieve a fineness of 700-900 m2/ kilogram, the process is followed by grinding. The resulting material is known as metakaolin which is highly pozzolonic. It differs from other admixtures in chemical composition. Unlike metakaolin, other admixtures may contain components like sulphur compounds; alkalies etc can readily undergo delayed reactions.

2. METAKAOLIN’S CHEMICAL COMPOSITION

<table>
<thead>
<tr>
<th>Chemical composition of Metakaoline</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>TiO₂</th>
<th>LOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Proportions</td>
<td>62.62</td>
<td>28.63</td>
<td>1.07</td>
<td>0.15</td>
<td>0.06</td>
<td>1.57</td>
<td>3.46</td>
<td>0.36</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Table 1 Metakaolin’s Chemical Composition

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Chemical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability in physical form</td>
<td>Sulphur dioxide (SiO₂) 51% to 53%</td>
</tr>
<tr>
<td>Mass specific gravity</td>
<td>Aluminium dioxide (Al₂O₃) 40% to 44%</td>
</tr>
<tr>
<td>Color</td>
<td>Titanium dioxide (TiO₂) &lt;3.5%</td>
</tr>
<tr>
<td>Brightness</td>
<td>Ferrous oxide 2.0% to 2.3%</td>
</tr>
<tr>
<td>Specific surface</td>
<td>Calcium oxide (CaO) &lt;0.20%</td>
</tr>
<tr>
<td></td>
<td>Magnesium-oxide (MgO) &lt;0.10%</td>
</tr>
<tr>
<td></td>
<td>Oxides of potassium, sulphur and others 0.5% to 1%</td>
</tr>
</tbody>
</table>

Table 2 Physical Properties - Table 3 Chemical Properties

2.1. Uses

2.1.1. Use in High Strength Concrete

Metakaolin finds its use in high strength concrete as when microslica is replaced by researchers with metakaolin in high strength concrete preparation, concrete of equivalent strengths and other additional properties were seen like workability, permeability etc.

2.1.2. Makes Finishing Easier

Due to the fineness of metakaolin and its highly reactive nature, it imparts a creamy as well as non sticky texture is imparted to the concrete thereby making the finishing easier.
2.1.3. Efflorescence Reduction
The whitish haze which appears on the surface of concrete is termed as efflorescence which is caused by reaction of calcium hydroxide and water in atmosphere. Thus if the components of this reactions are reduced, there will be no efflorescence. Metakaolin performs this function very well by reducing calcium hydroxide and thereby minimizes efflorescence.

2.1.4. Effect of Color on using Metakaolin
one of the biggest advantage of metakaolin lies in the fact that it does not affect the color of white concrete made with white Portland cement as compared to other pozzolans like silica fume or fly ash as these impart dark steel grey or lighter grayish color respectively

2.1.5. Effect of Metakaolin on Acid Stains
metakaolin is generally associated with a drawback of acid staining because of its property of consuming calcium hydroxide in a very aggressive fashion. This fact of metakaolin might lead to disappointment. Acid stains require the reaction of calcium hydroxide and if it is not present, the color may not develop enough.

2.2. Advantages
- There is better control of shrinkage and cracks due to reduction of heat of hydration
- It can be safely used for water retaining structures as well as structures near shore as its usage leads to water tightness
- It can be safely used in concrete as there is lesser rebound
- Metakaolin helps in production of abrasion resistant concrete as it lies second to diamond on hardness scale
- It imparts better spray ability to the cement products
- It enhances compressive as well as tensile strength of concrete
- It is environment acceptable or eco friendly or does not causes pollution
- In mixer it disperses very easily
- It leads to removal of formation at an earlier stage because of high initial set.

