Evaluation of Strength of PCC with Partial Replacement of Cement by Meta Kaolin and Fly Ash

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Abstract: The present reports deals with the effects of minerals admixtures, by partial replacement of cement, in terms of improved performance on compression strengths. Experimental work was carried out to investigate the effect of Meta kaolin and fly ash by partial replacing cement and keeping same water cement ratio to ordinary concrete and meta kaolin and fly ash. The concrete mixes had 5%, 10%, 20% of fly ash and meta kaolin, replacing cement partially, so as to determine the best proportion, which would give maximum compressive strength. It reveals that with 10% meta kaolin and fly ash each partial replacement of cement were favorable combinations for casting of concrete flexural members. Using the optimum mix proportions giving the best results in compressive strength of cube testing, beam specimens will casted and tested for their flexural strength. The beams will tested on universal testing machine to verify their flexural strength after 7days, 28days of curing with single point load. The results will compare with the beams of varying flexural strength of plane cement concrete, plane cement concrete with meta kaolin and fly ash.

Keywords: Cement, Aggregates, Compressive strength.

1. Introduction

Recent report 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. Lately some attention has been given to the use of Natural Pozzolans like Meta kaolin as a possible partial replacement for cement. Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete, the use of Meta kaolin is a relatively new approach. Meta kaolin, or heat-treated clay, may be used as a Supplementary Cementations Material in concrete to reduce cement consumption, to increase strength. Meta kaolin reduces the porosity of concrete. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Concrete is one of the most common materials used in the construction industry.

2. Methodology

- 1. Collection and study of data.
- 2. Materials used.
- 3. Mix Design.
- 4. Casting of Specimens.
- 5. Curing of Specimens.
- 6. Testing of Specimens.
- 7. Results and Conclusions.

The procedure which is given above is to be followed. This is the methodology for the project. In the preparation of PCC we have used M20 grade proportion, i.e., (1:1.5:3). The proportioning is done based on the requirement or given specification. The measurement of material can be done by weight batching or volume batching. Sand shall be measured on the basis of its dry volume. While measuring the aggregate, sacking, ramming or hammering shall not be done. PCC is allowed to be done by hand mixing only for small scale works. The base on which the concrete is mixed must be clean, watertight slab or a steel platform. Sand, cement, meat kaolin and fly ash mixed thoroughly followed with the addition of coarse aggregate. Lastly water is added and the mixture is mixed properly to gain an even color and consistency. Mixed concrete is placed in the cubes and firstly apply grease to the moulds, then pour concrete. We have to pour 3 layers and for each layer we have to give blows with tamper rod. Then put aside for one day. After that remove the mould and place the cubes in water for curing. Compaction shall be done before initial setting starts within thirty minutes of addition of water to the dry mixture. Freshly laid concrete shall be protected from rain by suitable covering. After the concrete has begun to harden that is about one to two hours after it has been laid it shall be protected with moist gunny bags, sand or any other materials against quick drying. Curing shall be done for a minimum period of 7 days and maximum period of 28 days.

3. Literature Review

Srivastava and Rakesh. (2012) in cement industries, continuous attempts have been made to reduce the cost of production of Portland cement. One of the ways includes use of natural pozzolana which mainly requires grinding and is thus less costly in terms of preparation to make pozzolanic cements (Blanks and Kennedy, 1995). Cement manufacturers have also shifted from use of wet to dry process of clinkerisation to lower the high energy requirements.

John. (2013) increase in population in the country is demanding more and more infrastructure projects and housing which intern is demanding more and more cement manufacturing. This is resulting in releasing of huge amount of CO2 into the atmosphere which is causing environmental problems. There is a need to look for alternative materials which lessen emanation of green house gasses. As a piece of this various alternative materials to cement have been explored by various researchers. In the present study it is focused on basalt, fly ash, meta kaolin, tank sediments, sludge of vitrified ceramic tile plant, clayey soil and clay deposits. Published articles related to the pozzolonic materials are collected and complied. Most relevant papers are sorted out and studied in depth to understand the problems, methodology, results obtained and conclusions drawn. Meta kaolin was tried by several researchers and it is found to be promising At Present meta kaolin available in the market is costly and this cost factor is one of the constraint in utilization, hence we need to explore alternative low cost materials that can be used in the place of existing meta kaolin after treatment.

