EFFECT OF MARBLE SLURRY DUST AND LIME STABILIZATION ON GEOTECHNICAL PROPERTIES OF FINE SAND

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Abstract

The present work has been carried out to study the effect of lime and marble slurry dust on geotechnical behavior of fine sand. Deserts and sea shores generally comprises of fine sand which not very effective for building infrastructure work or sub base work in road construction as it loose and vulnerable to collapse upon wetting. Fine sand is also unreliable for earthen dam construction as it has low shear strength and high permeability. Further, fine sand tend to absorb moisture from atmosphere which makes it constructing landfill liners and covers. The disposal of marble slurry dust from marble mines and cutting industries has been a major environmental concern over a period of last few decades. Marble dust can be used as an additive for soil stabilization.

An experimental program including scanning electron micrographs and x-ray diffraction has been performed to characterize the materials. Various proportions of mixes of fine sand with marble slurry dust with various percentages of lime were tested to find out the optimum percentage of marble slurry dust in order to improve the strength characteristics of fine sand.

Keywords: *Fine Sand, Marble Slurry Dust (MSD), Soil Stabilization, Scanning Electron Micrographs, X-Ray Diffractograms, Shear Strength, Triaxial Test.*

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1. INTRODUCTION

Sands are naturally occurring, relatively unconsolidated earth material. Sands are product of physical weathering or mechanical disintegration of rocks. They retain the minerals that were present in the parent rocks. Physical weathering of rocks is caused mainly by impact and grinding action of flowing water, wind, ice and splitting action of ice and plants.

Sands have rounded to angular, bulky, hard, rock particles, which have particle size range from 4.75 mm to .075 mm. Sands that have particle size range from 4.75 mm to 2.0 mm, are termed as coarse sands. Sands that have particle size range from 2.0 mm to 0.425 mm are termed as medium sands. Sands that have particle size range from .425mm to 0.075 mm are termed as medium sands.

Fine sand has very less use for engineering purpose as it impedes setting action of cement so can be used as a local material for nonstructural work.. Further, Fine sand create major problems for construction of infrastructures because of dampness and disintegration of work, because it draws moisture from atmosphere as it comprises of salts. This absorption of moisture makes it effective for construction work. Fine sand is also very ineffective in construction work as it is usually fine-grained and poorly graded. Fine sand has relatively high permeability and low shear strength, which makes it unsuitable for dam construction work. Thus, these causes evidenced that fine sand it also not reliable for construction of landfill liners and covers. [5]

Marble dust is a waste of marble industry. While marble blocks are cut by gang saws, water is used as a coolant. The blade thickness of the saws is about 5 mm and normally the blocks are cut in 20mm thick sheets. Therefore, out of every 25mm thickness of marble block, 5mm are converted into powder while cutting. This powder flows along with the water as marble slurry.

The total waste generation from mining to finished product is about 50 % of mineral mined. *Agra, Chennai, Bastar, Makrana, Rajasamund, Udaipur, Kishangarh, Chittorgarh, Jaipur and Banswara. aremjor concentration areas for Marble and Soft Stone Crafts.*Most of the slurry is dumped along road side or in open spaces which is leading to serious ecological and environmental hazards.

Marble dust contains silica which creates a cementitious material on reaction with calcite present in lime. So, marble can be used as an additive for soil stabilization. The use of traditional techniques to stabilize the soil faces problems like high cost, and/or environment issues. The improvement of soil by marble dust is the alternative solution. The soil stabilized by marble dust finds bulk utilization in roads, canal lining, construction of pavement structures and foundations.

2. LITERATURE REVIEW

Akshaya K. Sabat and Radhikesh P. Nanda (2011) has done work to investigate the effect of Marble dusts on strength and durability of an expansive soil stabilized with

optimum percentage of Rice Husk ash (RHA). The MDD keeps decreasing and OMC keeps on increasing by whatever the percentage of addition of Marble dust to RHA stabilized expansive soil. The UCS of the RHA stabilized expansive soil increased up to 20% addition of Marble dust. Further addition of Marble dust decreased the UCS of the expansive soil.And the UCS of the virgin soil has 228% increase.

B. Diouf et al.(1990): To stabilize sand dunes is temporary stabilization is done by any material that stops surface sand movement. The second step is biological stabilization,which consists of establishing a permanent vegetative cover To develop inexpensive technology to stabilize highly erodible soils and arrest migrating sand dunes,B. Diouf et al.(1990), has carried out a research work to evaluate the effectiveness of adding clay to very sandy soil to reduce wind erosion susceptibility.