3. LITERATURE REVIEW
- Erhan Guneyisi, et al., (2007) reported that the inclusion of metakaolin as a supplementary cementitious material in concrete helps in a wonderful way to reduce drying shrinkage strain. The pore structure of concrete was greatly enhanced due to the utilization of ultrafine metakaolin which was also accompanied by the decrease in the harmful large pores thereby improving the overall permeability of concrete. The imperviousness was greatly seen at 20% replacement level. The studies also revealed that the strength was dependent on the levels of replacement, water cement ratio and age of testing and also the strength enhancement was in varying magnitudes.
- G. Batis, et al.,(2005) mentioned in the results of his studies that if metakaolin is added for the purpose of corrosion resistance properties of mortar , there is no significant change in 1 day strength but 2 days and 28 days strength were greatly enhanced.
- Terrence Ramlochana, et al.,(2000) observed that metakaolin is highly effective in controlling the alkali silica reaction, expansion. Approximately 10 to 15% of metakaolin was required to limit the expansion within the range of 0.04% at the end of 2 years, the limit being strongly dependent on the usage of type of aggregates
- A.V.S.Sai. Kumar et.al investigated the effect of strength of concrete with partial replacement as Metakaolin. Different replacement using 2.5%, 5.0%, 7.5%, 10.0%, 12.5% metakaolin was carried out with cement and they had reported that metakaolin can be used as a partial replacement of cement.
• Vivek sood et.al concluded that metakaolin when used as replacement of silica fume in the has all the properties of being good pozzolana. It can be a good substitute of silica fume which is being imported, thereby can successfully diminish the requirement of importing. In addition to this, chemical reacting properties of microfine are comparable to that of metakaolin.

• Dinakar (2011) conducted study on behavior of highly reactive metakaolin in concrete and observed that if water cement ratio is kept similar for concrete containing silica fume and metakaolin, the concrete mix containing metakaloin had comparatively lesser water reducer requirement. This lesser demand has two benefits viz better finishing and lesser tendency of surface tearing during finishing. The super plasticizer requirement was adversely affected with increase in dosage of highly reactive metakaolin. For every 5% increase of metakaolin, the increase in super plasticizer was near about 0.6%. He also observed that the compressive as well as flexural strength of concrete using metakaolin was not only higher than that of ordinary concrete but also higher than that of silica fume concrete.

• Chandrakant Mehetre et.al(2014) conducted study on properties of concrete on adding metakaolin as one of the mineral admixture and reported that the addition of 10 % Metakaolin along with Cement Kiln Dust in self compacting concrete mixes enhances various self compact characteristics like flowing ability, segregation resistance etc.

• Morsy M. S., et al.,(2008) investigated the properties of Portland cement mortar by using nano kaolin. The partial substitutions of ordinary portland cement with nano metakaolin were carried out at 0%, 2%, 4%, 6%, 8% by weight of cement. It was clearly depicted by the results that there were increase in compressive as well as tensile strengths of concrete prepared with nano-metakaolin as compared with those of normal concrete. About 49% increase in tensile strength was observed.

• K. Anbuvelan et.al (2014) studied the characteristics of concrete on addition of metakaolin for empirical purposes and reported that the experimental flexural tensile strength was comparatively higher for all the percentage on addition of Metakaolin in plain concrete.

4. CONCLUSION

On the basis of study of metakaolin, these conclusions can be drawn out:

• On the basis of study it is seen that metakaolin replacement has a good influence on strength parameters.

• It (metakaolin) can be replaced upto 25% & optimum is at 10 %

• The increase of Compressive strength varies between 5-38% for M20 grade, 2-37% for M30 grade, 3-13% for M40 grade and 3-18% for M50 grade of concrete.

• The increase of Split Tensile strength varies between 5-36% for M20 grade, 2-13% for M30 grade, 2-34% for M40 grade and 2-26% for M50 grade of concrete.

• The increase in cost for 10% replacement varies between 11-13% for all grades of concrete.

This increase is marginal compared to the improvement in strength. Hence Metakaolin may be adopted as an effective pozzolanic material to partially replace cement in Concrete.

Metakaolin is environmental friendly. Also it has been seen that both the split tensile and flexural strength has increased as well as compressive strength is also enhanced. Due to the high initial setting wastage of conceret gas been reduced. Also metakaolin is 2nd toughest material after diamond so good for abrasion also; hence good durability. It is also good for permeability.

REFERENCES


Incorporation of Metakaolin in Concrete: A Review


