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STUDY OF EFFECT OF FLY ASH AND NANO SILICA ON STRENGTH OF CONCRETE MIX AND IT'S MICROSTRUCTURE ANALYSIS

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Abstract - *Huge quantity of fly-ash is being generated from thermal power stations throughout the world. Disposal of the fly-ash is one of the major concerns for the industries. The fly-ash can be used (to some percentages) in the cement concrete mix as a replacement of cement. Nanomaterials can also be used to improve the properties of concrete.This Project work focuses on studying the effect of fly-ash and nano-silica on strength of cement concrete mix. An experimental investigation has been carried out by replacing the cement with fly-ash 20% and with nano-silica 0.3%, 0.5%, 0.75% and 1% by weight of cement. The compressive strengthtest conducted on samples show that there is noticeable increase in early age strength and small increase in the later days strength. The considerable increase in strength is observed on increasing percentage of nano-silica. The 28 days strength of M20 and M30 grade of concrete is increased by 8.96% and 14.86% respectively at 0.75% of nano-silica and 20% of fly-ash. The Field Emission Scanning Electron Microscope (FESEM) analysis is also performed on the cement concrete specimens and it is observed that the microstructure of the concrete become very dense on the addition of fly-ash and nano-silica at varied percentages by weight of cement.*

Key Words: Concrete, Fly-ash , Nano-silica, Compressive strength, Workability, FESEM

1. INTRODUCTION

Concrete is the basic material for the construction work of present as well as future generations. The wide use of it in structures, highways, buildings to factories, from bridges to airports, makes it one of the most useful materials of the 21st century. At present, various infrastructure developmental projects are being undertaken throughout the country and it is contributing in rapid economic growth of the nation. In most of the infrastructural projects, cement concrete is used as basic material. Out of the various materials used in the production of concrete, cement plays a important role due to its adhesive property. In order to enhance the properties such as strength, durability etc of cement concrete mix various research work has already been carried out .Most of the researchers have used materials such as fly-ash, blast furnace slag, rice husk, silica fume etc. for this purpose. The topic of this project work is "Effect of fly ash and nano-silica on the strength of cement concrete mix".

1.1 Objective of the Study

The main objectives of the present study are as mentioned below:

i) To compare compressive strength of ordinary cement concrete mix of M20 and M30 grades with modified cement concrete mix. (Modified with fly-ash and nano-silica at varied percentages)

ii) To determine the optimum percentage of nano-silica with fixed quantity of fly-ash for maximum compressive strength.

iii) To study the microstructure of both the type of concrete mix using FESEM.

2. PROPOSED METHODOLOGY

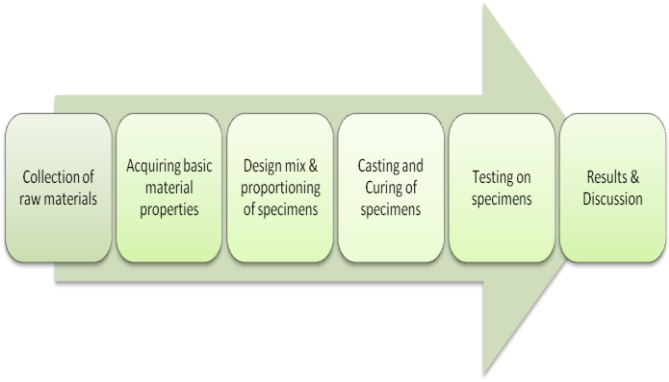


Fig 1: Proposed Methodology

3. EXPERIMENTAL PROGRAM

3.1 Design mix method

The Design mix method is used for the preparation of M20 and M30 grade of concrete in accordance with Indian Standard Code IS: 10262-1982.

3.2 Preparation of concrete mix

Test samples using ordinary cement concrete mix and modified cement concrete mix of M20 & M30 grades of concrete were prepared. To arrive at the M20 and M30 grades of concrete mix, a mix design was carried out. Throughout the whole experiment hand mixing is adopted.

.The mixing of concrete is performed in such a manner that the obtained mix will have a minimum voids.

3.3 Casting and Curing of Test Specimens

For preparation of test samples cubes of size 150x150x150 mm are casted in cube molds. After successful casting, the concrete specimens are de-molded after 24 hours and immersed in water for 7 and 28 days maintaining 27 +/- ºC. Figure shows some concrete specimen casted in laboratory. 12 No. of cubes were prepared using ordinary cement concrete mix, 6 cubes each for M20 and M30 grades of concrete. Ordinary cement concrete mix was prepared by basic ingredients like cement, fine aggregate, coarse aggregate and water. Cement concrete mix was modified by replacing cement at fixed quantity of fly-ash and varied percentages of nano-silica.

