

Characteristics of Cement Concrete with Nano Alumina Particles

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Abstract. Concrete can be nano-engineered by incorporating nano sized building blocks or objects (e.g., nano particles and nano tubes) to control material behaviour and add novel properties. In this work an attempt has been made to study the effect of nano alumina on the properties of concrete composite. In order to investigate the effect of nano-alumina on the mechanical strength of cement composite, the specimens with different volume percentages (0%, 0.5%, 0.75% and 1%) nano-alumina, in each proportion three sample were cast totally making 58 specimens and after 28 days of curing they were tested. Based on experiment, the compressive strength of concrete cubes was all increased by incorporating nano alumina into matrix, when the fraction of nano alumina was 1% of the cement by weight the compressive strength of composites increased by 33.14% at 28 days. The test results showed that addition of nano alumina enhanced the compressive strength and reduced the initial setting time of concrete composite. Micro analysis was carried out by Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS). The studies indicated that nano particle was uniformly distributed by improving the microstructure of concrete.

1. Introduction

Nanotechnology is perhaps the buzzword of all buzzwords. There is something intrinsically interesting about the study of phenomena at a scale so small that lengths, diameters and circumferences can be measured relatively as small number of atoms. Addition of nano silica with in nano scale –size particles can bring about significantly enhanced properties and same synthetic synthesis [1]. It is incorporated with customary building materials fundamental main impetus in the development to design be that as it may, now it is utilization is expanded durability is have in a few components such as micro-cracking of concrete, stiffness and compression strength, firmness and pressure quality and contrasted and the instance of thick structure network for matrix polymer [2-4]. Since bond lattice has free structure between the concrete and total there are nano measured air voids which may have critical impact and inorganic materials including dynamic composite ($\text{SiO}_2, \text{Al}_2\text{O}_3, \text{CaO}$), such as, slag, zeolite and coal powder were turned out to be crucial element of some high-quality concrete and some examination comes about, it is important for enhancing mechanical properties, solidify defrost sturdiness, the vibration damping limit, abrasion resistance, bond strength, corrosion resistance [5-6]. Disappointment is recognized in appearance of splits. It ought to be noted most auxiliary materials, outside anxieties. Since the concrete as of now has breaks exhibit in it the purpose behind utilizing nano material is to fill these splits which help in increment of toughness, quality of the concrete by increment of compressive quality, creep quality. The expansion of nano alumina lessens miniaturized scale breaking and increment compressive quality.



2. Materials

2.1 cement

Ordinary Portland cement of 53 grade confirming to IS 8112:1989 of locally available RAMCO cement which comprises good quality. The chemical configuration of cement was found using X-ray fluorescence analysis and has the following properties are given in Table 1.

Table 1. Shown in properties of cements

Description	Composition
Physical Properties	
Color	Grey
Specific gravity	3.15
Specific surface area (cm ² /g)	3540
Chemical Composition	
CaO (%)	62.8
SiO ₂ (%)	20.3
Al ₂ O ₃ (%)	5.4
MgO (%)	2.7
Na ₂ O (%)	0.14
K ₂ O (%)	62.8

2.2 Fine Aggregate

River sand was utilized as fine aggregate modulus aggregate is 3.32 and it has a place with coarse sand class which can be utilized for concrete mixing. The specific gravity of was noted as 2.64. Table 2 appeared in of fine aggregate.

Table 2. Fineness modulus of Fine aggregate.

IS Sieve (mm)	Weight retained (Kg)	Percentage Retained (%)	Cumulative percentage (%)	Cumulative percentage finer (%)
4.75	4.75	8	0.53	0.53
2.36	2.36	48	3.2	3.73
1.18	1.18	4	0.26	3.99
0.600	0.6	454	30.26	34.26
0.420	0.43	136	9.06	43.32
0.300	0.3	260	17.33	60.65
0.150	0.15	480	32	92.65
0.075	0.075	12	0.8	93.45
Pan	-	96	6.4	99.85

2.3 Coarse Aggregate

The table 3 aggregate passing through 16 mm sifter and held on 12.5 mm sieve was utilized as coarse total in the concrete mixture. The specific gravity of the coarse aggregate was noted as 2.65. The fineness modulus of the coarse total is acquired as 6.8.

