EXPERIMENTAL INVESTIGATION ON FRESH AND HARDENED PROPERTIES OF METAKAOLIN - MICRO SILICA BASED HIGH STRENGTH SELF COMPACTING CONCRETE USING MANUFACTURING SAND AS FINE AGGREGATE

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ABSTRACT

The work aims to make high-strength self-compacting concrete by utilizing supplementary cementitious materials (SCMs) in cement partially. The SCMs used in the present work are fly ash, Metakaolin, and Micro silica (MS). In the present work, five mixes were prepared. Mix SCCMS0 is cement replaced with fly ash by 10% and 10% of Metakaolin in all mixes. 2.5%, 5%, 7.5%, and 10% of micro silica were added to the mixes, SCCMS2.5, SCCMS5, SCCMS7.5, and SCCMS10 respectively. The tests performed are fresh, mechanical, and durable. To find the fresh properties slump flow test, V-funnel test, and L-Box test are performed. To find mechanical properties compressive strength tests at 28 and 56 days, flexural tests at 28 and 56 days, and split tensile tests at 28 and 56 days of curing are performed. And durability test performed are rapid chloride permeability test (RCPT). From the results, it was observed adding the fly ash and Metakaolin improves the fresh properties whereas adding micro silica decreases the fresh properties of self-compacting concrete. This combination of slag-based admixtures and micro-silica mixes showed good performance in terms of strength and durability improvement.

Keywords: fly ash, Metakaolin, Micro silica, rapid chloride permeability test (RCPT).

I INTRODUCTION

A. General

Self Compacting Concrete is the ability to compact by itself under the action of gravitational force or by its own self weight without vibration and without bleeding and segregation. SCC will take up the shape of any complicated formwork without any pores and it will permit entry of air and it also effectively covers the reinforcement. The utilization of binder, which is an inorganic binder emerged as a new engineering material to replace the conventional fine aggregate. The use of fine aggregate replacement material such as fly ash, blast furnace slag and silica fume would increase the fresh and hardened properties of the concrete mixture without increasing its cost of manufacturing.

The manufacturing process of self compacting concrete requires in depth knowledge in concrete technology and also it needs more knowledge about new pozzolanic materials and testing procedures for SCC. The advantages of self compacting concrete is that it saves the cost on machinery, energy and manpower for vibrating the concrete, lessens the cost of the formwork, better compaction, better cover protection for the reinforcement, excellent bond between cement binder and aggregates, reduces the demoulding time and it also reduces noise pollution. The compressive strength of high strength Concrete is 60 MPa and greater. High-strength concrete mixtures will have a high cementitious material content that increase the heat of hydration and possibly higher shrinkage leading to the potential for cracking. It carries loads more efficiently than normal-strength concrete. These mineral admixtures induce additional strength to the concrete by reacting with the hydration products of portland cement to produce more C-S-H gel, which is responsible for concrete strength. It requires low water–cement ratio and these low w/c ratio are only attainable with large doses of high range water reducing admixture. The concrete to be SCC, it is essential that it should have passing ability, filling ability and resistance over the segregation property etc., These features are due to limiting the coarse aggregate/fine aggregate content and using lower water–powder ratio with super plasticizers (Siddique 2011).

B. Metakaolin

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin is a valuable admixture for concrete/cement applications. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of Metakaolin is smaller than cement particles but not as fine as silica fume. Metakaolin, is a relatively new material in the concrete industry is effective in increasing strength reducing sulphate attack and improving air-void network. Pozzolanic reactions change the microstructure of concrete and chemistry of hydration products by consuming the released Calcium Hydroxide (CH) and production of additional Calcium Silicate Hydrate (C-S-H) resulting in an increased strength and reduced porosity and therefore improved durability.

