COMPARATIVE STUDY OF POZZOLANIC ACTIVITY OF ULTRAFINE POZZOLANA

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Abstract

Accelerated pozzolanic activity of various ultrafine materials like silica fume, metakaolin and microfine cement(ultra fine slag) with different percentage level of replacement has been compared. There is increase of 14% to 40% increase of pozzolanic index with the incorporation of ultrafine pozzolanic material. Maximum gain in strength has been observed in case of microfine. With the use of superplasticizer there is gain of about 40% in accelerated pozzolanic activity of microfine compared to control. With 7.5% silica fume the pozzolanic activity is comparable to 7.5% of microfine.

Key Words: Pozzolan, Cement, Compressive strength, particle size distribution, Fineness

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INTRODUCTION:

Role of various pozzolanic materials as supplementary materials has become vital for the development of durable/high performance concrete [1-10] namely flyash, slag, silica fume, metakaolin and rice husk ash etc. These pozzolanic materials are blended in cement as mineral admixtures. Pozzolanic activity is the index of lime-pozzolana reaction between lime liberated by cement and silica of the pozzolana. Fineness of the pozzolana plays an important role in this pozzolanic reaction. At early ages, the fineness plays an important role in strength development, via a micro -filler or cement dispersant effect or both. However, at later stage, the soluble silica content of the pozzolana becomes more significant, [11]. In view of this high surface area pozzolana are being used in the concrete using high range superplasticizers. In the present study accelerated pozzolanic activity index of three high surface area pozzolan silica fume, metakaolin and microfine cement (high surface slag) has been compared as per ASTM [12]

Materials: -

Cement: Ordinary Portland cement 43 grade conforming to BIS 8112/1989 was used in the present study. The physical and chemical properties of the cement are given in table no. 1 .

Metakaolin:

Metakaolin was procured from 20 microns a conforming to ASTM C 618. Its physical and chemical properties are given in table no. table no.2

Microfine cement: This high surface area slag named microfine cement (1203) was supplied by M/s Alkccofine industries Goa. Its physical and chemical properties are given in table no. 3

Silica Fume: Silica fume was supplied by M/s Elkem India. Its physical and chemical properties are given in table no.4

Particle Size Analysis:- The particle size analysis of all the samples were determined using Horiba 950SA Particle size analyzer and the results are shown in figure Nos 5-8 .

XRD: X-ray of all the samples is shown in figure nos. 1- 4.

Surface Area: The surface area of all the samples were determined by Microtrac, USA . The values are given in table no. 6.

Superplasticizer: - Naphthalene sulphonate formaldehyde condensate (SNF) was used in the present study. One percent dose by weight of binder was used in all the test mixtures.

Experimental Procedure: -

Accelerated pozzolanic activity

Control Mixture: - The control mixture was prepared with 250 gm of portland cement with 687.5gm of graded sand and ml of water to get a flow of 110 ± 5%.

Test mixture: - The test mixture was prepared with 225 gm of cement with various percentages of pozzolana (Metakaolin, Microfine and silica fume) respectively. The water content in all the sets was adjusted to keep the flow at 110 ± 5%. The above set of experiments was repeated with 1.0 % Superplasticizer.

Mixing Procedure:- The mortar mixes were prepared using ELE(UK) Automatic Mortar mixer. 50 mm. cubes were cast for the present study.

Storage of Specimens:- After 24 hours of initial curing in a moist room(25± 2^0C) with relative humidity not less show 95%.The cubes were placed in a air tight glass containers and stored at 65± 2^0C for 6 days.

Determination of Compressive Strength: -The compressive strength of mortar cubes after 7 days of demoulding of control and test mixture was determined and average of the three samples is reported in Table No 5.

Results and Discussion:

X-ray graph of microfine, metakaolin and silica fume is shown in figure nos.1,2 &4. It is clear from microfine X- ray that a small peak of Calcite, Merwinite(2CaO. $Al_2O_3.SiO_2$) and Melilite (solution of gehlenite and akernite) is visible. (calcite, $2\theta=29^o$, Merwinite 34^o and Melilite 30^o). In case of metakaolin strong peaks of silica, alumina and iron oxide is visible. In case of silica fume amorphous peak of silica is visible.