V. Aggrawal and Mohit Gupta (2000) has used marble dust as stabilizing additive to expansive soil is evaluated. Different test are done on soil mixture with varying proportion of marble dust (from 0 to 30%).They had concluded that:The addition of the marble dust to the expansive soil reduces the LL, raises the SL and decrease in the plasticity index of soil and thus swelling potential. Activity of the soil reduces by the addition of marble dust. By curing the samples, the rate of swell and swelling percentage decreased.

3. EXPERIMENTAL WORKS

3.1 Materials Used

A sample of fine sand was collected from beech in Chennai region and sample of marble was collected from Naraina Industrial Area, Delhi. Properties of fine sand are shown in Table 1 below.

Table-1: Properties of Fine Sand

Properties	Fine sand
Specific gravity	2.63
Plastic Limit	Non-Plastic
Optimum moisture content (%)	8.81
Maximum dry density (gm/cc)	1.60
Un-soaked CBR (%)	7.75
Cohesion (kPa)	14.03
Angle of internal friction (deg.)	36.54

3.2 Admixture Proportions and Tests Conducted

Lime was added as 3%, 6%, 9% and 12% by weight to fine sand. Later on different proportions of marble slurry dust as 5%, 10%, 15% and 20% by weight, is mixed with various amounts of lime with fine sand. Sample proportions are given in Table 2 below.

Table-2: Sample Proportions

Sample	Lime (L) %	Marble Slurry Dust (MSD) %
Fine Sand (FS)	3	0
		5
		10
		15
		20
	6	0
		5
		10
		15
		20
	9	0
		5
		10
		15
		20
	12	0
		5
		10
		15
		20

The following experiments were conducted on the fine sand mixed at different mixes of fine sand, lime and marble slurry dust. The formation of bonds was found under scanning electron microscope (SEM) and mineral composition of materials was observed with x-ray diffraction technique (XRD). Specific gravity test was conducted as per IS: 2720 (Part 3)-1980. Plastic limit was calculated as per IS: 2720 (Part 5) -1985. Particle size distribution was conducted as per IS: 2720 (Part 4) -1985. Standard Proctor test was conducted as per IS: 2720 (Part 7) -1980. UU triaxial test was conducted as per IS: 2720 (Part 11) -1983. California Bearing Ratio (CBR) was conducted as per IS: 2720 (Part 16) -1987.

4. RESULTS AND DISCUSSION

4.1 Scanning Electron Microscope Analysis

Scanning Electron Microscope provides information about the sample's surface topography and composition of the sample. SEM micrographs of lime-fine sand mixtures and MSD-lime-fine sand mixtures are shown from fig. 1 to 23. SEM micrographs showed that fine sand are sub-angular and MSD particles are sub-rounded in shape which implies better interlocking between fine sand, MSD particles and lime. Hence mixing of MSD and lime in fine sand enhances the strength of the mixture due to densification of the material.

4.2 X- Ray Diffraction

In order to gain information about the crystal structure and chemical composition of materials X-ray diffraction technique is used. X-ray diffractogramsof dry sample of fine sand, pond ash and lime are shown from fig. 24 to 26**.**The peaks in XRD showed the presence of quartz, mullite in fine

sand, presence of silica in marble slurry dust(MSD)and presence of calcite in lime, when matched with JCPDS (*Joint Committee on Powder Diffraction Standards*) data book.

4.3 Particle Size Distribution

The results from the grain size analysis reveal that the materials were not well graded fine sand is uniformly graded and marble slurry dust is poorly as shown in fig. 27. Particle size distribution graph shows that graded. And their Particle size distribution is much parallel.

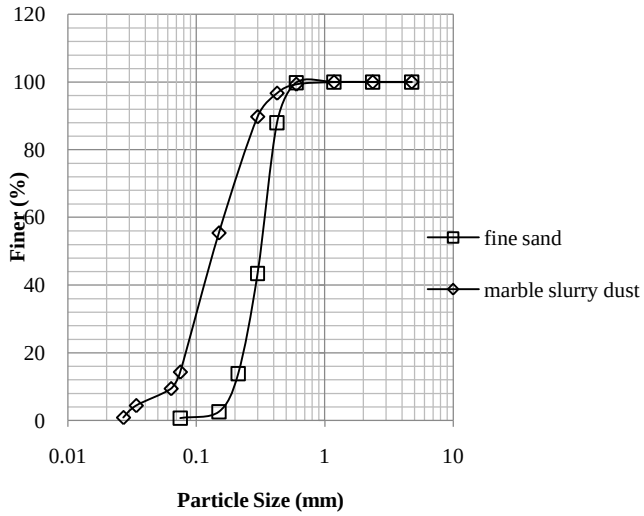

Fig -27: Comparison of Sieve Analysis

4.4 Standard Proctor Compaction Test

The deviation in maximum dry density and optimum moisture content for lime-fine sand mixture is signified are in fig. 28 and 29 and variation for MSD-lime-fine sand mixture are presented in fig. 30 and 31. MDD and OMC are increasing with increase in lime percentage in fine sand upto 9% after that it declines. MDD is increases with increase in MSD percentage in fine sand upto 15% after that it decrease. OMC first decreases when MSD is added and on further addition of MSD, change in OMC in very less.