Table 3. Properties of Coarse aggregate

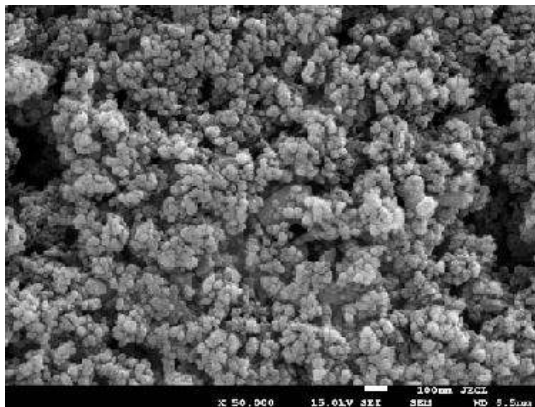
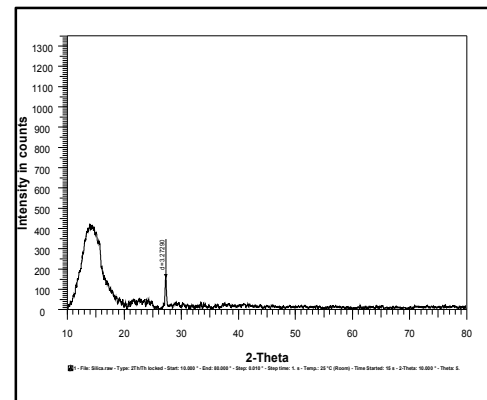
Properties	Observed values
Fineness modulus	6.80
Specific gravity	2.75
Bulk density	1530 kg/m ³
Loose density	1445 kg/m ³
Aggregate crushing value	29%
Aggregate impact value	32%
Maximum size of aggregate	12.5 mm
Water absorption	0.15%

2.4 Nano Alumina (Al_2O_3)

Pure Nano- Alumina (Al_2O_3) was brought and its properties are tested in manufacture company give by table 4 as shown and SEM figure 1.

Table 4. Properties of Nano- Alumina (Al_2O_3)

Test item	Standard Requirement	Test result
Specific surface area(M^2/G)	200-210	$>202 \text{ m}^2/\text{g}$
Crystal structure and type	Alpha	yes
Particle shape	spherical	yes
pH value	3.7-8.5	6
Loss on drying @105 ⁰ c (5)	<1.5	0.47
Loss of ignition @1000 ⁰ c (%)	<2.0	0.66
SiO_2 content	>99.8	99.88
Carbon content	<0.15	0.10

**Figure 1.** SEM of Nano Alumina (Al_2O_3)**Figure 2.** TEM Analysis

2.5 Super plasticizer

Conplast SP430 (G) is utilized where a high level of workability and its maintenance are required, here postponements in transportation or setting are likely or when high surrounding temperatures cause quick droop misfortune. It encourages generation of excellent cement.

2.6 Water-cement ratio

The water cement ratio was kept at 0.33, as the rate of silica smoke expanded; the necessity of water required likewise expanded.

3. Experimental program

3.1 TEM test on Nano- Alumina (Al_2O_3)

Transmission electron microscopy (TEM) is a microscopy procedure in which a light emission is transmitted through a ultra-thin example, associating with the example as it goes through it [5-7]. A picture is shaped from the cooperation of the electrons transmitted through the level of picture is amplified and centered onto an imaging gadget, for fluorescent screen on a layer of photographic film or to be recognized by a sensor as CCD camera. TEMs are fit for imaging at a fundamentally higher determination than light magnifying lens. the instrument's client to look at fine detail—even as little as

a solitary section of particles, which is a huge number of times littler than the littlest resolvable protest in a light magnifying lens [8]. TEM shapes a noteworthy examination strategy in a scope of logical fields, in physical, synthetic and organic sciences. The specimen TEM result appeared in Figure 3.

