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Effect Of Silica Fume And Metakaolin Combination On High Strengtgh Concrete

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ABSTRACT:

The use of supplementary cementitous materials is fundamental in developing low cost construction materials for use in developing countries. By addition of some pozzolanic materials, the various properties of concrerte viz, workability, durability, strength, resistance to cracks and permeability can be improved. Silica fume is a byproduct resulting from the reduction of high – purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or silicon alloys. Silica fume is known to improve both the mechanical characteristics and durability of concrete. The principle physical effect of silica fume in concrete is that of filler, which because of its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. As for chemical reaction of silica fume, because of high surface area and high content of amorphous silica in silica fume, this highly active pozzolan reacts more quickly than ordinary pozzolans.The use of silica fume in concrete has engineering potential and economic advantage. Metakaolin is also one of such waste/ non - conventional material which can be utilized beneficially in the construction industry. This paper presents the results of an experimental investigations carried out to find the suitability of silica fume and metakaolin combination in production of concrete.

Keywords: Silica fume, metakaolin, pozzolan, compressive strength, OPC.

INTRODUCTION: Concrete is the most widely used man-made construction material in the world. It is obtained by mixing of fine aggregates, coarse aggregates and cement with water and sometimes admixtures in required proportions. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction. This is particularly true of concrete structures which were constructed since 1970 or thereabout by which time the following developments are came subsequently.

(a) The use of high strength rebar's with surface deformations (HSD) started becoming common.

(b) Significant changes in the constituents and properties of cement were initiated.

(c) Engineers are started using supplementary cementations materials (SCM) and admixtures in concrete, often without adequate consideration.

The use of supplementary cementite's materials (SCMs) is fundamental in developing low cost construction materials for use in developing countries. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrerte viz, workability, durability, strength, resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixtures, which improve the microstructure as well as decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction. The subsequent modification of the microstructure of cement composites improves the mechanical properties, durability and increases the service-life properties. When fine pozzolana particles are dissipated in the paste, they generate a large number of nucleation sites for the precipitation of the hydration products. Therefore, this mechanism makes paste more homogeneous.

SILICA FUME: Expansion of silica seethe additionally diminishes the porousness of cement to chloride particles, which shields the strengthening steel of cement from consumption, particularly in chloride-rich conditions, for example, beach front locales .When silica fume is fused, the rate of bond hydration increments at the early hours because of the arrival of OH ÿ particles and soluble bases into the pore liquid. The expanded rate of hydration might be owing to the capacity of silica smoke to give nucleating locales to hastening hydration items like lime, C±S±H, and ettringite. It has been accounted for that the Pozzolanic response of silica fume is exceptionally noteworthy and the non-evaporable water content reductions in the vicinity of 90 and 550 days at low water/fastener proportions with the expansion of silica seethe. Amid the most recent decade, extensive consideration has been given to the utilization of silica seethe as a fractional substitution of bond to deliver high-quality cement.

METKAOLIN:

High –reactivity metkaolin is a high processed reactive alumina silicate pozzolan, a finely-divided material that reacts with slaked lime at ordinary temperature and in the presence of moisture to form a strong slow-hardening cement. It is formed by calcining purified kaolinite, generally between 650–700 °C in an externally fired rotary kiln. It is also reported that HRM is responsible for acceleration in the hydration of ordinary portland cement (OPC), and its major impact is seen within 24 hours. It also reduces the deterioration of concrete by Alkali Silica Reaction (ASR), particularly useful when using recycled crushed glass or glass fines as aggregate.

Metkaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, paper sludge waste which contains kaolinite, oil sand tailings contains kaolinite. Metkaolin is a de-hydroxylated form of the clay mineral kaolinite. Metkaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, paper sludge waste which contains kaolinite, oil sand tailings contains kaolinite. From the previous observations it is proved that use of waste product namely Metkaolin increased compressive and flexural strengths, increases durability. Metkaolin usage helps in developing high performance and high strength in concrete. Quarry dust is a residue tailing or other non-voluble material after extraction and processing of rocks to form fine particle less than 4.75mm. Quarry waste, which is generally considered as a waste material, causes an environmental load due to disposal problem. The successful utilization of quarry waste as fine aggregate would turn this waste material into a valuable resource. In addition, the strain in the supply of natural sand will be reduced, and the cost of concrete production will be offset if the quarry waste is used as a partial

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replacement of cement. However, it should be ensured that the incorporation of quarry waste does not harm the key properties and durability of concrete at the expense of cost reduction. It is evident that the concrete strength development depends upon the strength of the cement motor and its synergetic with coarse aggregate. Pebbles as coarse aggregate, due to smooth surface texture impart lower mortar aggregate bond strength than that imparted by crushed coarse aggregates. In the present work, fine aggregate consisting of natural sand conforming to grading zone II of IS 383-1970 is used.