3.4 TEST PERFORMED

3.4.1 Slump Test

Slump test is a laboratory or field test which used to measure the consistency of concrete. Slump test depicts an indication of the uniformity of concrete in different batches of concrete. The shape of the concrete slumps shows the necessary information on the workability and quality of desired concrete. The characteristics property of concrete with respect to the tendency of segregation can be also predicted by making a few tamping or blows by tapping rod on the base plate. This test is continues since very old time due to the easiness of apparatus and procedure. The shape of the Slump cone shows or displays the workability of concrete.

Fig 2: Slump test

3.4.2 Compressive Strength Test

It is measured by the resistance offered by hardened concrete towards compression. The strength of concrete is generally defined and determined by the crushing strength of cube 150mm x 150mm x 150mm, at age of 7 and 28 days. It is the most important characteristic of concrete since concrete structures experience heavy compression hence it is of immense importance to determine the tolerable limit of compressive load on concrete. This test is carried out by preparing concrete cube specimens of size 150mm x 150mm x 150mm by filling in fresh concrete in cubical moulds; this process is called casting of specimens. After the casting it is then cured for certain desired number of days and then put under the compression testing machine (CTM) or universal testing machine (UTM) to find out the tolerable compression load of the hardened concrete cubes. This area when divided by the cross sectional area of the cube gives the compressive strength of concrete. The compressive strength test is performed in Construction Material Testing lab in NITTTR.

Fig 3: Testing of Cube

3.4.3 Microstructure Analysis of Cement Concrete Specimens Using Field Emission Scanning Electron Microscope (FESEM)

A FESEM is a magnifying instrument that works with electrons used to comprehend electronic properties and nuclear/atomic geographical subtleties of substance. The Field Emission Scanning Electron Microscope (FESEM) is an instrument which is like the SEM, gives a huge assortment of data from the specimen surface, however with slight higher resolution and a larger energy range. It works much the same as a conventional SEM the specimen surface is checked with an electron beam while a monitor shows the data that intrigues us based on the identifiers available.

Microscopic images were captured using FESEM of the test samples prepared with ordinary cement concrete and modified cement concrete.Microscopic images are shown in Fig 10 to Fig 14.

Since these tests were performed by specialized specialists, these are not explained here and just the results are presented.

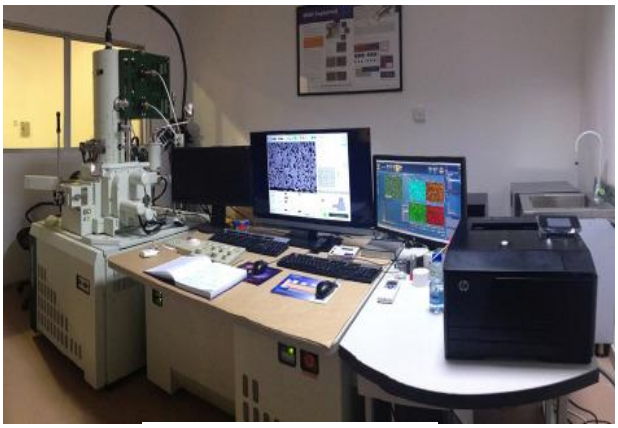


Fig 4: FESEM instrument

4. TEST RESULTS AND DISCUSSSIONS

Table 1: Slump for M20 Grade

Sl.No.	Material Composition	Slump (mm)
1	Ordinary Concrete	77
2	*NS 0.3% & ** FA 20%	79
3	NS 0.5% & FA 20%	84.5
4	NS 0.75% & FA 20%	69
5	NS 1% & FA 20%	53

***NS- Nano-silica **FA- Fly ash**

Table 2: Slump for M30 Grade

Sl.No.	Material Composition	Slump (mm)
1	Ordinary Concrete	69
2	NS 0.3% & FA 20%	72
3	NS 0.5% & FA 20%	67.5
4	NS 0.75% & FA 20%	58
5	NS 1% & FA 20%	46.4

From the above table it can be seen that workability of concrete increases on addition of small percentage of nano-silica but on increasing percentage of nano-silica beyond 0.3% workability starts decreasing.