Table.1 Properties of Cement and Metakaolin

Chemical composition	Cement %	Metakaolin %
Silica (SiO_2)	34	54.3
Alumina Al_2O_3	5.5	38.3
Calcium oxide CaO	63	0.39
Ferric oxide (Fe_2O_3)	4.4	4.28
Magnesium oxide (MgO)	1.26	0.08
Potassium oxide (K_2O)	0.48	0.50
Sulphuric anhydride	1.92	0.22
LOI	1.3	0.68
Specific gravity	3.15	2.5
Physical Form	Fine Powder	Powder
Colour	Grey	Off white

C. Micro silica

Micro silica is a by-product obtained by the smelting process in the silicon and ferrosilicon industry. The reduction of high purity of quartz material to silica at temperatures reaching 20000C generates silica vapours which oxidizes and condense in the low temperature zone to low particles containing non-crystalline silica. The silicon metal and ferrosilicon alloys having silica contents of 75% or more bears 85%-95% non- crystalline silica. Micro silica is also identified as silica fume, condensed silica fume, volatilized silica or silica dust. The American Concrete Institute (ACI) defines micro silica as "very fine non- crystalline silica produced in an electronic furnace as a by-product of production of elemental silicon or alloys containing silicon". It is generally a grey cultured powder, fairly similar to Portland cement or some fly ashes. It can display both pozzolanic and cementitious properties.

Micro silica has been recognized as a pozzolanic admixture that is effective in improving the mechanical properties to a great extent. By using micro silica along with super-plasticizers, it is comparatively easier to obtain higher compressive strengths. Addition of micro silica to concrete improves the durability of concrete through reduction in permeability, pore structure, reduction in the diffusion of harmful ions, brings down calcium hydroxide content which turns into a higher resistance to sulphate attack. Improvement in durability will also improve the ability of micro silica concrete in protecting the embedded steel from corrosion.

Micro silica has the following advantages:

- High initial compressive strength.
- High tensile, flexural strength and modulus of elasticity.
- Very low permeability to chloride and water intrusion.
- Enhanced durability, toughness, abrasion resistance on decks, floors, overlays and marine structures.
- Superior resistance to chemical attack from chlorides, acids, nitrates and sulphates.
- Higher bond strength, high electrical resistivity and low permeability.

D. M – Sand

Nowadays, natural or river sands have become too scarce especially along the east coast of our Country. Further crushing process of aggregates leave sand-size material. These factors have encouraged the utilisation of 'Manufactured Sand' or M-Sand. Processing of crussed rock or aggregates to get optimum fines content is being done in the manufacture of M-Sand. Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

The major advantage of manufactured sand is that it is highly cohesive and compressive in strength. It has lesser impurities which helps in producing better quality concrete. Moreover, controlled gradation of Zone-II is possible, suitable for concrete. In some case studies it was found that concrete produced by using manufactured sand obtained 6-9 percent higher compressive strength and 12-15 percent higher flexural strength compared to river sand of same grade. Nearly 30 percent increase in masonry strength is obtained with the use of manufactured sand. It requires lower water-cement ratio if mortar is mixed with manufactured sand, which also results in better characteristics in the hardened state. Manufacturing sand also eliminates environmental impact occurred due to lifting of natural sand from river bed.

II SURVEY OF RESEARCH

Nikhil and Ajay Hamane (2015) explained about the Plain concrete is a brittle material and fails suddenly. Addition of Metakaolin and Fly ash to concrete changes its brittle mode of failure into a more ductile one and improves the concrete ductility. The compressive strength and flexural strength of concrete increases with Metakaolin and fly ash content. It is true up to 15% replacement if we replace cement by more than 15% strength starts reducing. Therefore it always preferable to use Meta kaolin & Fly ash with 10% replacement of cement and it gives us better result

Beulah and Prahallada (2012) observed the compressive strengths of HPC mixes decreases with increasing water binder ratio. It can be concluded that the residual. Compressive strength after 30, 60 and 90 days of acid immersion decreases with increasing water binder ratio. This may be due to porous transition zone leading to the formation of ettringite at higher water levels. It can be concluded that the addition of metakaolin increases the resistance to acid attack of HPC. Optimum results obtained were at 10% replacement of cement by metakaolin. It can be concluded that the residual compressive strength of HPC decreases with increasing age of acid immersion. It can be concluded that the percentage decrease in compressive strength decrease rapidly upto 10% replacement cement by metakaolin as from then onwards it decreases gradually. It can be concluded that the percentage weight loss due to acid attack increase with the increasing W/B ratio. It can be concluded that for 10% metakaolin based HPC, the weight loss due to acid attack is minimum.