CHEMICAL COMPOSITION OF METKAOLIN:

Oxide Name	Oxide Compound	Percentage
Calcium	Cao	**36**
Silica	Sio_2	**34**
Alumina	Al2o3	**18.5**
Iron Oxide	Fe2o3	**2.5**
Magnesium oxide	Mgo	**11.5**
Sulphate	SO3	**0.65**
Others	Alkalis	**------**

METHODOLOGY:

The scope of present investigation is to high strength concrete on plain concrete, concrete with replacement of varying percentages of silica fume and Metkaolin in different total percentages of 0%,10%,20%,30%,40% and 50% for M60 & M80 concrete mix.

The coarse aggregate used here with having maximum size of 20mm. We used the IS 383:1970 to find out the proportion of mix of coarse aggregate, with 60% 20mm size and 40% 10mm.

Fine aggregates are materials passing through an IS sieve that is less than 4.75mm gauge. Simply the aggregates which are passing 4.75mm sieve are called as Fine Aggregates. The most important function of the fine aggregate is to provide workability and Uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension.

Super Plasticizers are new class of generic materials which when added to the concrete causes increase in the workability. They consist mainly of naphthalene or melamine sulphonates, usually condensed in the presence of formaldehyde.

Concrete mixes were designed for compressive strength and flexural strength of 60MPa and 80MPa with a water cement ratio 0.37 respectively adopted by experience In the design mixes the Portland cement was replaced by fly ash with 0%, 10%, 20% and 30% and GGBS of 10% to 40% and the specimens are casted.

The measured quantities of coarse aggregate and fine aggregate were placed in laboratory tilting drum miller which is available in our college laboratery and machine is started for a uniform mixing of coarse and fine aggregates. Then the ordinary Portland cement of Ultratech made is pored into drum mixer. Similarly the measured percentages of fly ash and GGBS were pored in to drum mixer and the machine rotated for 2 to 3 minutes to obtain uniform mix. Then the required quantity of water is added to the dry mix and it was thoroughly mixed to obtain homogeneous concrete. The time of rotation of tilting drum miller was maintained 2 to 3 minutes to get the uniform mix of concrete. The mixed concrete

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was placed in a trays on a plain surface to casting of specimen cubes and specimen prisms.

The cube moulds shall be 150mm x 150mm x 150mm size and Prisms moulds shall be 150mm x 150mm x 700mm confirming to IS 10086-1982 are cleaned and all care was taken to avoid any irregular dimensions. The joints between the sections of moulds were coated with mould oil and a similar coating of mould oil was applied between the contact surfaces of the bottom of the moulds and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the moulds were thinly coated with mould oil to prevent adhesion of the concrete and for easy removal of moulds after casting. Then the moulds are arranged on the plain platform for casting.

The specimens of Standard cube moulds (150mm x 150mm x 150mm) and standard prism moulds (150mm x 150mm x 700mm) are placed in trays and the mixed concrete pored in to specimen moulds in three layers and compacted with a tampered rod thoroughly to reach required shape and compaction. By this way we have casted 420 no. of cubes and 320 no. of prisms. The cubes and prisms were casted for the replacement of cement with fly ash and GGBS in different percentages for two grades of concrete i.e., M60 and M80. These prepared cubes and prisms were placed at plain leveled surface for 24 hours.

The test specimen cubes and prisms were stored in place, free from vibration in most air at 90% relative humidity and at a temperature of $27^0c^+_-$ 2^0c for 24 hours. Hour from the time of addition of water to the dry ingredients. After 24 hours the cubes and prisms were demolded and immediately immersed in clean, fresh water sump for a period of 28 days. Every three to four days the water is removed from water sump and placed with fresh water to avoid any chemical reaction of water.

Slump Test is a most commonly used method for measuring the consistency of concrete, which can be employed either in laboratory or at site of work. It is used conveniently as a control test, and gives an indication of the uniformity of concrete from a batch.The slump test is performed as per standard procedure with standardized apparatus.

Bottom diameter of Frustum of cone =20cm.