Table 3: 7 day Compressive Strength in (MPa) of M20 Grade with 0% fly ash & 0% Nano-silica

Sample No.	Compressive Strength (MPa)
***S-1**	15.38
S-2	15.44
S-3	14.36
Average Strength	**15.06**

*S-Specimen

Table 4: Compressive Strength in (MPa) of M20 Grade for 7 day with 20% fly-ash & varied % of Nano-silica

Sample No.	NS 0.3% FA 20%	NS 0.5% FA 20%	NS 0.75% FA 20%	NS 1% FA 20%
	Compressive Strength (MPa)			
S-1	15.87	19.30	22.13	16.53
S-2	18.26	18.44	19.21	17.84
S-3	14.50	16.38	20.94	19.84
Average Strength	**16.21**	**18.04**	**20.76**	**18.07**

Table 5: 28 days compressive strength of M20 grade with 0% fly ash & 0% Nano-silica

Sample No.	Compressive Strength (MPa)
S-1	24.27
S-2	26.58
S-3	23.79
Average Strength	**24.88**

Table 6: Compressive Strength in (MPa) of M20 Grade for 28 day with 20% fly-ash & varied % of Nano-silica

Sample No.	NS 0.3% FA 20%	NS 0.5% FA 20%	NS 0.75% FA 20%	NS 1% FA 20%
	Compressive Strength (MPa)			
S-1	25.71	26.19	27.42	24.12
S-2	26.68	27.38	28.68	26.87
S-3	23.30	25.18	25.23	25.24
Average Strength	**25.23**	**26.25**	**27.11**	**25.41**

Table 7: 7 day compressive strength of M30 grade with 0% fly ash & 0% Nano-silica

Sample No.	Compressive Strength (MPa)
S-1	22.18

S-2	20.24
S-3	27.11
Average Strength	**23.17**

Table 8: Compressive Strength in (MPa) of M30 Grade for 7 day with 20% fly-ash & varied % of Nano-silica

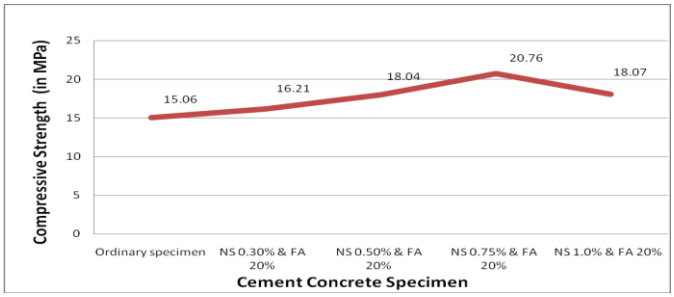
Sample No.	NS 0.3% FA 20%	NS 0.5% FA 20%	NS 0.75% FA 20%	NS 1% FA 20%
	Compressive Strength (MPa)			
S-1	24.58	25.16	32.47	25.24
S-2	22.11	27.54	30.88	26.15
S-3	25.07	25.31	31.84	27.48
Average Strength	**23.92**	**26.01**	**31.73**	**26.29**

Table 9: 28 day Compressive strength of M30 grade with 0% fly ash & 0% Nano-silica

Sample No.	Compressive Strength (MPa)
S-1	37.24
S-2	34.11
S-3	33.38
Average Strength	**34.91**

Table 10: Compressive Strength in (MPa) of M30 Grade for 28 day with 20% fly-ash & varied % of Nano-silica

Sample No.	NS 0.3% FA 20%	NS 0.5% FA 20%	NS 0.75% FA 20%	NS 1% FA 20%
	Compressive Strength (MPa)			
S-1	38.22	37.18	39.66	38.11
S-2	35.14	37.24	42.35	34.88
S-3	33.56	35.02	38.29	33.24
Average Strength	**35.64**	**36.48**	**40.10**	**35.41**