Saravanan & Sivaraja (2016) have investigated the comparative studies on high strength concrete using micro silica and Nano silica. The secondary of C-S-H gel is formed by adding the micro silica in cement contents. The superior properties are due to the addition nano materials with concrete composites. Furthermore, calcium silicate hydrate formed because of the pozzolanic activity. It increases the strength as well as reduces the calcium hydroxide. The microstructure is enhanced and durability is decreased due to addition of nano silica. It also creates a durable concrete and improve the cohesiveness among the concrete particles.

Mahmoud Nili & Ahmad Ehsani(2015) investigated on the effect of interfacial transition zone and the cement paste on the hardened property of concrete containing the various percentage of nano silica and micro silica. They observed that the transition zone is not upto the limit in terms of microstructural arrangements for the concrete with the conventional ingredients especially with the powder materials. Blended powder components such as nano silica (0%, 1.5%, 3%, 5% and 7.5%) and micro silica (0%, 5% and 7.5%) were added with respect to the weight of cement. They proved that the concrete contains 3% or 5% nano silica, free of micro silica will show better effect in compressive strength for both cement paste and concrete.

Zhang et al. (2016) have investigated the reinforcement mechanism of nano silica to cement based materials with the theoretical calculation and experimental evidence. The content of nano silica will increase by the use of calcium hydroxide. Nano silica has a high level in fineness, specific surface area and pozzolanic activity than micro silica. Nano silica increases the hydration of cement because of the nucleus effect which improves the strength. Nano silica resorts to form the tensile cement matrix. Thus, the nano silica enhanced the flexural strength, electrical resistivity and compressive strength.

Hussain & Sastry (2014) have investigated the effect of micro silica and nano silica on the mechanical properties of the fibre reinforced concrete. Compressive strength, tensile strength, modulus of elasticity and water absorption were found out. The introduction of silica fume and nano silica in the fibre reinforce concrete improves the elastic modulus due to increase in compactness of cement paste bond with aggregates and also tensile strength.

Janani et al. (2015) dealt with experimental study of geopolymer concrete using manufactured sand (M-Sand). Due to the depletion of river sand, alternate fine aggregate was tried as replacement. When river sand is fully replaced by M-Sand, compressive strength increased by 9%, tensile strength by 12% and flexural strength by 10%.The work reported that since no cement was used in concrete, it proved to serve as greener concrete.

Nagajothi et al. (2016) carried out strength assessment of geopolymer concrete using M-Sand. The work aimed at proposing environmental friendly alternative material for cement and river sand. Geopolymer was found to be a better alternative to Cement and M-Sand to scarce river sand. All the strength parameters were investigated to arrive at the above conclusion.

III OBJECTIVES

- Comparative study on the properties of conventional self compacting concrete and concrete containing metakaolin – micro silica based self compacting concrete.

- Study on the workability of conventional self compacting concrete and concrete containing metakaolin – micro silica based self compacting concrete.
- Determine its mechanical property such as compressive strength, split tensile strength and flexural strength with the replacement of cement with metakaolin and micro silica.
- Determine its durability property such as RCPT test with the replacement of cement with metakaolin and micro silica.

IV METHODOLOGY AND MIX DESIGN

A. Methodology

- Collect the micro silica and metakaolin, sieve with 75microns. Passed from 75microns used for this project as cement replacement.
- Physical properties tests on basic materials : metakaolin, micro silica, coarse aggregate, fine aggregate, and cement.
- Mix design for M65 and its proportions. Find out the individual proportions for partial replacement of cement with metakaolin and micro silica.
- Find out the fresh properties of concrete by slump flow, l-box and v funnel tests.
- Prepare the Cubes, cylinders and beams for mechanical property testing of concrete.
- Find out the Harden properties of concrete by Cube Compressive strength, Cylinder tensile strength and beam flexural strength.
- Find out the durability property of concrete by RCPT test.
- Results and discussions.
- Conclusions

B. Mix design

M65 grade high strength self compacting concrete was chosen for this paper, the mix proportions was mentioned below table. In this project cement replacing with 10% by metakaolin and fly ash 20%. The fine aggregate was 50% replacing with M-Sand to achieve good strength.