3.2 Concrete Mix design

The mix design can be characterized as the way toward choosing the reasonable elements of cement and deciding their relative extent with the question of creating cement of certain base quality and sturdiness as monetarily as would be prudent. The reason for outlining the blend is to accomplish the stipulated least quality and to make the solid in the most efficient way.

3.3 Casting Details

Concrete cubes of size 100 mm x 100 mm x 100 mm were thrown to concentrate the compressive strengths of shapes supplanted with Nano-alumina subsequent to subjecting to curing in ordinary condition. Quality trial of solid shapes was performed in programmed pressure testing machine with a limit 3000 kN.

3.4. Cylinders

Cylinders of size 300 mm x 100 mm were casted study the effect of Split tension and Modulus of elasticity in Compression testing machine.

4 Test procedures

4.1 compressive strength test

The compressive strength test is the most widely recognized test directed on the grounds that the vast majority of the alluring trademark properties of cement and the auxiliary outline reason for existing are subjectively identified with compressive strength. Test was conducted in compression testing machine of 3000kN capacity for different ages of concrete viz. 7, 14 and 28 days as per the specifications given in IS 5816: 1999 under normal room temperature and figure 3 and 4 shown in experimental setup of compression, split tension.

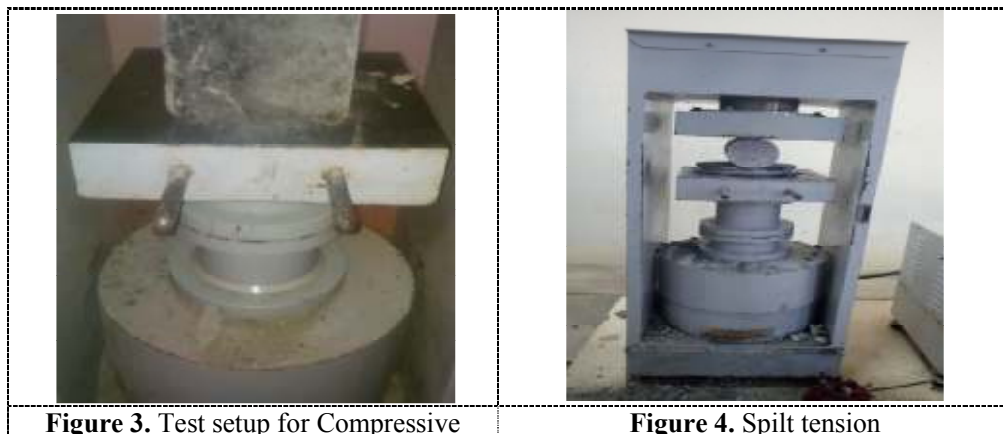


Figure 3. Test setup for Compressive

Figure 4. Split tension

4.2 Split tensile strength test

This is an indirect test to decide the tensile strength of cylindrical specimens. Part elasticity tests were completed at 28 days for the concrete cylinder specimens of size 150 mm length across and 300 mm utilizing pressure testing machine of 3000kN limit according to IS:5816-1999. The load was applied gradually till the specimen splits and readings were noted.

4.3 SEM and EDX Results

An examining electron magnifying instrument (SEM) is a sort of electron magnifying lens that produces pictures of an example by filtering it with an engaged light emission. The electrons connect with atoms in the sample, creating different signs that contain data about the specimen's surface geography and arrangement. The electron pillar is for the most part examined in a raster filter design, and the shaft's position is joined with the recognized flag to deliver a picture [9].

SEM can accomplish determination superior to 1 nanometer. Specimens can be seen in high vacuum, in low vacuum, in wet conditions (in ecological SEM), and at an extensive variety of cryogenic or lifted temperatures. SEM test is done on 2% and 4% Nano-silica in part supplanting cement. EDS depends on a connection of some wellspring of X-beam excitation and a specimen. Its portrayal capacities are expected in vast part to the central rule that every component has a remarkable nuclear structure permitting extraordinary arrangement of crests on its X-beam emanation range.