Top diameter of Frustum of cone =10cm

Height of the cone =30cm The surface of the mould is thoroughly cleaned initially. The mould is paved on a smooth horizontal right and non-absorbent surface. The mould is then filled in four layers each approximately one-fourth of the height of the mould. Each layer is tamped 25 times by tamping rod, taking care to distribute the strokes evenly over the cross-section. After the top layer has been rubbed the concrete is struck of level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.

Slump cone test

Flexural Testing

Mixing and placing of concrete:

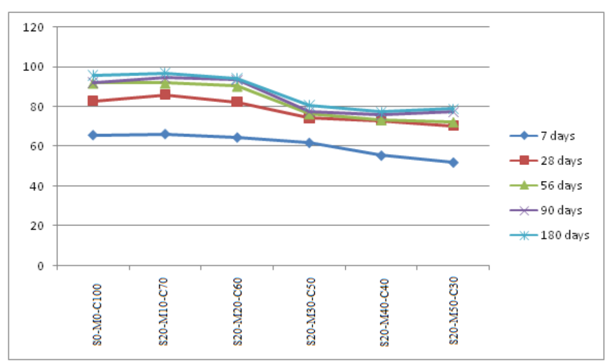
The measured quantities of coarse aggregate and fine aggregate were placed in laboratory tilting drum miller which is available in our college laboratery and machine is started for a uniform mixing of coarse and fine aggregates. Then the ordinary Portland cement of Ultratech made is pored into drum mixer. Similarly the measured percentages of fly ash and GGBS were pored in to drum mixer and the machine rotated for 2 to 3 minutes to obtain uniform mix. Then the required quantity of water is added to the dry mix and it was thoroughly mixed to obtain homogeneous concrete. The time of rotation of tilting drum miller was maintained 2 to 3 minutes to get the uniform mix of concrete. The mixed concrete was placed in a trays on a plain surface to casting of specimen cubes and specimen prisms.

Casting and compaction of test specimens:

The cube moulds shall be 150mm x 150mm x 150mm size and Prisms moulds shall be 150mm x 150mm x 700mm confirming to IS 10086-1982 are cleaned and all care was taken to avoid any irregular dimensions. The joints between the sections of moulds were coated with mould oil and a similar coating of mould oil was applied between the contact surfaces of the bottom of the moulds and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the moulds were thinly coated with mould oil to prevent adhesion of the concrete and for easy removal of moulds after casting. Then the moulds are arranged on the plain platform for casting.

The specimens of Standard cube moulds (150mm x 150mm x 150mm) and standard prism moulds (150mm x 150mm x 700mm) are placed in trays and the mixed concrete pored in to specimen moulds in three layers and compacted with a tampered rod thoroughly to reach required shape and compaction. By this way we have casted 420 no. of cubes and 320 no. of prisms. The cubes and prisms were casted for the replacement of cement with fly ash and GGBS in different percentages for two grades of concrete i.e., M60 and M80. These prepared cubes and prisms were placed at plain leveled surface for 24 hours.

RESULTS AND DISCUSSIONS



Compressive strength for different percentages of metakaolin and 10% silica fume for M60.

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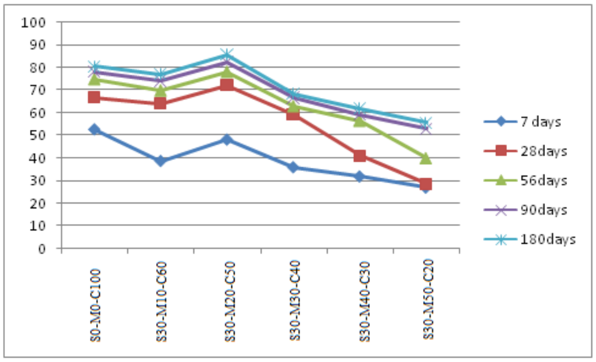
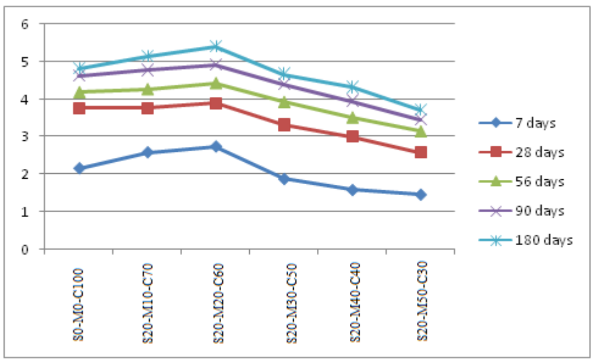
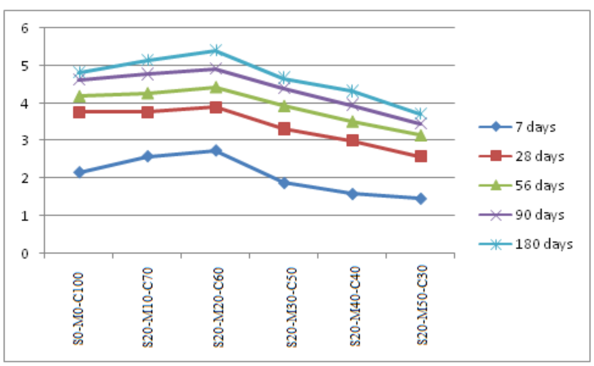