Table.2 Mix proportion of SCC

Micro-silica %	Cement (Kg/m³)	Fly ash (Kg/m³)	Metakaolin (Kg/m³)	Water (Kg/m³)	Coarse aggregate (Kg/m³)	M sand (Kg/m³)	Fine aggregate (Kg/m³)	SP (Kg/m³)	Micro silica (Kg/m³)
0	434	124	62	196	754	410	410	6	0
2.5	423.15								10.85
5	412.3								21.7
7.5	401.5								32.5
10	390.6								43.4

V EXPERIMENTAL WORK

All the required quantities of micro silica, metakaolin, m sand, cement, fine aggregate and coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water and super plasticizer are added to the composite mixture and mix thoroughly until a uniform mixture is formed. The same procedure is repeated for different mixes which includes the replacement of cement with micro silica. The complete mixing is done by hand mixing. After the concrete is mixed, the fresh concrete tests are to be carried out to measure the workability.

A. WORKABILITY MEASUREMENT

The workability test is conducted to find the flowability, passability, fillability and segregation of high strength SCC. Fresh concrete tests include slump flow test, V funnel test, L-box and U-box test.

The Slump test was conducted as per BIS 1199-1959 to measure the workability of HSSCC mixes. The slump cone of top diameter 100 mm and bottom diameter 200 mm with a height of 300 mm. The slump cone was placed over the graduated leveled surface. The water is sprinkled over the steel plate prior to unloading the mixture from the mixer to avoid absorption of water from the HSSCC mix. The fresh concrete mix was placed in three layers into the cone without compaction. The cone is to be lifted to allow the flow of concrete in the plate. The diameter of the concrete spread was measured after the concrete had stopped flowing. Diameter of concrete circle is a measure for filling ability of concrete. This test is most commonly used test for workability and it gives the good assessment of filling ability of concrete.

According to the guidelines for testing fresh self compacting concrete issued by EFNARC guidelines funnel flow test method is used to find the viscosity of the concrete and also to determine the arching effect of aggregate. The flow time through the funnel is measured. The V funnel test apparatus consists of funnel with rectangular dimensions of 490 mm × 75 mm in plan and bottom dimension 70 mm × 75 mm attached with rectangular opening size of 70 mm × 75 mm and depth of 150 mm. The concrete is poured into the funnel with gate blocking the bottom opening. The funnel is completely filled with the HSSCC mix, the bottom gate is opened and concrete flow out time taken is noted for V funnel test.

L-box test is used to measure the ability of the concrete to flow in vertical direction to the horizontal direction. This test consist of L shaped tubular configuration with a vertical leg of dimensions 700 mm × 200 mm × 80 mm and horizontal leg of same length but cross section 160 mm × 200 mm. The vertical and horizontal legs are separated by a sliding vertical gate at the junction of vertical and horizontal leg. The HSSCC mix is filled in the vertical leg and when the gate is opened it flows into the horizontal leg. The length of flow through the reinforcement is in horizontal direction.

B. MECHANICAL PROPERTIES OF SCC MIX

Compressive strength test, split tensile strength test, flexural strength test are conducted to find the mechanical properties of high strength SCC. Compressive strength was computed at the age of 1 day, 3 days, 7 days, 14 days, 28 days, and 90 days as per Bureau of Indian Standards 516-1959 guidelines. Splitting tensile and flexural tests were carried out at the age of 28 days. Cubes of 150 mm size, cylinders of 150 mm × 300 mm and prisms of 100 mm × 100 mm × 500 mm were cast to determine the compressive strength, split tensile strength and flexural strength respectively. The specimens were demoulded and immersed in water for curing up to required age.