The pozzolanic activity of various pozzolana has been evaluated by different methods depending upon physical, chemical and mechanical. In the present study pozzolanic activity has been determined based on compressive strength as per ASTM method specified for silica fume. Since in the present study all the pozzolanic materials possess nearly the same surface area, thus the method to assess the pozzolanic activity of these samples is justified. The control pozzolanic activity of control mix has been found to be 34 MPa. Further it is clear from the table no. 5 that without the use of superplasticizer and with various percentages of replacement of pozzolana, silica fume shows gain in strength of about 20% upto 7.5% and beyond that there is small drop in strength suggesting there by that optimum dose level is about 7.5%. In case of microfine the gain in strength is about 35% upto 7.5 % and at 10% replacement it is only 20% compare to control. When metakaolin is replaced gain in strength is about 28% at 10% replacement. Extra gain in strength in case of microfine can be attributed due to the fact that slag is a hydraulic material and forms cementitious compounds similar to cement on hydration.

With the use of superplasticizer gain in strength is about 40% with 7.5% of silica fume and microfine and 10% metakaolin.

Conclusion:

It can be concluded from the present study that all the three ultra fine pozzolana shows comparable pozzolanic activity. However, microfine showing slightly more pozzolanic activity compare to others.

The use of metakaolin and microfine pozzolana can replace silica fume for the development of durable concrete.

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12.Standard specification for silica fume for use as a mineral admixture in hydraulic cement concrete, mortar and grout, ASTM 1240 (2000).

Table1- Chemical/Physical composition of Cementitious Materials

Composition,%	Cement
SiO2	20.5
Al2O3	3.8
Fe2O3	2.6
CaO	60.5
MgO	3.2
Chloride content	
SO3	2.5
CaO+MgO+ SiO2	—
SiO2 + Al2O3 + Fe2O3	—
LOI	1.0
Fineness cm^2/gm	3100

Table No.2 Physical and chemical properties of Metakaolin

Physical form	white to off white powder
Specific gravity	2.5
Residue 325 Mesh(% max)	0.5
Average partical size,fYm	1.5
Bulk density (gm/lt)	300
Accelerated pozzolanic index,%	97
$SiO_2 + Al_2O_3 + Fe_2O_3$	96 to 98%
LOI	1%

Table No. 3 Physical and chemical properties of Microfine

Bulk Density	700 - 800 kg/m^3
Chemical Composition	
CaO	32 - 34%
Al_2O_3	18 - 20%
Fe_2O_3	1.8 - 2%
SO_3	0.3 - 0.7%
MgO	8 - 10%
SiO_2	33 - 35%

Table No. 4Physical and chemical properties of Silica fume

Composition,%	%
SiO_2	90.5
Al_2O_3	0.9
Fe_2O_3	0.1
CaO	0.4
MgO	2.0
SO_3	---
LOI	2.5
Surface area m^2/g	16.4

Table No.5 Comparison of Accelerated Pozzolanic Index of various pozzolanic material

Sl.No.	W/C Ratio	CS-MPa	% Control
Control	0.520	34.0	100
5.0%Silica Fume	0.564	39.0	114.7
7.5% Silica Fume	0.588	42.0	123.5
With SP	0.525	48.0	141.1
10% Silica Fume	0.613	40.0	117.6
5% Microfine	0.547	44.0	129.4
7.5%Microfine	0.562	46.0	135.0
With SP	0.510	49.5	145.5
10%Microfine	0.586	41.0	120.5
5.0% Metakaolin	0.554	42.5	125.0
10% Metakaolin	0.578	43.5	127.9
With SP	0.525	47.5	139.7