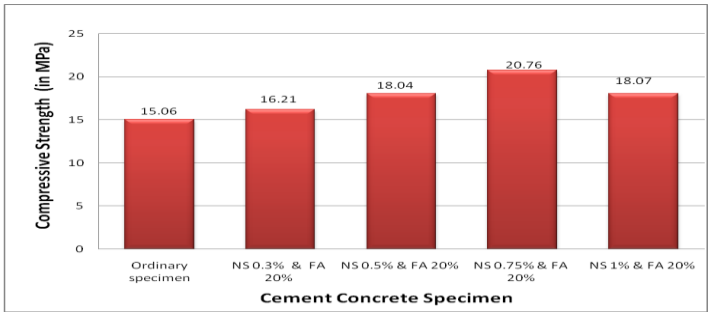
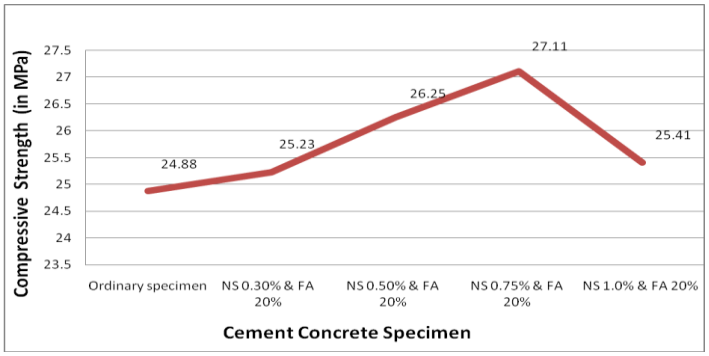


Fig 5: Graph representing 7 day compressive strength for M20 grade concrete



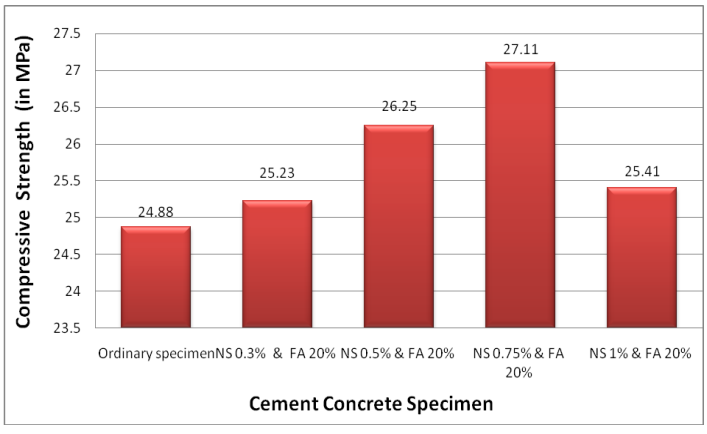


Fig 6: 28 Days compressive strength for M20 grade concrete

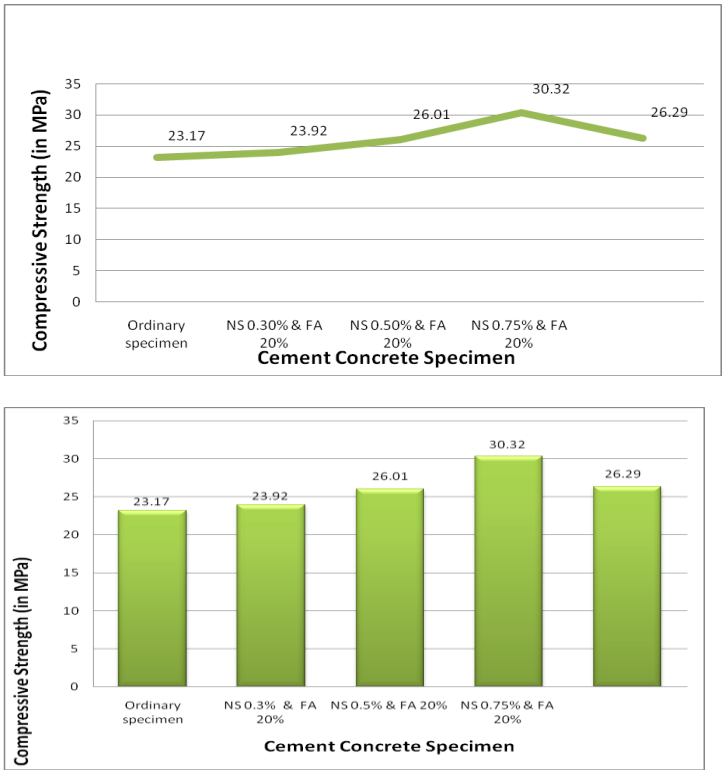
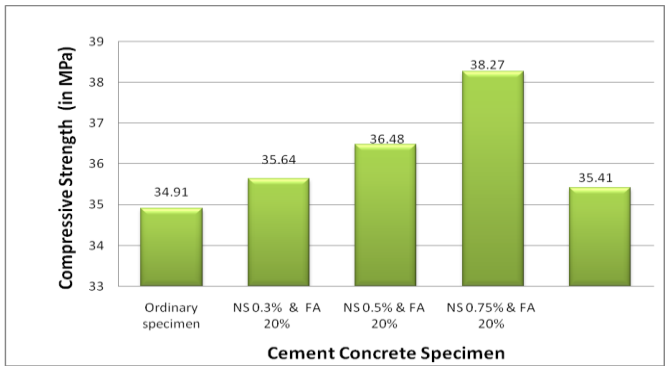