In this experimental investigation, HSSCC cube specimens ensured saturation condition after wiping out the surface moisture. Minimum three identical specimens with size of 150 mm × 150 mm 150 mm were used for testing compressive strength. The 200 Tonnes capacity Compressive Testing Machine (CTM) was used in this investigation as per IS: 516-1959. The load is applied as per IS codal provisions. The experimental setup of compressive strength is shown in below Figure. The load at which the specimen failed was recorded. The compressive strength was determined by dividing failure load by cross sectional area of specimen.

Figure.1 Experimental setup for compressive strength test

The split tensile strength test was carried out as per BIS 5816:1999. The cylindrical concrete specimens with size of 150 mm diameter and 300 mm height were cast and tested for their split tensile strength using 73 Compression Testing Machine (CTM) at the age of 28 days. Three identical specimens were tested and the average value was recorded. Below Figure shows the experimental setup for split tensile strength of HSSCC specimens at the age of 28 days.

Figure.2 Experimental setup for split tensile strength test

Flexural strength tests were carried out at the age of 28 days for 100 mm x 100 mm × 500 mm prism using 100 Tonnes capacity Universal Testing Machine (UTM) subjected to two point loading condition as per IS : 516-1959. Figure below shows schematic diagram for flexural strength test up. Figure below shows experimental setup for flexural strength test of HSSCC. The initial and failure load is noted.

Figure.3 Experimental setup for flexural strength test

C. Durability Properties

Rapid chloride permeability test (RCPT) calculate the charge passing through the concrete and measured in Columbus. The test conducted for 6 hours of time and for every half an hour we measure the readings then sum up all the readings we get the total charge passes through the concrete. Based on the amount of charge passing ASTMC 1202 categories the concrete quality. If charge passing greater than 4000 the concrete is poor quality. If charge passing 2000-4000 concrete is moderate quality, if charge passing between 1000-2000 low and if 100-1000 it is very low. The specimen size used for the test are 100mm diameter and 50mm thickness. Figure below shows the RCPT setup.

Figure.4 RCPT test conducting

VI RESULTS AND DISCUSSIONS

A. Fresh properties of high strength self compacting concrete

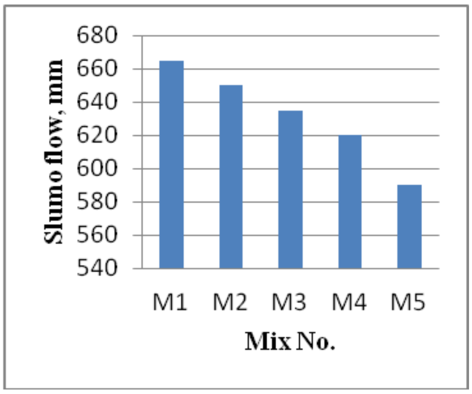
With SCC technology, the issues of maintaining concrete flow in congested reinforcement, a sloppy site, and limiting energy consumption in vibration, which are all common during the building and placement of standard weight concrete, are easily addressed. Workability decreased as the amount micro silica increases, were added to concrete although they remained well within EFNARC limits.

Table.3 Mixes Table

Mix	Micro silica %
M1	HS SCC MS0%
M2	HS SCC MS 2.5%
M3	HS SCC MS 5%
M4	HS SCC MS 7.5%
M5	HS SCC MS 10%

