EXPERIMENTAL STUDY OF STRENGTHENING PROPERTIES ON CONCRETE BY USING POZZOLANA MATERIALS

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Abstract: Recent days the partial replacement of ordinary Portland cement with pozzanals has been increasing widely. Most commonly used pozzanals are fly ash, silica fume, metakaoline, ground granulated blast furnace slag. A pozzolan is a material which, when combined with calcium hydroxide, exhibits cementitious properties. Pozzolans are commonly used as an addition to cement concrete and in some cases to reduce .The material cost of concrete. Recent research aimed at energy conversation in the cement and concrete industry has in part, focused on the use of less energy intensive materials such as fly ash, slag and silica fume. Of the late some attention has been given to the use of natural pozzanals like metakaoline as possible partial replacement for cement. Amongst the various method used to improve the durability of concrete, and to achieve high performance concrete, the use of metakaoline is a relatively new approach, the chief problem with its extreme fineness and high water requirement when mixed with cement. The present work focus on investigating the mechanical and durability properties of M20 grade concrete with the partial replacement of metakaoline (10%,20%,30%), flyash (5%,10%,15%), silica fume (2%,4%,6%), the cubes, cylinders and prisms are tested for compressive strength. Keywords: Metakaoline, Flyash, Silica Fume. Mix Design

I. INTRODUCTION

Metakaoline is a manufactured pozzolanic mineral admixture which significantly enhances many performance characteristics of cement based mortars, concrete and related products. The use of pozzolanic materials in the manufacture of concrete has a long, successful history. Most pozzolans used in the world today are by products from other industries, such as coal flash, blast furnace slag, rice husk and silica fume. As such there has been relatively little work done with regard to manufactured, optimized and engineered pozzolanic materials which are specially intended for use in Portland cement based formulations. The use of Metakaoline and various chemical admixtures have become staple ingredients in the production of concrete with designed strength in excess of 7500psi (>50Mpa)or where service environments, exposure or life cycle cost considerations dictate the sue of High performance concrete (HPC). Among the various methods used to improve the durability of concrete, and to achieve high performance concrete the use of Metakaoline is relatively a new approach. The partial replacement of ordinary Portland cement with pozzolanic materials can be advantageous in increasing the durability of paste, mortar or concrete if the proper curing regime is adopted. This is due to the fact that the Calcium Hydroxide produced by the cement hydration reacts with the pozzolana and produces additional gel which has a pore blocking effect and therefore alters the pore structure and the strength. In addition there is a reduction in Calcium Hydroxide (CH) which leads to improved resistance to sulphate attack and alkali-silica reaction. Recently Metakaoline which is an ultra fine pozzolan produced form clacined clay that has been added to the list of pozzolanic materials.

METAKAOLINE:
Metakaoline is a dehydroxylated form of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaoline is smaller than cement particles, but not as fine as silica fume. Metakaoline is a high quality pozzolanic material, which is blended with Portland cement in order to improve the strength and durability of concrete and mortars. The Meta prefix in the term is used to denote change. It is a borrowing from Greek meaning after, along with, beyond. It is used, and is recognizable, in the formation of compound words metabolic, metamorphosis. The scientific use of the prefix is used for a combining form denoting the least hydrated of a series. In the case of Metakaoline, the change that is taking place is dehydroxilation, brought on by the application of heat over a defined period of time.

STRENGTH PARAMETERS:
Metakaoline contains similar range of silica and alumina oxides. Metakaoline contain high silica and super fineness, its reactivity is more, comparative to other pozzolanic admixtures. As a result, it contributes to strength improvement. Compressive strength of Metakaoline concrete continuous to increase with replacement levels at all ages u to optimum dosage. Ultra high strength concrete of the order of 40 to 120N/mm² is now possible for field placeable concrete with Metakaoline admixture. Such high strength concrete has increased modulus of elasticity, lower creep and drying shrinkage. Another strength parameter of Metakaoline is its gain in strength.