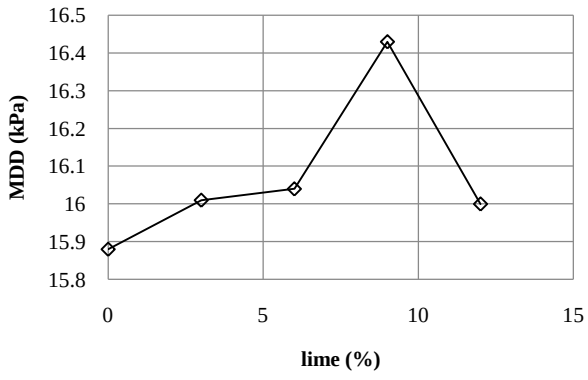

Fig-28: Influence of lime on MDD

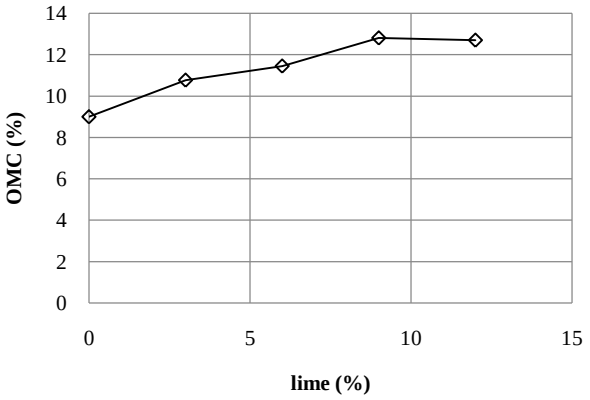

Fig-29: Influence of lime on OMC

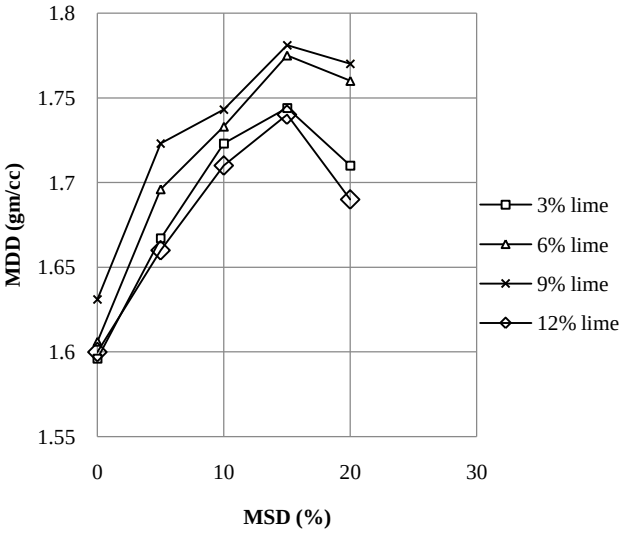

Fig-30: Influence of MSD on MDD

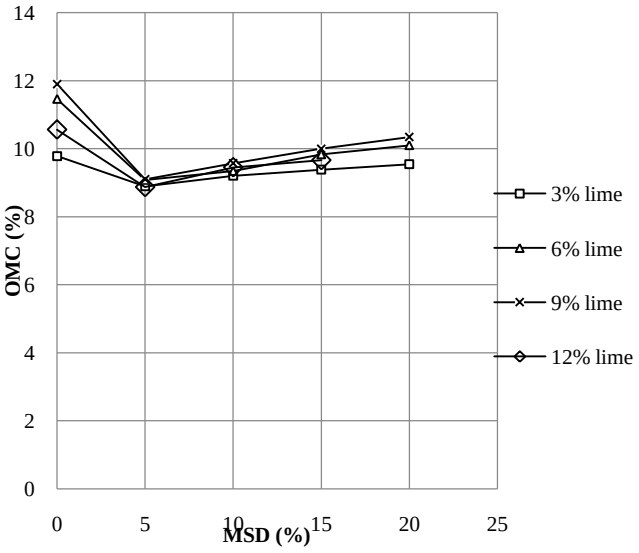

Fig -31: Influence of MSD on OMC

4.5 CBR Test (Unsoaked)

The CBR test results presented in fig. 32 to 33. Test results divulges that CBR value rises when lime percentage is increased upto 9% after that it declines. On addition of MSD, CBR value increases upto 15% of MSD after it decreases.