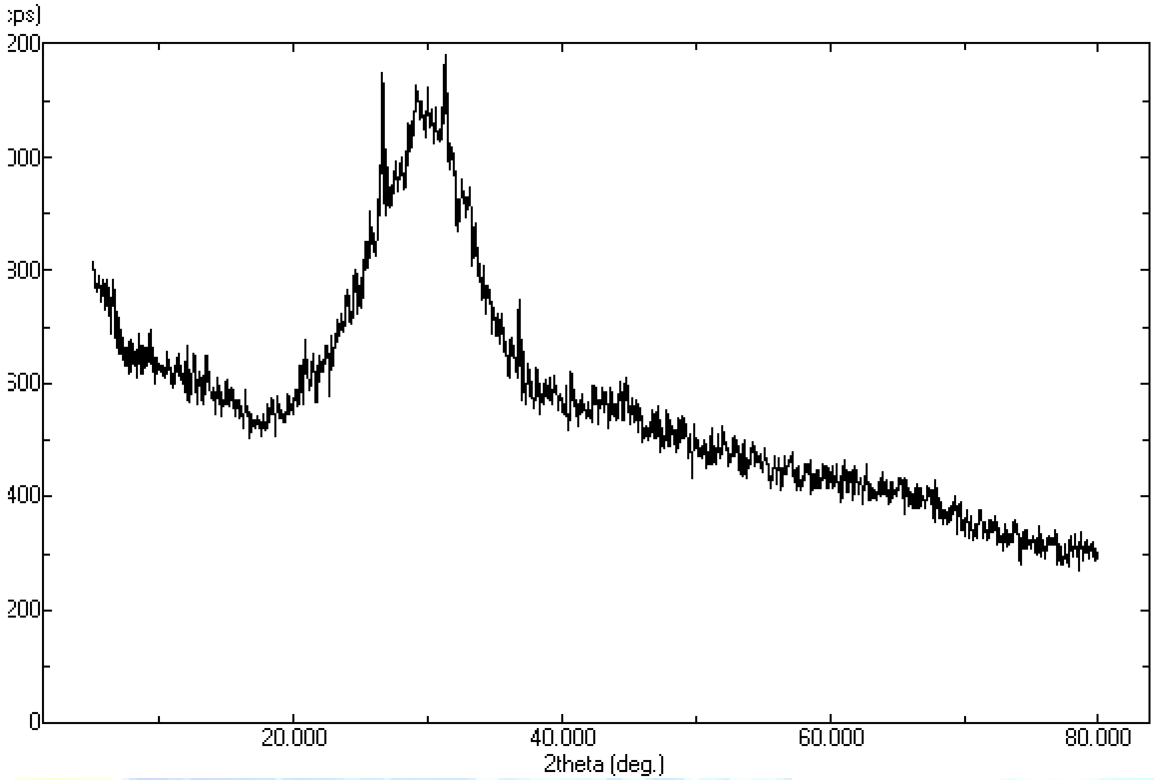

Fig. 1 XRD profile of Microfine sample

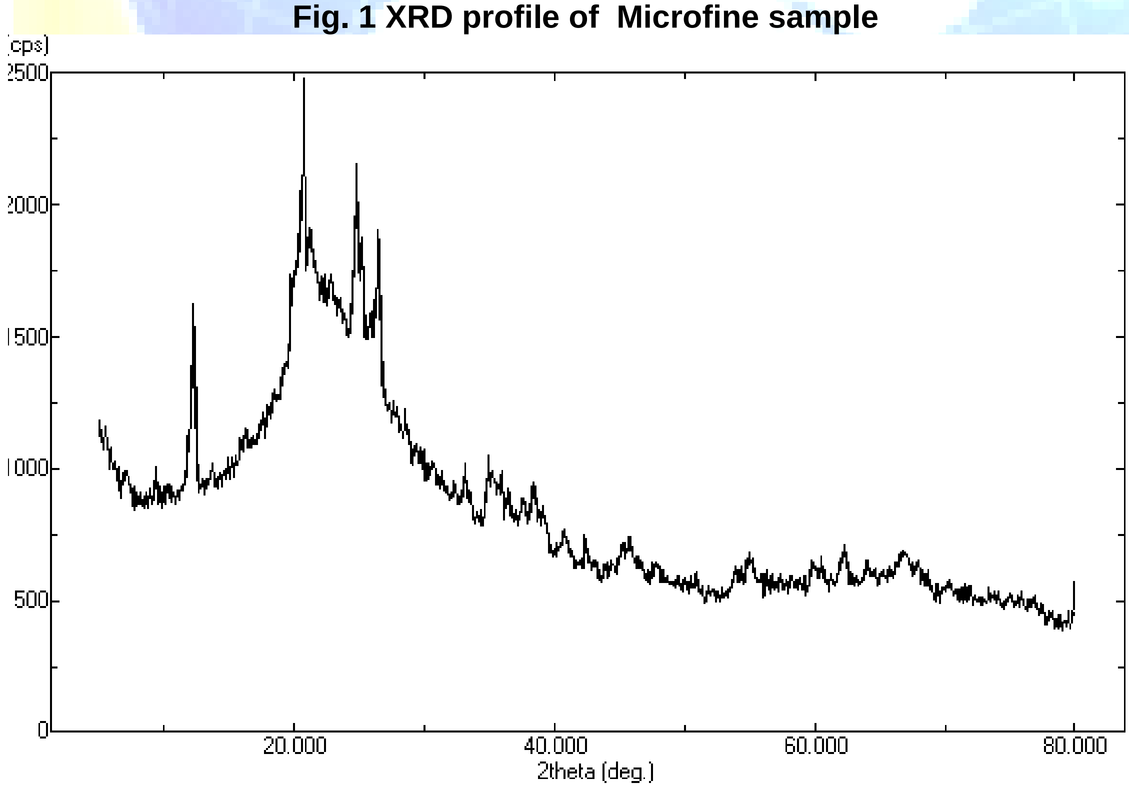

Fig 2 XRD profile of Metakaloin sample

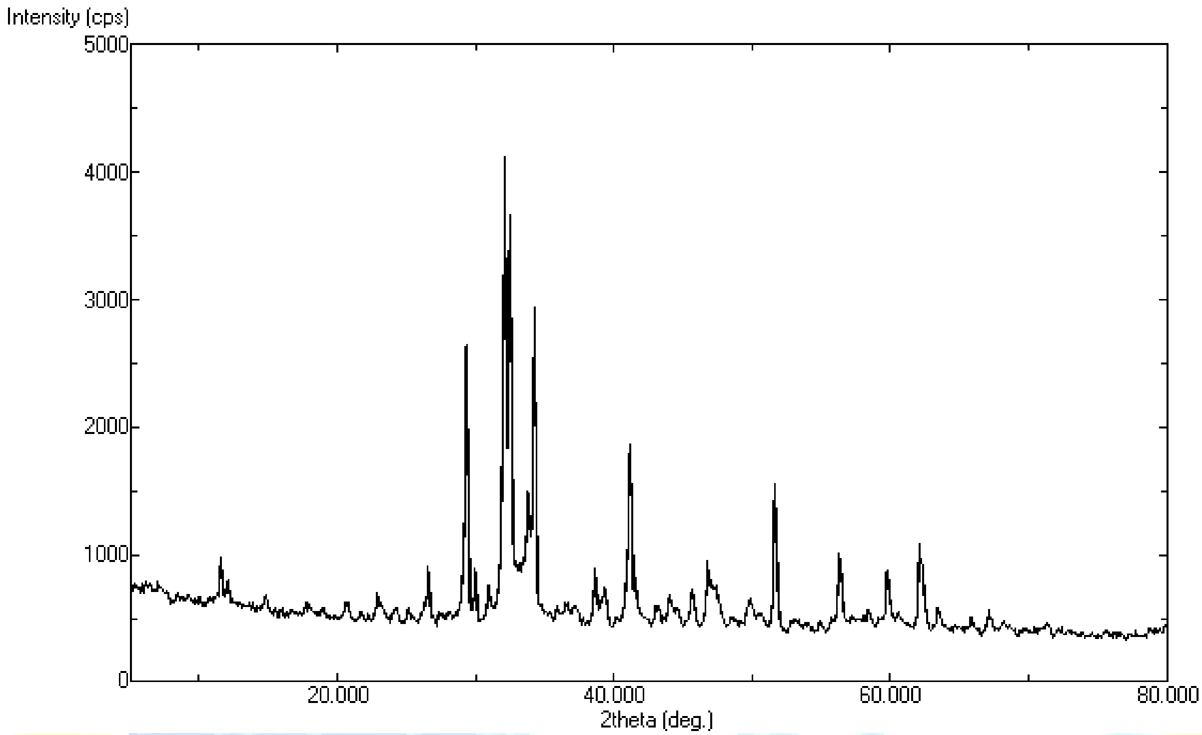

Fig. No.3 XRD profile of anhydrous Cement