4. Materials Used

4.1. Cement

The cement used was ordinary Portland cement of 43 grade. Cement is the major raw material used in any construction. Therefore, quality of cement must be checked before using it as a building material. Ordinary Portland cement is used to prepare the mix design of M20 grade. The cement used was fresh and without any lumps.

4.2. Fine Aggregates

River sand produced locally was used for fine aggregates. Fine aggregate plays a very important role in concrete. It manages to fill voids between the powders and the coarse aggregate. We have used good quality of fine aggregate, passing 2.36mm is used as a fine aggregate the experimental program was locally procured and conformed to grading zone 3 as per IS:383-1970. Grading of fine aggregates shall confirm to IS and shall within limits of one of the four zones given in IS 383-1970. The properties of sand were analyzed. Fine aggregate shall be of coarse sand consisting of hard, sharp and angular grains. Sand shall be of standard specifications, clean and free from dust, dirt and organic matter. Sea sand shall not be used.

4.3. Coarse Aggregates

Coarse aggregate used in the PCC must be of hard broken stone of granite or similar stone, free from dust, dirt and other foreign matter. The coarse aggregates are locally available was used having maximum size of 20mm. Coarse aggregate differ in nature and shape depending on their extraction and production. The coarse aggregate obtained from a local source. Coarse aggregates occupy 60 to 70 % of concrete cube volume. Aggregates are insert fillers floating in the cement. Aggregate shall be stored in such a way that it does not get mixed with mud, grass, vegetables and foreign matter. The best way is to have a hard surface platform made out of concrete, bricks o planks. In this study, graded 20mm crushed granite coarse aggregate was used as the natural coarse aggregate.

4.4. Fly Ash

Fly ash is the ash removed from the exhaust gas of burning coal at power plants to generate electricity. The ash is removed from the exhaust by air pollution control equipment such as electrostatic precipitators before the exhaust is emitted through stacks or chimneys into the atmosphere. Fly ash, is also known as flue-ash, it is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is classified into two classes as Class F fly ash: Fly ash normally produced by burning anthracite or bituminous coal, usually has been than 5% CaO. Class F fly ash has pozzolanic properties only. Class C fly ash: Fly ash normally produced by burning lignite or sub-bituminous coal. Some fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties, class C fly ash also possesses cementations properties.

4.5. Meta Kaolin

The Meta kaolin is in conformity with the general requirement of pozzolona. The specific gravity of Meta kaolin is 2.4. Considerable research has been done on natural pozzolans, namely on thermally activated ordinary clay and kaolinitic clay. These unpurified materials have often been called Meta kaolin. Such a product, white or cream in color, purified, thermally activated is called High Reactive Meta kaolin(HRM). High reactive meta kaolin shows high pozzolanic reactivity and reduction in Ca(OH)2 even as early as one day. It is also observed that the cement paste undergoes distinct densification. The improvement offered by this densification includes an increase in strength and decrease in permeability. The Meta kaolin using as a cement replacement in concrete mixes, instead of other pozzolans such as silica flume. Meta kaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of Meta kaolin is smaller than cement particles, but not as fine as silica fume.

4.6. Water

Potable water was used in the work for mixing concrete and also for curing. Cubes are placed in clean water. Combining water with cementious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids with it and makes it flow more freely. A lower water to water cement ratio yields a stronger, more durable concrete. Water used shall be clean and reasonably free from injurious quantities of deleterious materials such as oils, acids, salts and vegetable growth. Generally, potable water shall be used having a p_H value not less than 6.

5. Concrete Mix Design

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength, durability and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and hardened state. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability therefore becomes vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties depends upon many factors, e.g. quality and quantity of cement, water and aggregates, batching, mixing, placing, compaction. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregates, thus the aim is to produce as lean mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g. a concrete mix of inadequate workability may result in high cost of labour to obtain a degree of compaction with available equipment.

r	Table I: Mi	x Proportion		
S.NO	MIX	FLY ASH	МЕТА	
		(%)	KAOLIN	
			(%)	
1	MIX 1	5%	5%	
2	MIX 2	10%	10%	
3	MIX 3	10%	10%	
4	MIX 4	20%	20%	
5	MIX 5	20%	20%	

6. Casting

Once the mix proportions are finalized, required quantities of materials were weighed. First cement, fly ash and Meta kaolin were mixed in dry state, then coarse and fine aggregates were mixed together in a mixer of to obtain homogeneous mix. Then water is added. Total duration of mixing was about five minutes. The casting was done immediately mixing, after carrying out the tests for fresh properties. The top surface of the specimens was scraped to remove excess material and achieve smooth finish. From each concrete mix, 5 cubes of 150mm x150mm x 150mm were casted. Specimens for normal concrete mix were cast in three layers then vibration was done with tamping rod. All specimens were unmolded after 24 hours, immediately after unmolding specimens were transferred to curing tank.