a. Slump flow

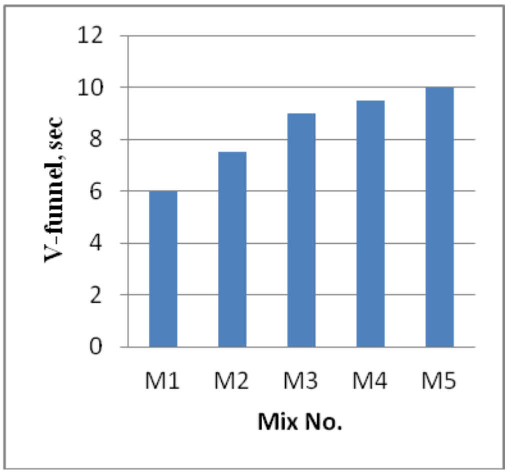
From mix M1 to M5 the flow properties shows decrement. Mix M1 and M2 shows higher flow ability compared to other mixes. From mix M3 onwards drastic decrement in slump flow was observed because of presence of Micro silica. Mix M5 shows the lowest slump flow value. According to EFNARC guidelines the limits for slump flow diameter given is 650 to 800mm.



Graph.1 Slump flow test results graph

b. V-funnel test

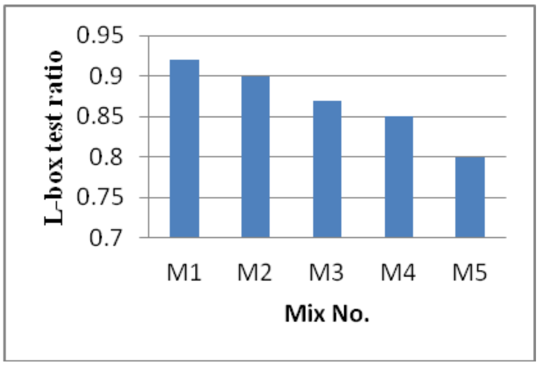
V-Funnel test performed to determine the segregation resistance of the concrete and also filling ability of the concrete. The V-Funnel test results are interpreted as in seconds. The test results are indicated in below Graph.2 shows the conducting V-Funnel experiment test in lab represents the graphical representation of the test results. From the graphs we observed that after addition of micro silica that is from mix M5 the v-funnel time increases that indicates the less flow and mix M1 and M5 shows good flow property.



Graph.2 V-Funnel test results graph

c. L-box test

L-box test is very important in indicates the passing ability of the self compacting concrete. It has three steel rod which implicates the practical congested reinforcement situations. The values of the L-box test represents as the ratio of heights near to the test bars and the height at the ends.

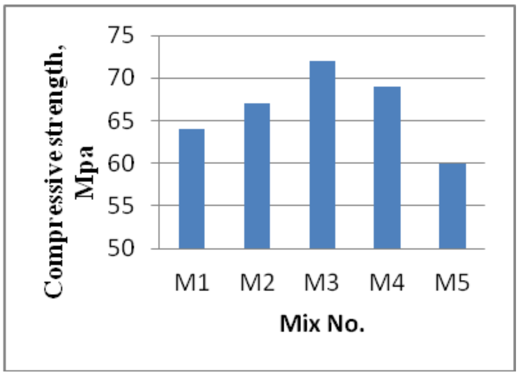


Graph.3 L-box test results graph

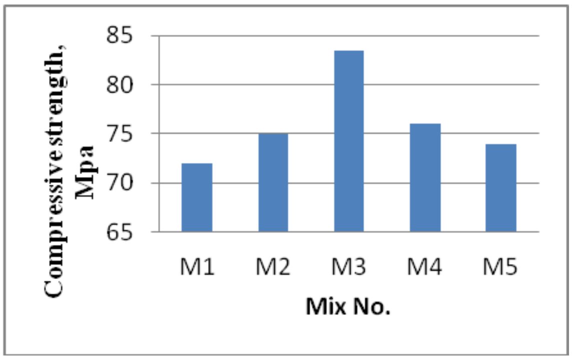
The L-Box test conducting in the lab shows the l-box test results in a graphical form the L-box test results followed a similar trend as of slump flow and v-funnel test that mix M1 and M2 shows the good fresh properties and mix M5 showed the least value.