5. Results and Discussions

5.1 compressive strength tests

Three examples of size 100 mm x 100 mm x 100 mm were utilized for compression testing for each group of blend. Perfect and surface dried examples were put in the testing machine. The platen was brought down and touched the top surface of the specimens the heap was connected step by step and most extreme load was recorded. Figure 4 and 5 as appeared in compressive and split tensile test of nano alumina. Three specimens of size 100 mm x 100 mm x 100 mm were used for compression testing for each batch of mix the test procedure follows as IS code.

Table 5 Compressive strength of Nano-alumina

Nano Alumina Content (%)	Compressive Strength Sample 1 (MPa)	Compressive Strength Sample 2 (MPa)	Compressive Strength Sample 3 (MPa)
0	26.2	25.9	26.6
0.5	28	28.4	27.2
0.75	33.6	32.3	31.8
1	38.4	36.8	37.8

5.2 Split Tensile strength Test

Split tensile test was conducted on cylinders of size 150mm diameter and 300mm height. Clean and surface dried specimens were placed in the testing machine. The platen was lowered and was allowed to touch the top surface of the specimen. The force was applied and maximum load at which the specimen failed was recorded.

Table 6 Split tensile strength of Nano-alumina

Nano Alumina Content (%)	split tensile (Mpa) sample1	split tensile (Mpa) sample2	split tensile (Mpa) sample3
0	2.98	3.13	3.06
0.5	3.54	3.44	3.47
0.75	3.72	3.76	3.69
1	3.94	3.90	3.84

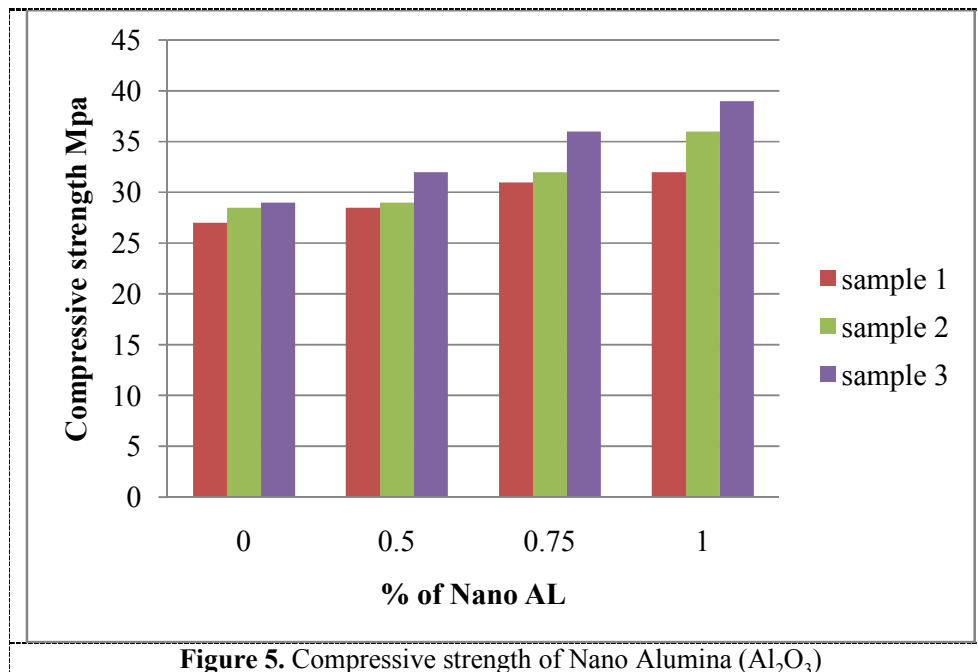


Figure 5. Compressive strength of Nano Alumina (Al_2O_3)