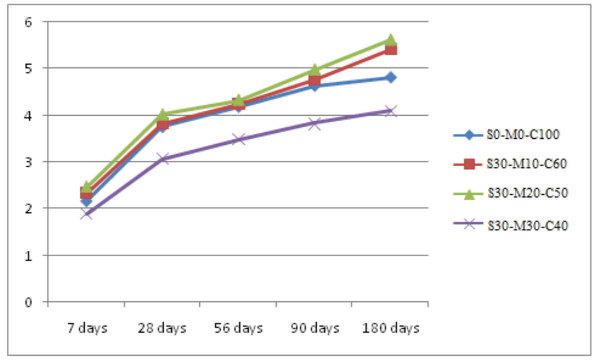
Compressive strength by increasing metakaolin & 20% silica fume for M60.



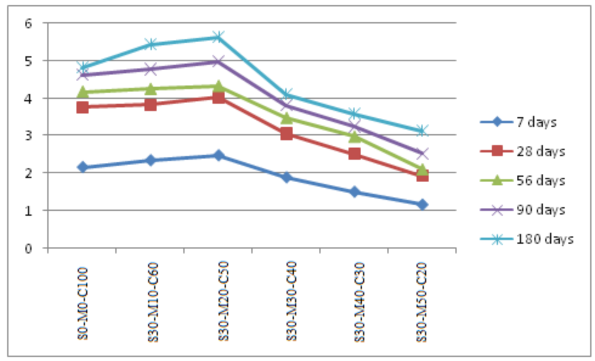
Compressive strength by increasing metakaolin & 30 % silica fume for M60.



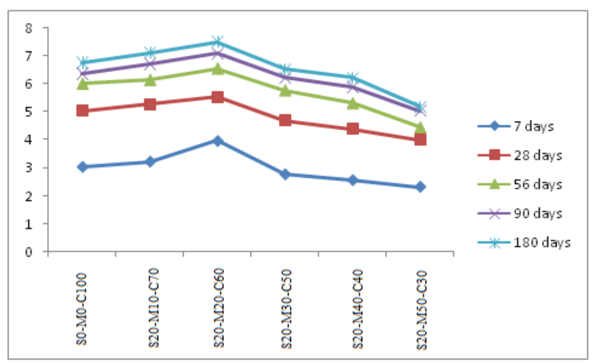
Compressive strength for different percentages of metkaoliun and 10% silica fume for M80.



Compressive strength for different percenrtages of metakaolin & 20% of silica fume For M80.



Compressive strength for different percentages of metakaolin & 30% silica fume for M80



Flexural strength for different percentages of metakaolin &10% silica fume for M60

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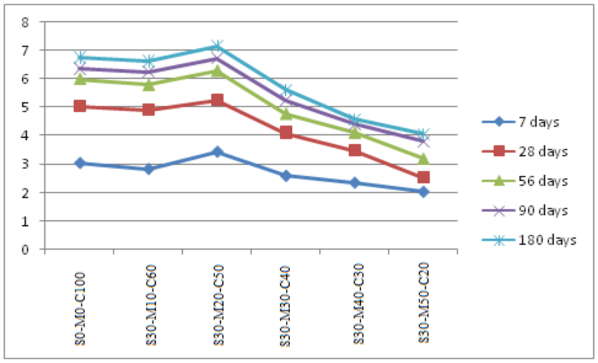
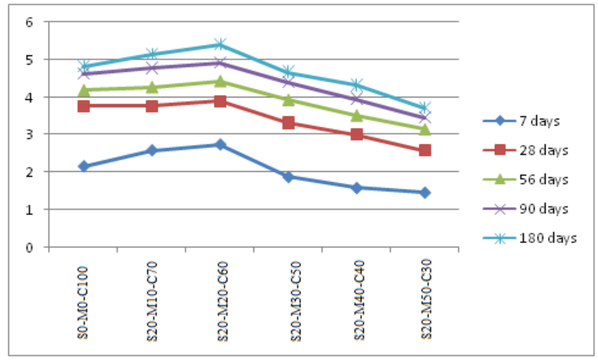
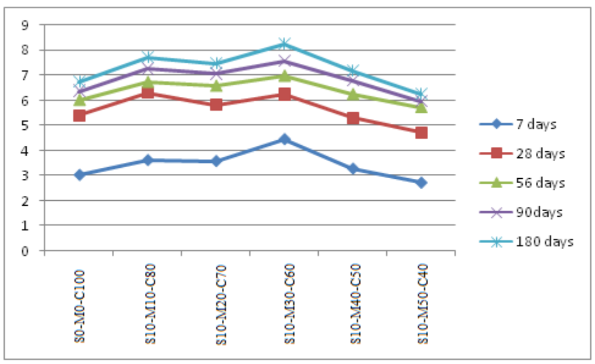