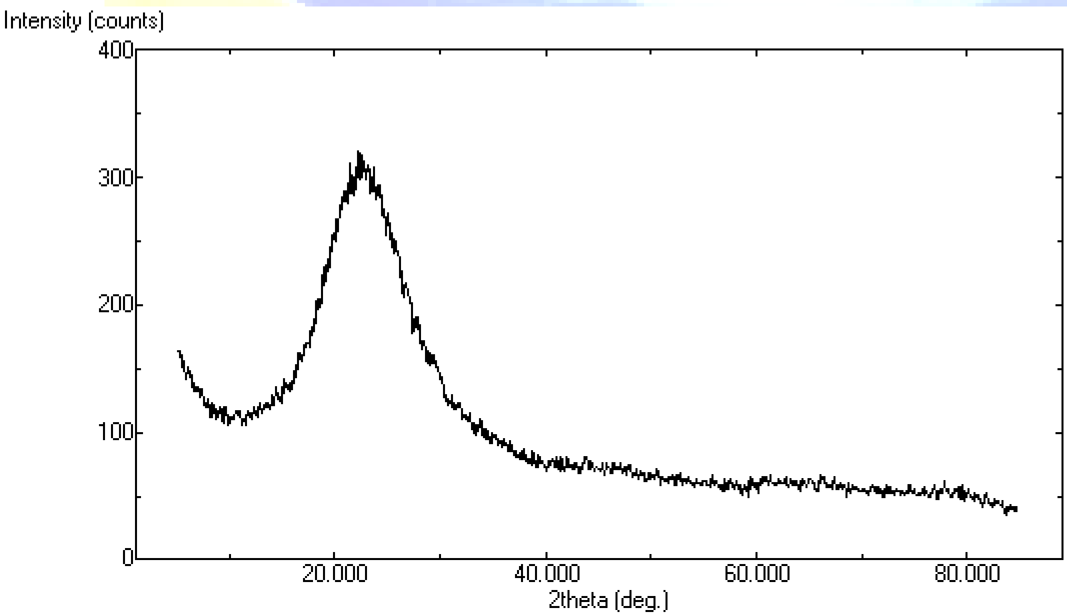

Fig No 4 XRD Profile of Silica Fume

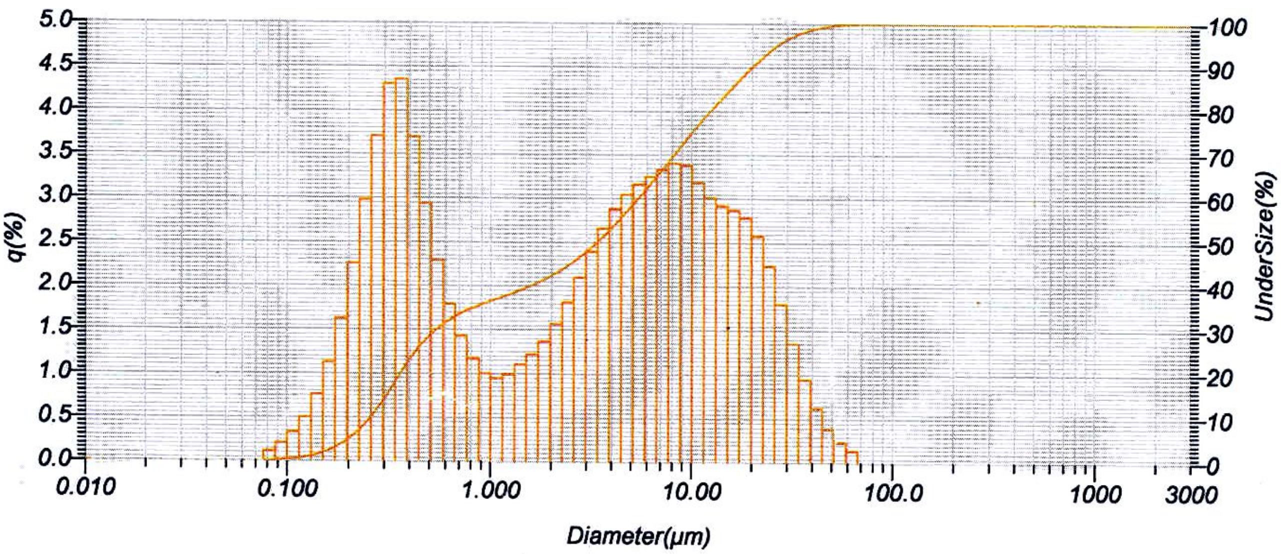

Fig No. 5 Particle Size Distribution of Metakaolin

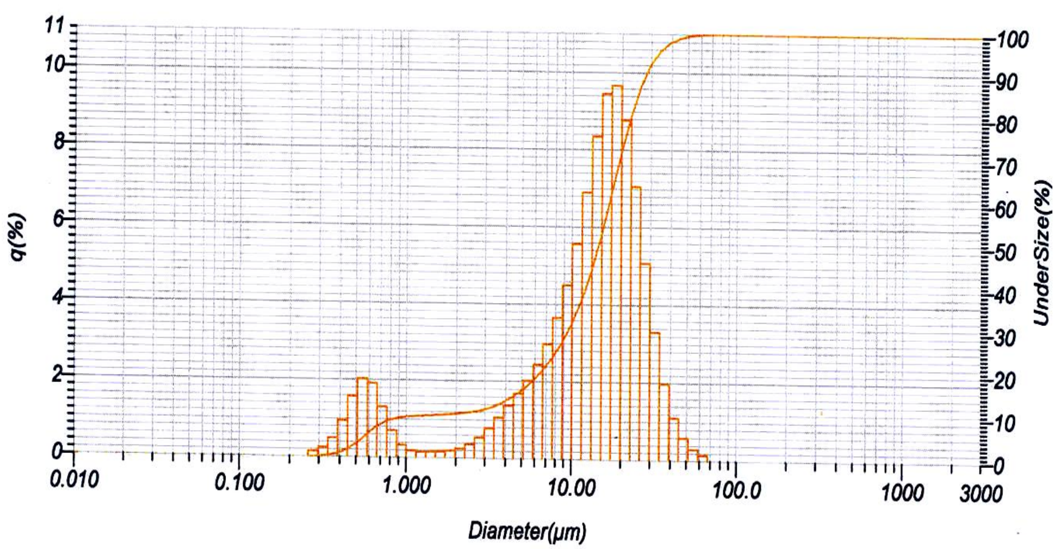

Fig No. 6 Particle Size Distribution of Cement