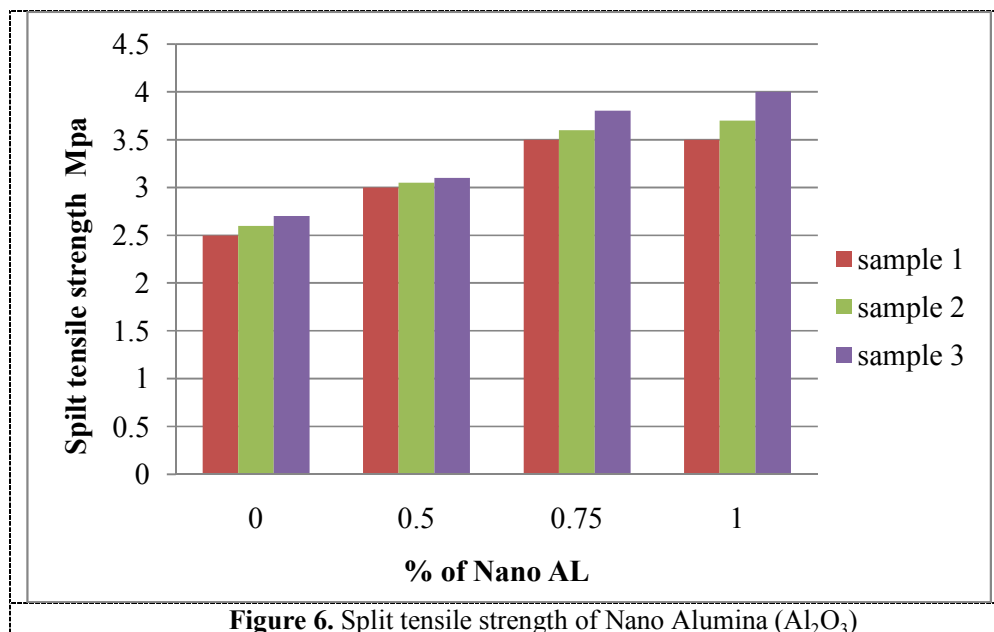


Figure 6. Split tensile strength of Nano Alumina (Al_2O_3)

5.3 SEM and EDS Results

The SEM picture and EDS range of concrete demonstrated that there exists noteworthy contrast between the 0% test and 1% nano-alumina concrete. Around the total there exist breaks under wraps test while there is a thick blame zone around the total in ITZ of 1% expansion mortars [10-12], and Figure 7 to 9 as appeared if variant of alumina present specifically region in that segment, There is more measure of aluminum and alumina around the total of the mortars with 1% alumina than the check test as appeared in Figures. Hence, amid the development of C-H-S (C-CaO , S-SiO_2), and

(H₂O) gel, nano-alumina topped off the pores of free net structure around the sand molecule, and diminished the porosity and expanded the thickness level of ITZ [11-12].