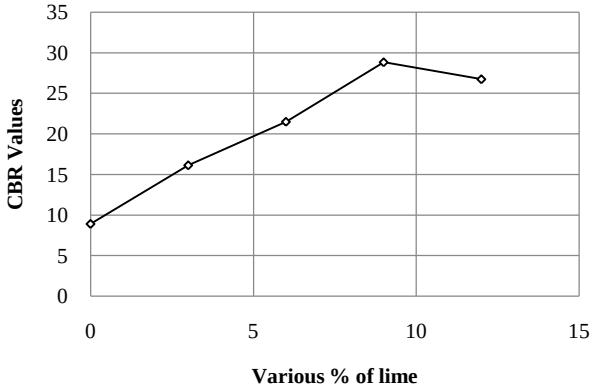

Fig-32: Influence of lime on CBR values

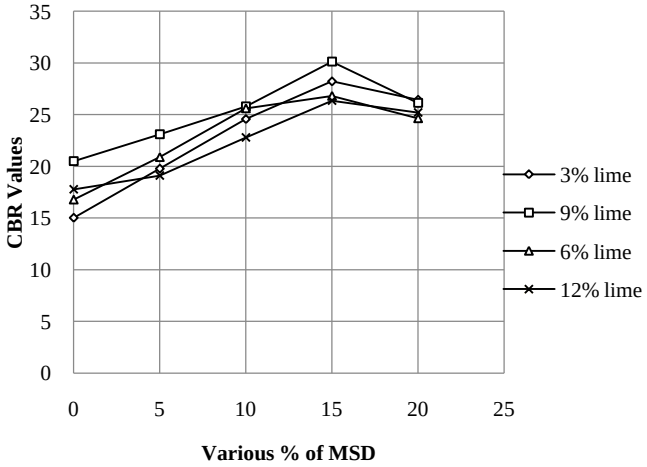

Fig-33: Influence of MSD and lime on CBR values

4.6 UU Triaxial Test

The UU triaxial test results are represented in fig. 34 to 37.UU test results divulges that cohesion and angle of internal friction (ϕ) increases with increase in lime percentage in fine sand up to 9% lime after that it is decreases. And with addition of marble slurry dust (MSD) with various percentages of lime as 3%, 6% & 9%, there is further results into escalation in cohesion up to 15% marble slurry dust after that it slightly declines. Whereas change in angle of internal friction is very less. It is very difficult to prepare sample of fine sand mixed with marble dust at 12% of lime, so avoided.