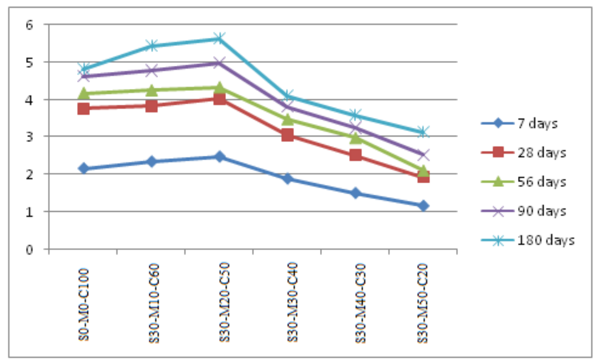
Flexural strength for different percentages of metakaolin & 20% silica fume M60.



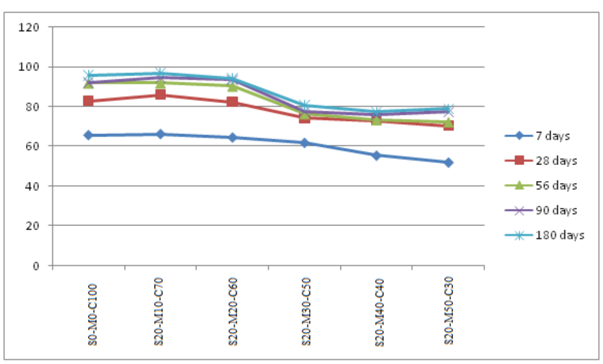
Flexural strength for different percentages of metakaolin & 20% silica fume for M80.



Flexural strength for different percentages of metakaolin & 30% silica fume M60.



Flexural strength for different percentages of metakaolin &30% silica fume for M80.



Flexural strength for different percentages of metakaolin & 10% silica fume for M80.

CONCLUSION:

Based on experimental investigations the following conclusions are drawn.

1. Cement replacement by in combination of silica fume and adding metakaoline leads to increase in compressive strength and flexural strength up to 40% to 50% replacement for both M60 and M80 grades of concrete. Beyond 50% replacement of silica fume and metakaoline compressive strength and flexural strength decreased.
2. It is observed that at 28days compressive strength and flexural strength of M60 grade concrete are increased for different combination of mix proportions and for M80 grade of concrete is controlled concrete.

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3. It is observed that at 90days compressive strength and flexural strength of M60 grade concrete are increased for different combination of mix proportions and for M80 grade of concrete is controlled concrete.
4. It is observed that at 180days compressive strength and flexural strength of M60 grade concrete are increased for different combination of mix proportions and for M80 grade of concrete is controlled concrete.

5. From the above observations we have concluded that the compressive and flexural strengths are increasing normally for 28 days and increasing rapidly for 90 and 180days when compared with controlled concrete.
6. There is a decrease in workability as the replacement level increases, and hence water consumption will be more for higher replacements.
7. From the present study it is observed that, being the silica fume is maintained 10% constant the optimum value of metakaoline is 30%. i.e., the total replacement of ternary Blended cement was 40%, for the both M60 and M80 grades.
8. And it is observed that, being the silica fume is maintained 20% constant the optimum value of metakaoline is 20%. i.e., the total replacement of ternary Blended cement was 40%, for the both M60 and M80 grades
9. And also it is observed that, being the silica fume is maintained 30% constant the optimum value of metakaoline is 20%. i.e., the total replacement of ternary Blended cement was 50%, for the both M60 and M80 grades.
10. The addition of metakaoline has further increased initial 28 days, 90 days and 180 days strength as evident from the tables.

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