Fig 7: Graph representing 7 day compressive strength for M30 grade concrete



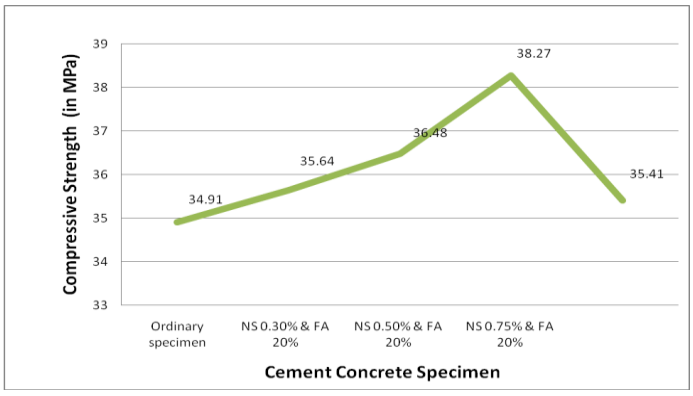


Fig 8: Graph representing 28 day compressive strength for M30 grade concrete

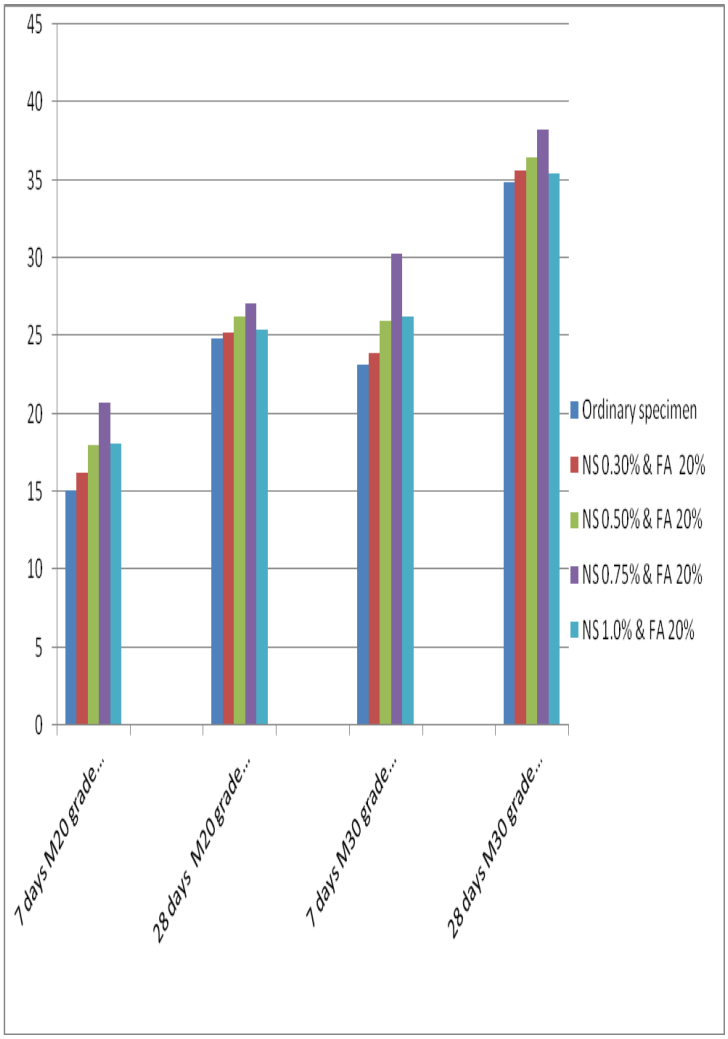


Fig 9: Comparison of compressive strength of all specimens of concrete shown by bar chart

Field Emission Scanning Electron Microscope (FESEM) Micro images of samples

The FESEM micro images for the five types of cement concrete samples are shown in below Figures. For the aim of comparison two different types of magnifications are selected. Due to constraints in the pandemic only 28 days M20 grade concrete FESEM photographs of different percentages of nano-silica with 20% fly-ash and ordinary specimen could only be taken.