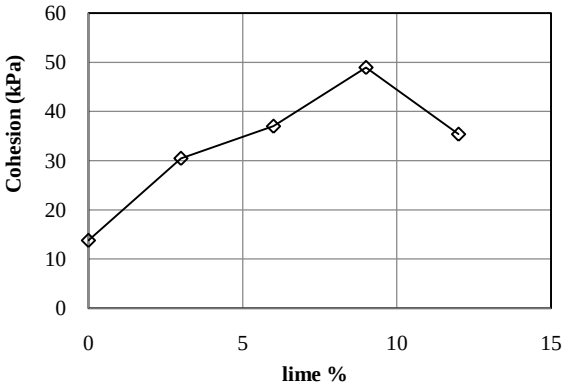

Fig-34: Influence of lime on cohesion

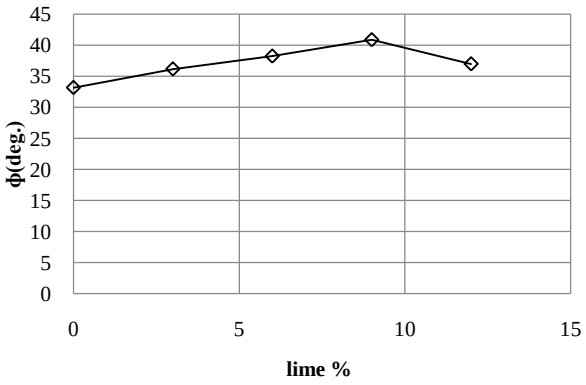

Fig-35: Influence of lime on angle of internal friction

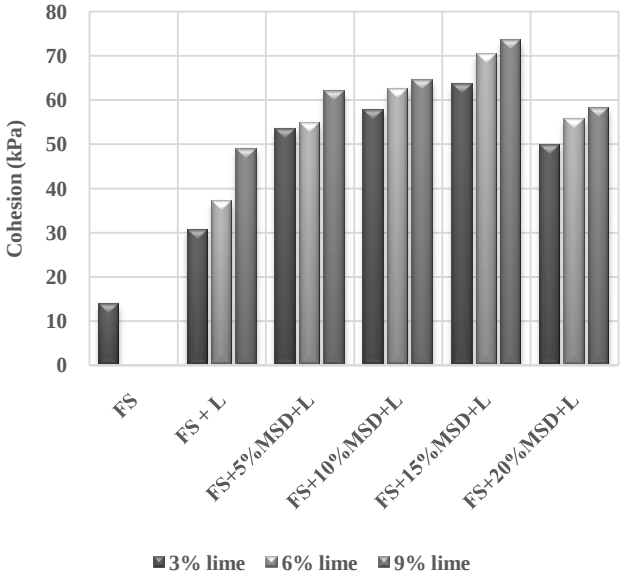

Fig-36: Influence of lime on cohesion

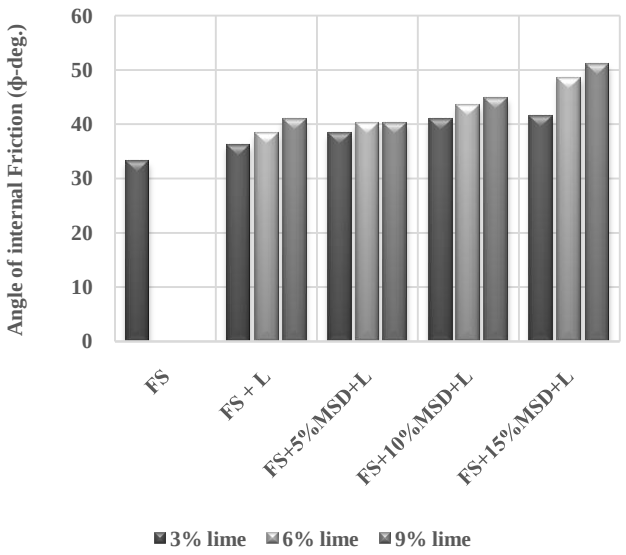

Fig -37: Influence of lime on angle of internal friction

5. CONCLUSION

1) The Scanning Electron Microscopy of fine sand shows the angular particles of quartz. Marble Slurry Dust particles can be seen with sharp edges due to cutting with abrasive cutters. It shows better interlocking between fine sand, marble slurry dust particles and lime, which can result in enhanced strength of fine sand.
2) The XRD pattern of fine sand, marble slurry dust and lime evidences the presence of quartz, mullite in fine sand, presence of silica in marble slurry dust and presence of calcite in lime. This results demonstrates that silica present in marble slurry dust and calcite present in lime, forms a cementitious material which can result in better strength of material.
3) The density bottle tests reveal that the specific gravity of the fine sand is 2.63 and of marble slurry dust is 2.54.
4) The results from the grain size analysis reveal that the materials were not well graded. Particle size distribution graph shows that fine sand is uniformly graded and marble slurry dust is poorly graded. And their Particle size distribution is much parallel which specifies their suitability to be mixed well.
5) The standard proctor test shows that MDD and OMC are increase with increase in lime percentage in fine sand upto 9% after that it declines. This is due to densification of fine sand with lime particles. Over again due to densification of material MDD is increases with increase in MSD percentage in fine sand upto 15% after that it decrease. OMC first decreases when MSD is added and on further addition of MSD, change in OMC in very less. Because of replacement of heavier particles of fine sand with lighter particles of marble slurry dust.
6) The CBR test discloses that CBR value increases every time when lime% is increased upto 9 %. This can be due to the interlocking of lime particles in fine sand & also due to binding properties of lime on hydration. CBR is futher increased on addition of marble slurry dust to the sample mix. CBR value is maximum at 15% marble slurry dust and 9% lime.
7) The UU triaxial results shows that angle of internal friction (ϕ) and cohesion increases with increase in lime percentage in fine sand up to 9% lime then there is decreases because of slippage that caused due to excessive amount of lime. And with addition of marble slurry dust (MSD) at various percentages of lime, there is further results of increase in cohesion and slightly increase in angle of internal friction. Maximum Shear strength obtained at 15% marble slurry dust and 9% lime.

Thus, present work indicates that strength characteristics of fine sand can be improved with marble slurry dust and lime. Which can be further use for construction work as slopes, sub base of roads. And also, can result into reduction in waste material disposal problem.

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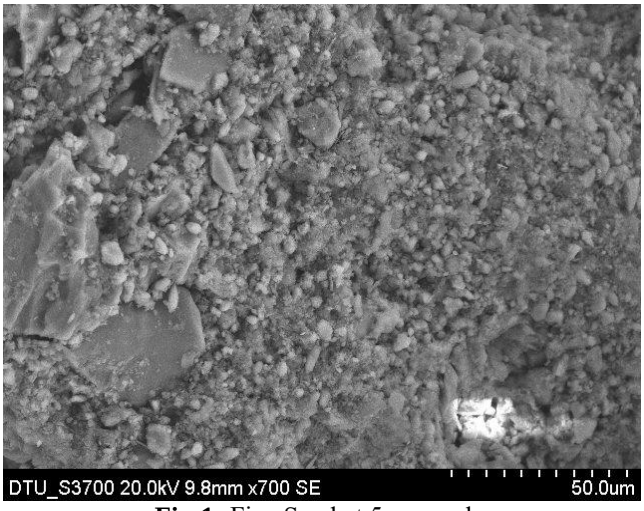