ADVANTAGES:
- Increased compressive and flexural strengths
- Reduced permeability.
- Increased resistance to chemical attack
- Increased durability
• Reduced effects of alkali-silica reactivity (ASR)
• Enhanced workability and finishing of concrete
• Reduced shrinkage, due to “particle packing” making concrete denser
• Improved colour by lightening the colour of concrete making it possible to tint lighter integral
colour.
• Reduced potential for efflorescence, which occurs when calcium is transported by water to the surface
where it combines with carbon dioxide from the atmosphere to make calcium carbonate, which
precipitates on the surface as a white residue.

Fly ash:
Fly ash is “the finely divided residue resulting from the combustion of ground or powdered coal, which is transported
from the fire box through the boiler by flue gases “. Fly ash is
a by-product of coal-fired electric generating plants. There
are about 70 thermal power plants in the country, which are
currently producing about 100 million tons of flyash per
annum. Out of this huge quantity of flyash, hardly less than
5% is being put for gainful purposes like brick making,
cement manufacture, void filling in tunnels, backfill, sludge
stabilization, glass manufacture agriculture, soil stabilization
e tc., leaving a massive portion of the ashis mixed with a
measured amount of water and pumped into lagoons from
where it can be later reclaimed. In spite of some inherent
problems associated with flyash utilization, the encouraging
engineering properties of the material prompted engineering
community to utilize it in bulk quantities for construction
purposes, which not only helps to dispose it off but also to
preserve the top fertile soil from using it for several purposes.

Silica fume:
It also known as microsilica, (CAS number 69012-64-2,
EINECS number 273-761-1) is an amorphous (non-
crystalline) polymorph of silicon dioxide, silica. It is an
ultrafine powder collected as a by-product of the silicon and
ferrosilicon alloy production and consists of spherical
particles with an average particle diameter of 150 nm. The
main field of application is as pozzolanic material for high
performance concrete

Properties:
Silica fume is an ultrafine material with spherical particles
less than 1 μm in diameter, the average being about 0.15 μm.
This makes it approximately 100 times smaller than the
average cement particles. [1] The bulk density of silica fume
depends on the degree of densification in the silo and varies
from 130 (undensified) to 600 kg/m3. The specific gravity of
silica fume is generally in the range of 2.2 to 2.3. The
specific surface area of silica fume can be measured with
the BET method or nitrogen adsorption method.

II. MATERIAL PROPERTIES
The materials used in the experimental work namely cement,
metakaoline, fine aggregates and coarse aggregate(20mm,
10mm)have been tested in the laboratory for use in mix
designs. the detail are presented below.

CEMENT
Ordinary Portland cement of 53 GRADE(deccan ) was used
in the investigation.

THE DETAILS OF TESTS CONDUCTED ON CEMENT
ARE DESCRIBED BELOW.

Specific Gravity of Cement
Specific gravity is calculated by using Le-Chatlier’s flask
method or by specific density bottle method.

Cement specific gravity:
Fineness Test on Cement
Fineness test on cement can be calculated by sieve test or air
permeability method, in commercial cement it is suggested
that there should be about 25to 30% of particles less than 7
microns in size.

Fineness of cement:

Initial and Finial Setting Time Test on Cement
Initial and finial setting time test on cement is obtained by
vicat’s apparatus, for initial setting time of cement vicat’s
needle should penetrate to a depth of 33 to 35mm from the
top, for setting time the vicat’s needle should pierce through
the paste more than 0.5mm. we to calculate the initial and
finial setting time as per IS:4031 (PART 5)-1998.

Initial setting time of test cement:
Finial setting time of test cement:

Standard Consistency Test
The standard consistency test of a cement paste of cement
paste is defined as that consistency which will permit vicat’s
plunger having the 10mm diameter and 50mm length to
penetrate to a depth of 33 to 35 from the top of the mould.
The basic aim is to find out the water content required to
produce a cement paste of standard consistency as specified
by the IS:4031(Part 4)-1988.