B. Harden properties of high strength self compacting concrete

a. Compressive strength



Graph.4 28days compressive strength test results graph



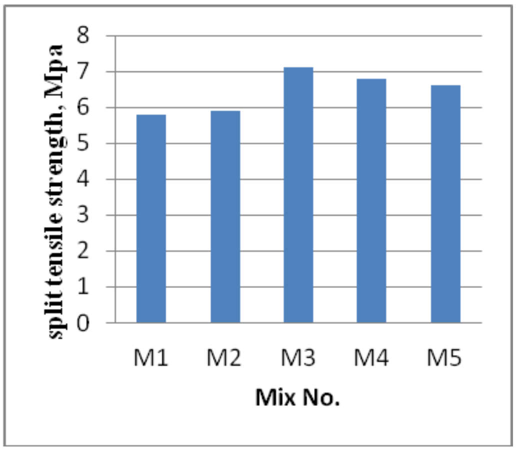
Graph.5 56days compressive strength test results graph

Compressive strength is a very important mechanical test. Above graph shows the digital compressive machine in which concrete specimen is kept and load will be applied load on the specimen will be act till it crushes. The size of the specimen used was 150x150x150mm. The test was conducted for 28, 56 days. can observe that among all the mixes mix

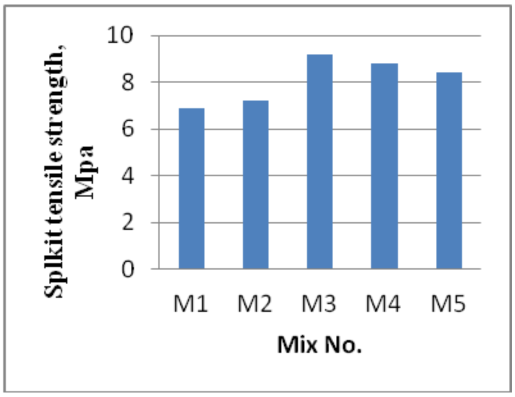
M5 and M1 shows the least strength after addition of Micro silica from mix M3 onwards Compressive strength test results shows drastic increment in strength because this micro and micro-silica undergoes a pozzolanic reaction with calcium hydroxide present in the concrete and produces secondary CSH gels. Mix M3 which is a combination of micro and Micro silica shows the highest compressive strength among all the mixes. The highest strength observed is 72 MPa.

b. Split tensile strength

To measure the direct tension of the concrete is practically impossible. The specimen used for the test is 100mm in diameter and 200 mm in height. Below graph shows the graphical representation of the split tensile values the mixes M1 and M5 show the least strength and mix M3 shows the highest strength among all the mixes.



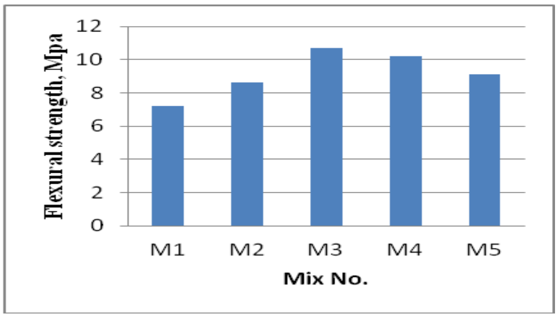
Graph.6 28days Split tensile strength test results graph



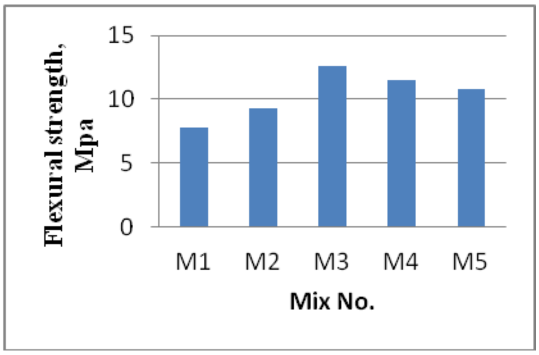
Graph.7 56days Split tensile strength test results graph

c. Flexural strength

Flexural test values represent the bending strength of the concrete. The specimen size used for the flexural test is 100x100x500mm size. Graph 5.8 shows the flexural test results represented in a graphical form. From figure we can observed that mix M1, M2 and M5 shows the least flexural values. From mix M3 shows drastic increases in flexural strength. The mix M3 shows the highest strength about 10.7 MPa among all the mixes. We can also observe that the increment in the strength for flexural are more compared to compressive.