Fig-1: Fine Sand at 5 µm scale

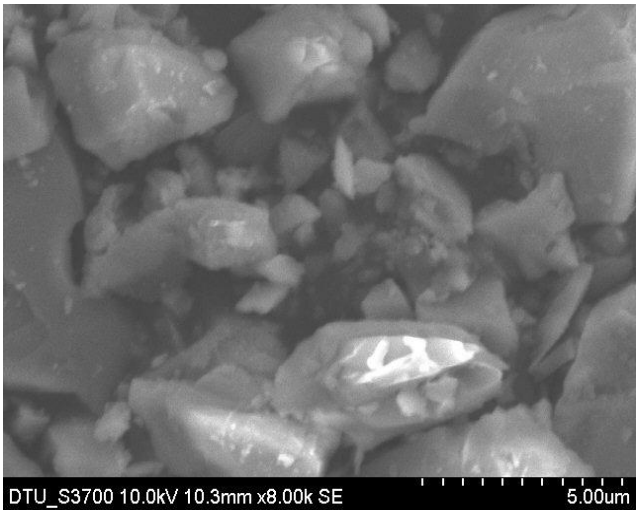

Fig-2: Marble slurry dust at 5 µm scale

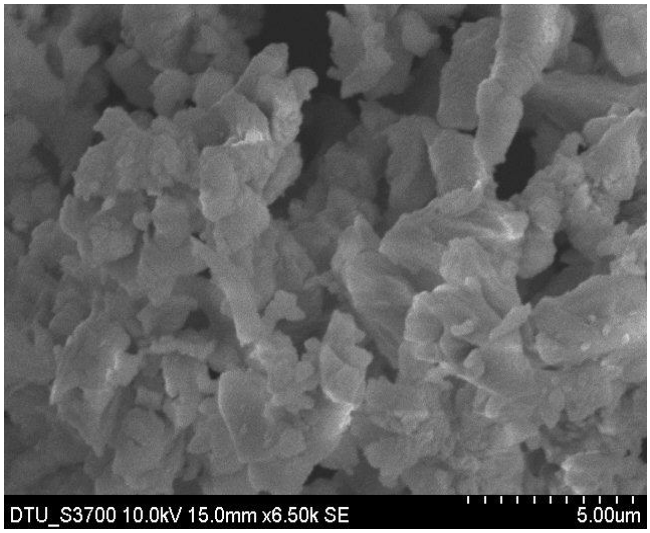

Fig -3: Lime at 5 µm scale

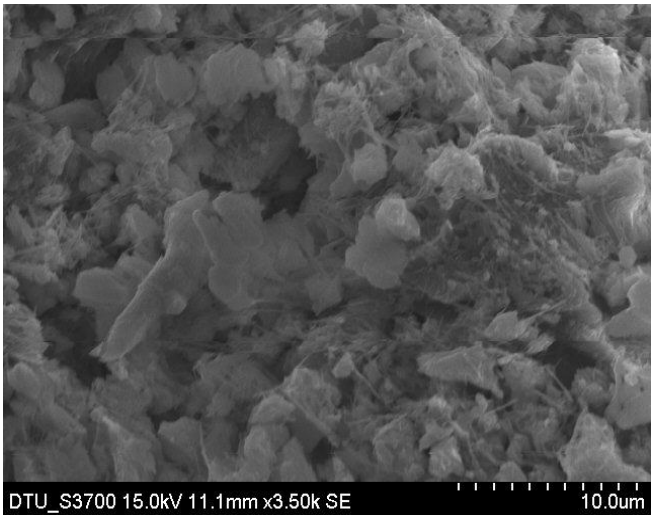

Fig -4: FS+ 3% L at 10 µm scale

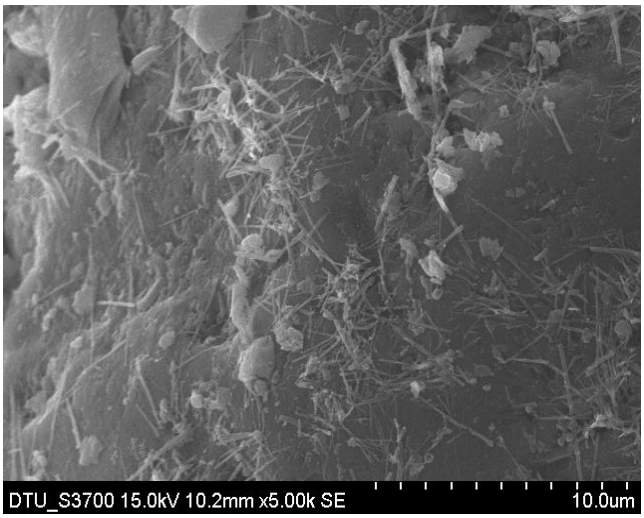