Standard consistency of test cement:

FINE AGGREGATE
Aggregates smaller than 4.75 mm and up to 0.075mm are
considered as fine Aggregates .

The Details of test conducted on fine aggregate are described
below.

Fineness Modulus
The standard definition of fineness modulus is as follows: “
An empirical factor obtained by adding the total percentages
of samples of aggregate retained on each of a specified series
of sieves, and dividing the sum by 100.”
Sieve analysis helps to determine the particle size
distribution of the coarse and fine aggregates. This is done
by sieving the aggregates as per IS:2386(part 1)-1963.

i) A set of IS sieves of sizes – 80mm, 40mm,
20mm,16mm, 10mm, 4.75mm, 2.36mm, 1.18mm,
600um, 300um, 150um.

ii) 80mm to 4.75 mm IS sieves are used for coarse
aggregate analysis and from 4.75 mm to 150um
IS sieves are used for analysis of fine aggregates.
Table 2.1 Sieve analysis of fine aggregate

COARSE AGGREGATE
Aggregate greater than 4.75mm are considered as coarse aggregate.
Specific Gravity
The specific gravity of coarse aggregate is

Table 2.2 Sieve Analysis of coarse Aggregates

Table 2.3 Physical Properties of Metakaoline

Table 2.4 Chemical properties of Metakaoline

COMPRESSIVE STRENGTH:

III. TEST RESULTS
Replacement of cement with METAKAOLINE of M20 grade concrete:
Calculate the mix proportion with partial replacement of OPC with 0%,10%,20% and 30% of metakaoline.
Mix proportions for M20 Grade Concrete:

Conventional concrete - 1:1.9:3.62:0.55
10% replacement -0.9:1.9:3.62:0.55
20% replacement -0.8:1.9:3.62:0.55
30% replacement -0.7:1.9:3.62:0.55

WORKABILITY TESTS:

Table 3.1 Fly ash workability tests values for M20

Table 3.2 Silica fume workability tests values for M20

Figure 1. Graph between compressive strength of concrete M20 VS percentage of Metakaoline
fly ash:

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Percentage of fly ash</th>
<th>Compressive strength (N/mm²) 28days</th>
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<tbody>
<tr>
<td>1</td>
<td>5%</td>
<td>30.88</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>35.33</td>
</tr>
<tr>
<td>3</td>
<td>15%</td>
<td>30.3</td>
</tr>
</tbody>
</table>

![Graph Between compressive strength of concrete for M20 VS % of fly ash](image)

Silica fume:

<table>
<thead>
<tr>
<th>Sl no</th>
<th>percentage of silica fume</th>
<th>Compressive strength (N/mm²) In 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2%</td>
<td>30.95</td>
</tr>
<tr>
<td>2</td>
<td>4%</td>
<td>32.90</td>
</tr>
<tr>
<td>3</td>
<td>6%</td>
<td>33.54</td>
</tr>
<tr>
<td>4</td>
<td>8%</td>
<td>31.5</td>
</tr>
</tbody>
</table>

![Graph between compressive strength of concrete for M20 VS percentage of silica fume](image)

IV. VI. CONCLUSION

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn.

- The compressive strength of concrete increased when cement is replaced by metakaoline for M20 at 20% replacement of cement by metakaoline
- The compressive strength of concrete increased when cement is replaced by fly ash for M20 at 15% replacement of cement by fly ash
- The compressive strength of concrete increased when cement is replaced by silica fume for M20 at 6% replacement of cement by silica fume
- Workability of concrete decreases with increase in fly ash replacement level.
- Workability of concrete decreases with the increase in metakaoline replacement level.
- Workability of concrete decreases with the increases in silica fume replacement level

REFERENCES


reinforced concrete, sp44, ACI. PP195 – 207.


[22] M.S.Shetty, “Concrete Technology”.