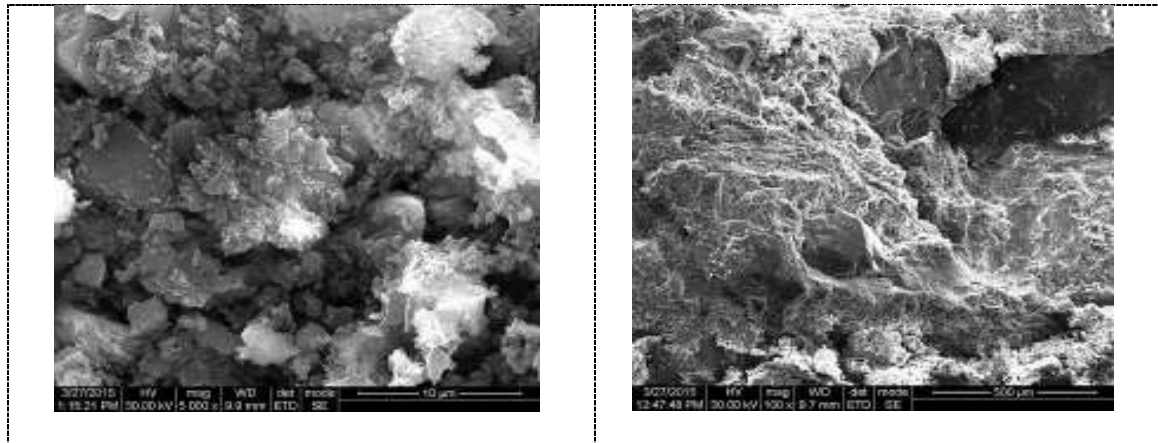


Figure 7. SEM image of concrete hydrated for 28 days with 0%& 0.5% nano-alumina

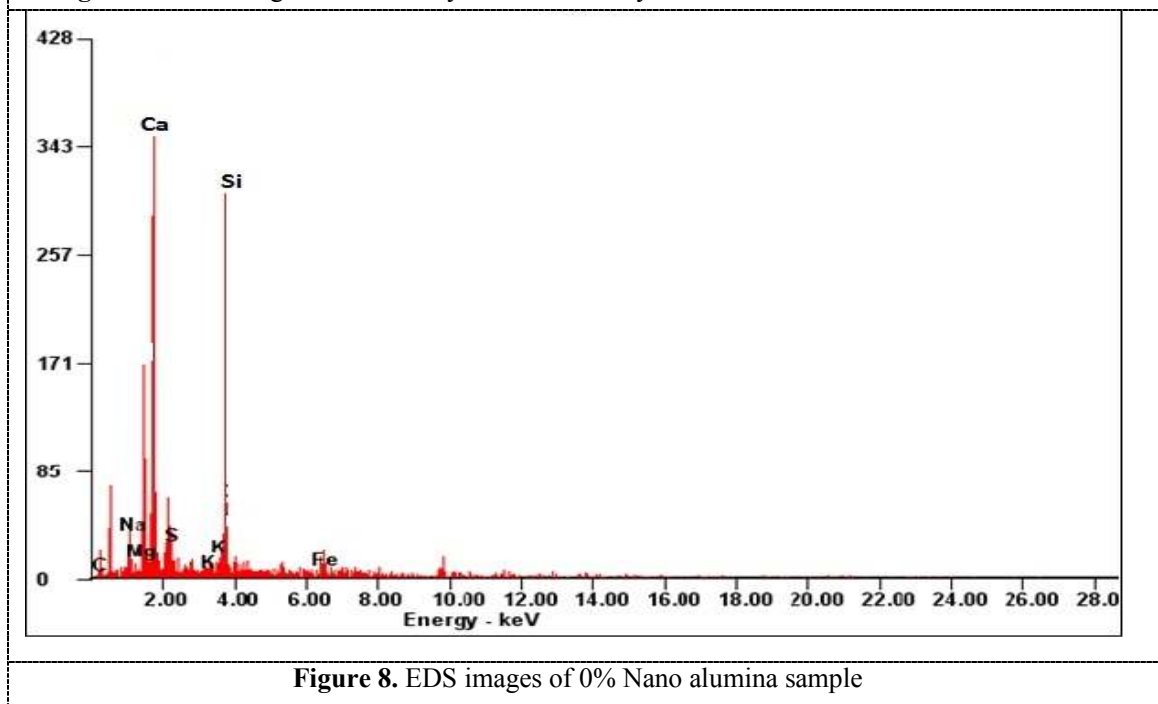


Figure 8. EDS images of 0% Nano alumina sample

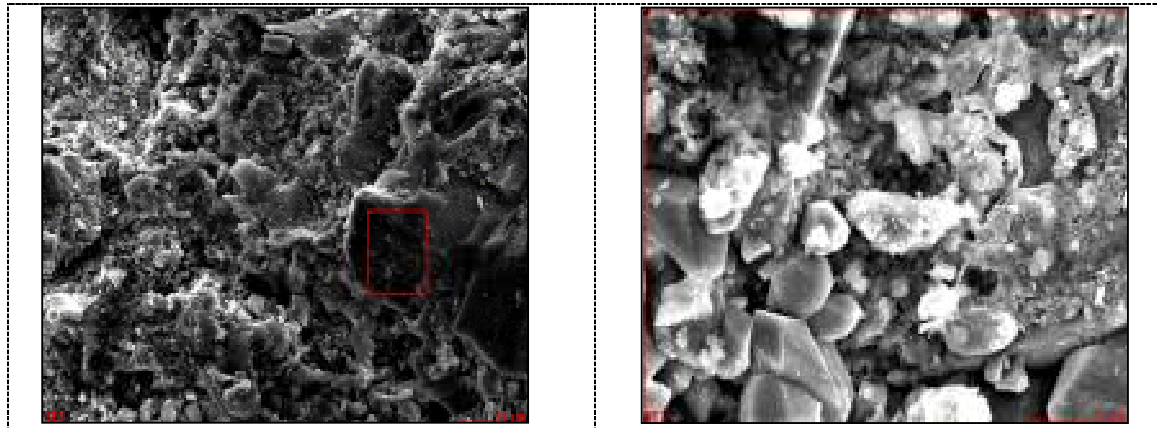


Figure 9. SEM image of concrete hydrated for 28 days with 0.75 % & 1 % nano-alumina