Fig -5: FS+ 6% L at 10 µm scale

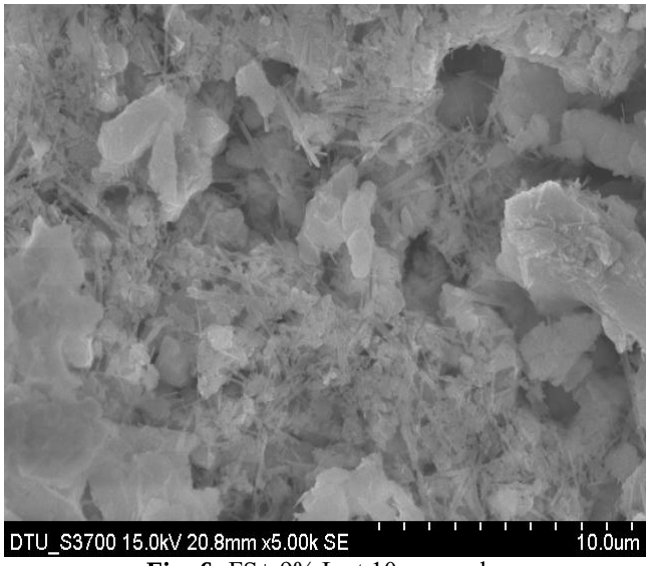

Fig -6: FS+ 9% L at 10 µm scale

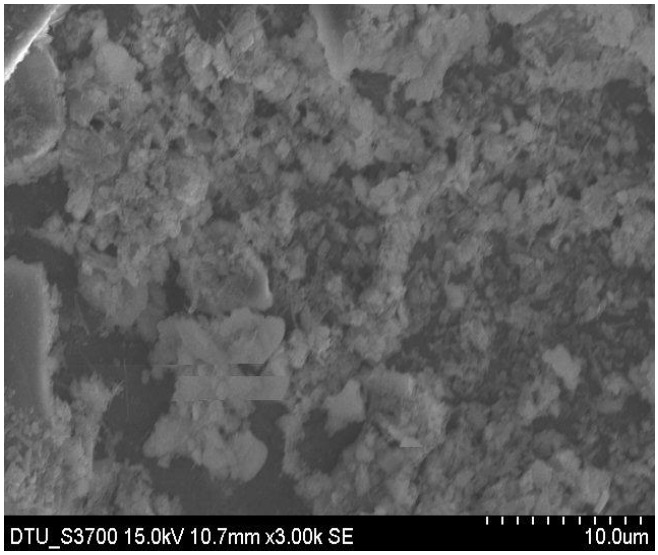

Fig -9: FS+5% MSD +6% L at 10 µm scale

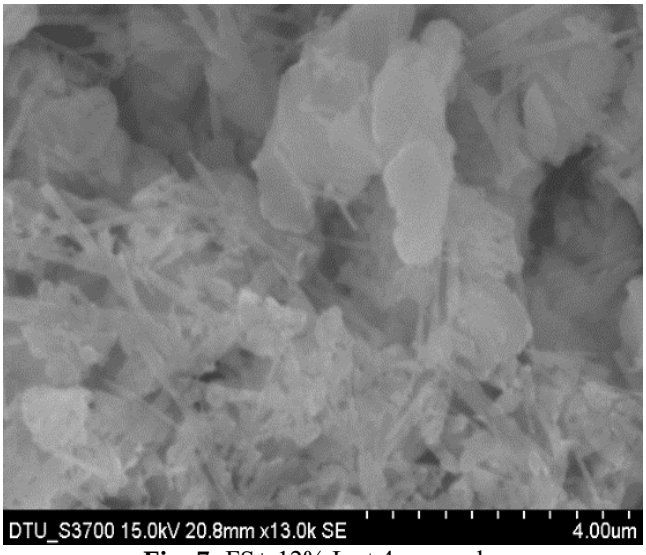

Fig -7: FS+ 12% L at 4 µm scale

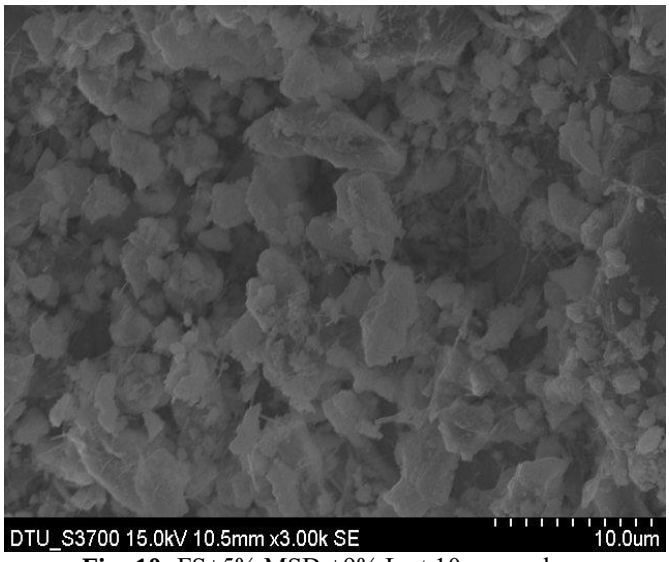