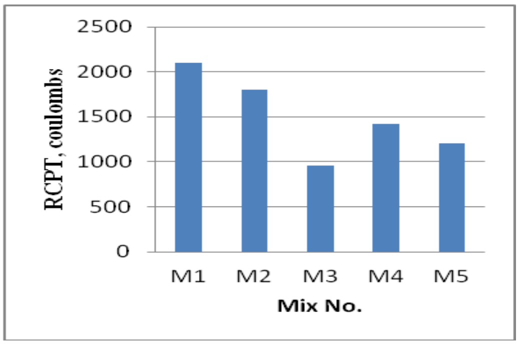
Graph.8 28days Flexural strength test results graph



Graph.9 56days Flexural strength test results graph

C. Durability properties of high strength self compacting concrete

The RCPT test was conducted to determine the chloride penetration into the concrete. The mix that contains only 5% micro silica shows good results as compared with the control mix M1 and mix with optimum Micro silica (M3). The reason behind the decrease in RCPT value for the mix M3, the pores filled by micro silica, and improvement of microstructure at the nanoscale level by forming the flower-like crystals. The reduced permeability stops the chloride penetration into the concrete very low. Below table represents the values of RCPT values for various mixes.



Graph.10 RCPT test results

CONCLUSIONS

- The workability of all Self-compacting concrete mixes was reduced when micro silica and metakaolin were added, due to the large surface area it will absorb more water it will reduce the flow of concrete.
- The partial replacement of cement with metakaolin resulted in a reduction in workability. However, the addition of suitable dosages of alphadine increases the workability of concrete.
- The Optimum dosage of metakaolin 10% of the weight of cement is used in all mixes by changing the micro silica dosage from 0% to 10% of the weight of cement with a difference of 2.5%.
- Micro-silica has a broad filling impact because of its nuclear layer resolution, prompting an expansion in unambiguous surface region contrasted with concrete. This diminishes workability since fine particles require more water. And yet start and speed up the pozzolanic movement in the mortar, framing a lot of C-S-H gel. The addition of micro-silica up to a limit of 10% does not affect the fresh properties of SCC.
- From the perspective of new properties SCCMS0 is a good workable mix, followed by SCCMS2.5. The addition of Micro Silica resulted in a significant reduction in fresh characteristics. SCCMS10 was the least workable due

to the addition of NS, which made the mixture extremely sticky.

- All the fresh properties of all mixes of slump flow are within the limits of EFNARC guidelines.
- The addition of Micro-silica improved the stability and reduced the separation and bleeding effect of SCC.
- At 28 and 56 days of curing, the compressive strength of the Control Mix SCCMS0 grade obtained 64 MPa and 72 MPa respectively.
- At 28 and 56 days of curing, the compressive strength of the Mix SCCMS5 grade obtained 72 MPa and 83.5 MPa respectively. SCCMS5 mix has 16% more strength compared with the control mix.
- At 28 and 56 days of curing, the split tensile strength of the Control Mix SCCMS0 grade was 5.6 MPa and 6.9 MPa respectively.
- At 28 and 56 days of curing, the split tensile strength of the Mix SCCMS7.5 grade obtained 7.1 MPa and 9.2 MPa respectively. SCCMS7.5 mix has 33% more strength compared with the control mix.
- At 28 and 56 days of curing, the Flexural strength of the Control Mix SCCMS0 grade obtained 7.2 MPa and 7.8 MPa respectively.
- At 28 and 56 days of curing, the Flexural strength of the Mix SCCMS5 grade obtained 10.7 MPa and 12.6 MPa respectively. SCCMS5 mix has 56% more strength compared with the control mix.
- As compared to the control mix, the micro silica 5% of the weight of the cement dose contained mix has lower RCPT values. Increased micro silica dosage inhibits concrete permeability, keeping chlorides from entering the concrete. RCPT values for all the mixes are within the limit.

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