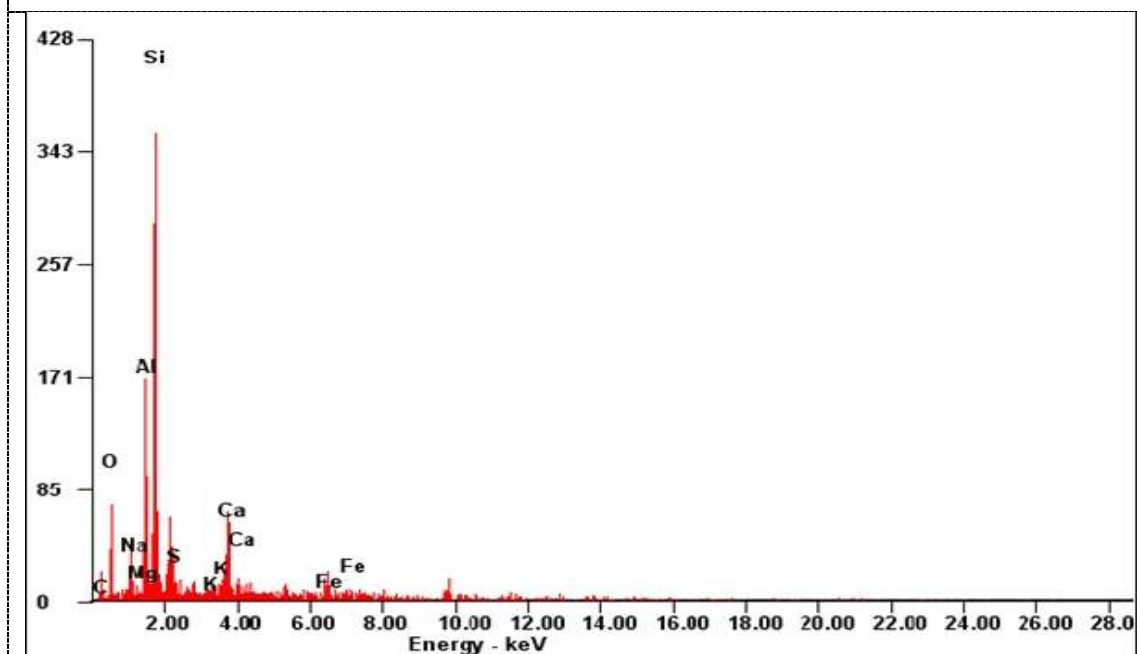


Figure 10. EDS images of 1 % Nano alumina sample

6. Conclusions

The accompanying were the conclusions touched base from the analyses directed on specimens in Standard condition: Based on the outcome, it was found that for the expansion in rate of nano alumina, mechanical properties demonstrated reliably enhanced results. The compressive strength expanded significantly, the split tensile strength increased marginally. However the split tensile strength of the concrete could be enhanced by utilizing more reasonable reinforcements with nano particles. The SEM contemplates demonstrated that the nano particles are consistently conveyed and there by microstructure of cement is progressed. The SEM perceptions likewise uncovered that the nano-particles were going about as filler, as well as an activator to elevate hydration demonstrates and to enhance the microstructure of the concrete if the nano-particles were consistently scattered. The void investigation done utilizing image J programming uncovered that the rates void brought down when

the extent on nano alumina expanded. The rate voids if there should be an occurrence of 1% nano alumina content cement is relatively lesser than that of 0% nano alumina concrete. Additionally ponder toward this path is suggested, since more number of perceptions is required for getting the ideal amount of nano-particles.

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