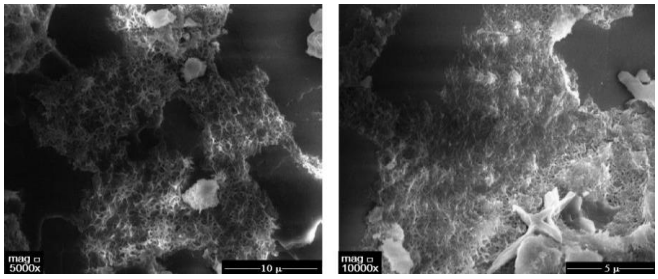


Fig 10: FESEM Microimage of ordinary cement concrete sample with Different magnifications

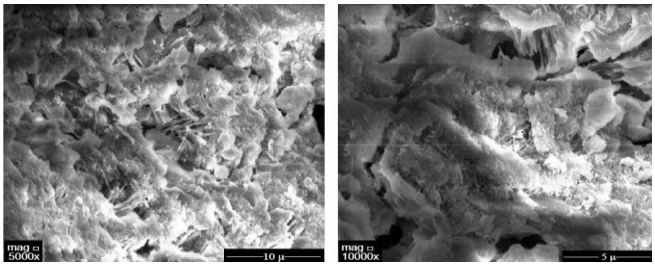


Fig 11: FESEM Microimage of sample with 20% fly-ash and 0.3% nano-silica by weight of cement with different magnifications

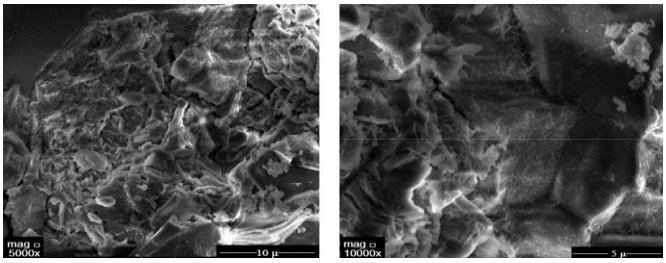


Fig 12: FESEM Microimage of sample with 20% fly-ash and 0.5% nano-silica by weight of cement with different magnification

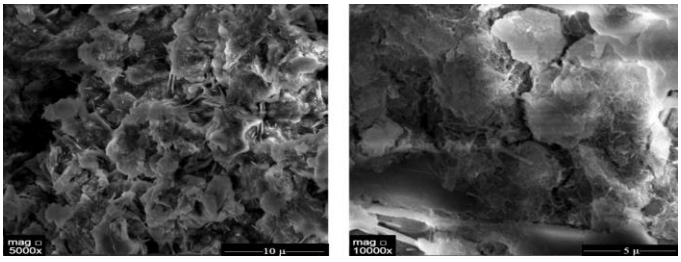


Fig 13: FESEM Microimage of sample with 20% fly-ash and 0.75% nano-silica by weight of cement with different magnification

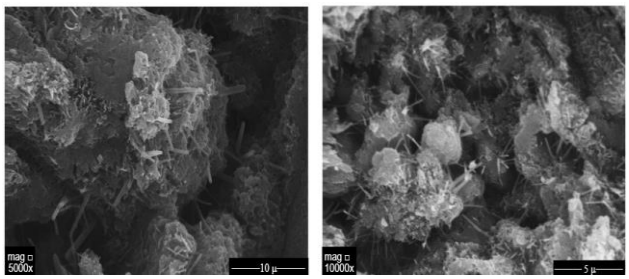


Fig 14: FESEM microimage of sample with 20% fly-ash and 1% nano- silica by weight of cement with different magnification

5.1 CONCLUSIONS

From the test results obtained from the experimental investigations, following conclusions can be drawn.

- Increase in the compressive strength for both the type of concrete mix (M20 and M30 grades) with the increased percentage of nano-silica up to 0.75% and fly-ash 20% by weight of cement and then strength is getting reduced with the increased percentage of nano-silica. The maximum 28 days strength of modified concrete is obtained as 27 MPa and 40 MPa for M20 and M30 grades of concrete respectively with nano-silica of 0.75% and 20% of fly-ash by weight of the cement.
- Workability of concrete increases on addition of small percentage of nano-silica whereas workability starts decreasing with the increased percentage of nano-silica.
- It is observed that on addition of nano-silica there is considerable increase in 7 days strength of cement concrete mix compared to 28 day`s increase in strength.
- Microstructure of the concrete specimens becoming dense on addition of nano-silica.

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