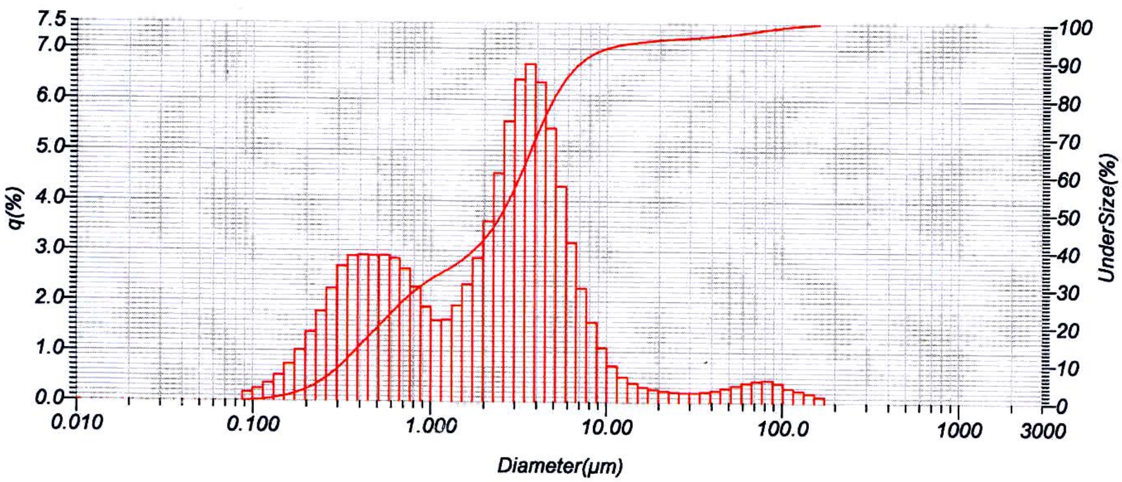

Fig. No. 7 Particle size Distribution of Microfine

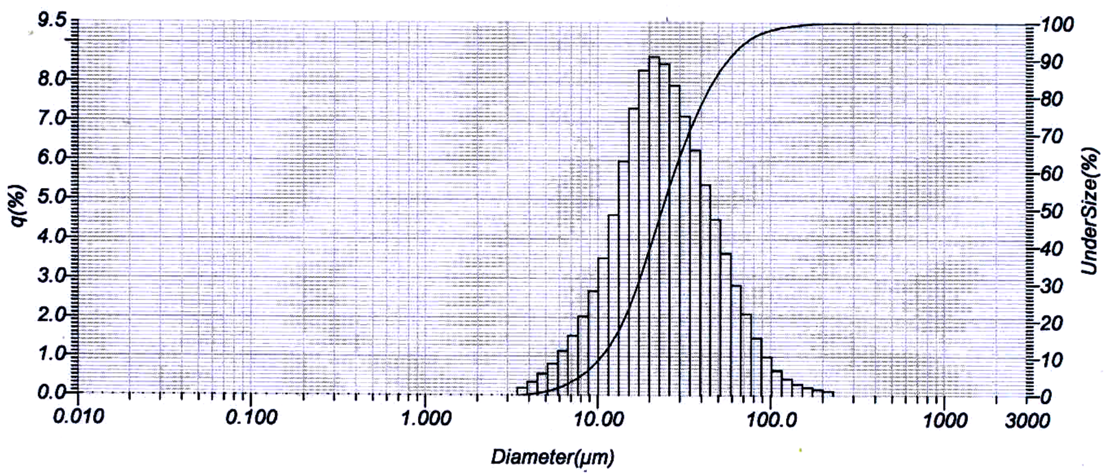

Fig No 8 Particle Size Distribution of Silica Fume

Table

Microtrac

Specific Surface Area Report(BET Single-point)

Title: MFMTKSF

Preparation: 105° C Vacuum drying 2 hours

Notes: N/A
Model: Microtrac SAA
Operator: N/A
Checked By: N/A

No.	Sample ID	P/Po	V	1/[V(Po/P-1)]
1	B8	0.30	46.49060	0.00923
2	MF	0.30	0.51164	0.83892
3	SF	0.30	5.39848	0.07951
4	MTK	0.30	4.11097	0.10441

No.	Smaple ID	Mass(mg)	Vm	SpecificSurfaceArea(m2/g)
1	B8	167.199	32.52850	141.82427
2	MF	994.9	0.35799	11.8642
3	SF	991.3	3.77720	16.46860
4	MTK	1013	2.87636	12.54092

Table No. 6. Surface area of different pozzolanic materials