Casting should be done carefully. Don't disturb the material after pouring it into mould. Keep a side moulds for 24 hours. And then remove the mould, keep the cubes in the water.

7. Tests

7.1. Compression Test

Out of many test applied to the concrete, this is the outmost important which gives an idea about all the characteristic of concrete. By this single test one judge that whether concreting has been done properly or not.

For cube test two types of specimens either cubes of 15cm x 15cm x 15cm or 10cm x 10cm x10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x15cm are commonly used.



Fig.1. Compression Testing Machine

8. Calculations

For cube 1:

Cement= 1.323×90%=1.1907kgs,

Meta kaolin= $1.323 \times 5\% = 38.9$ gms,

Fly ash =1.323×5%=38.9gms,

Sand= $1.5 \times 1.323 = 1.9845$ kgs,

Coarse aggregate=3×1.323=3.96kgs,

Water cement ratio= $0.43 \times 1.323 = 0.63$ lit.

For cube 2:

Cement= 1.323×80%= 1.05kgs,

Meta kaolin=1.323×10%=132gms,

Fly ash = 1.323×10%=132gms,

Sand =1.5 ×1.323=1.984kgs,

Coarse aggregate=3×1.323=3.96kgs,

Water cement ratio = $0.43 \times 1.323 = 0.63$ lit.

For cube 3:

Cement =1.323×80%=1.05kgs,

Meta kaolin=1.323×10%=132gms,

Fly ash =1.323×10%=132gms,

Sand=1.5×1.323=1.984kgs,

Coarse aggregate=3×1.323=3.96kgs,

Water cement ratio =0.43×1.323=0.63lit.

For cube 4:

Cement =1.323×60%=0.793kgs,

Meta kaolin=1.323×20%=0.264kgs,

Fly ash =1.323×20%=0.264kgs,

Sand =1.5×1.323=1.984kgs,

Coarse aggregate=3×1.323=3.96kgs,

Water cement ratio=0.43×1.323=0.63lit.

For cube 5:

Cement =1.323×60%=0.793kgs,

Meta kaolin=1.323×20%=0.264kgs,

Fly ash=1.323×20%=0.264kgs,

Sand =1.5×1.323=1.984kgs,

Coarse aggregate=3×1.323=3.96kgs,

Water cement ratio = $0.43 \times 1.323 = 0.63$ lit.

1. Compressive strength for cube1 = load/area = $510/0.15 \times 0.15 = 22.66$ KN/m².

2. Compressive strength for cube2 = $590/0.15 \times 0.15 = 26.22$ KN/m²

3. Compressive strength for cube3 = $600/0.15 \times 0.15 = 26.66$ KN/m².

- 4. Compressive strength for cube4 = $580/0.15 \times 0.15 = 25.77$ KN/m².
- 5. Compressive strength for cube5 = $616/0.15 \times 0.15 = 27.37 \text{KN/m}^2$.

9. Results

The Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. The following are the values which are from tests with different proportions when compared to normal PCC.

Normal PCC:

1. Compressive strength for normal PCC = 20 KN/m^2

Partial replacement of Fly ash and Meta kaolin:

- 1. Compressive Strength of cube $1 = 22.66 \text{ KN/m}^2$.
- 2. Compressive Strength of cube $2 = 26.22 \text{ KN/m}^2$.
- 3. Compressive Strength of cube $3 = 26.66 \text{ KN/m}^2$.
- 4. Compressive Strength of cube $4 = 25.77 \text{ KN/m}^2$.
- 5. Compressive Strength of cube $5 = 27.37 \text{ KN/m}^2$.



10. Conclusions

The replacement of cement with fly ash and meta kaolin gives more strength.

When compared to normal PCC our reports shows that it gives maximum strength

The partial replacement of cement with 20% of fly ash and 20% of meta kaolin gives more strength compared to fully added cement.

In future we can use this proportion, which gives more compression strength.

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