Fig -10: FS+5% MSD +9% L at 10 µm scale.

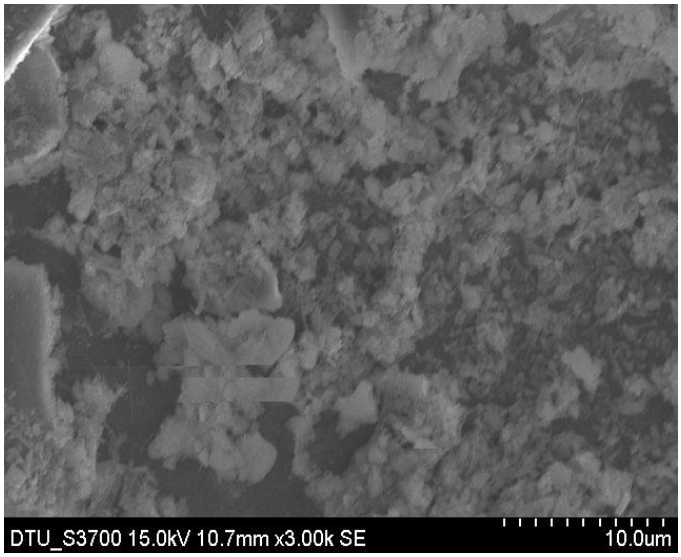

Fig -8: FS+5% MSD+ 3% L at 10 µm scale.

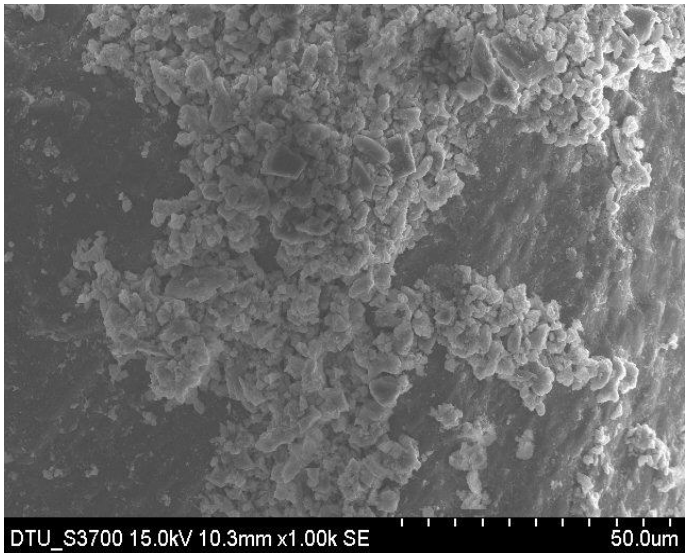

Fig -11: FS+5% MSD +12% L at 10 µm scale.

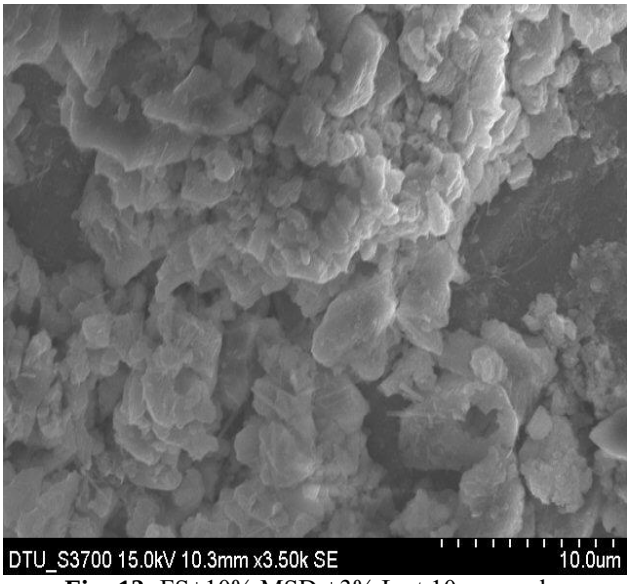

Fig -12: FS+10% MSD +3% L at 10 µm scale

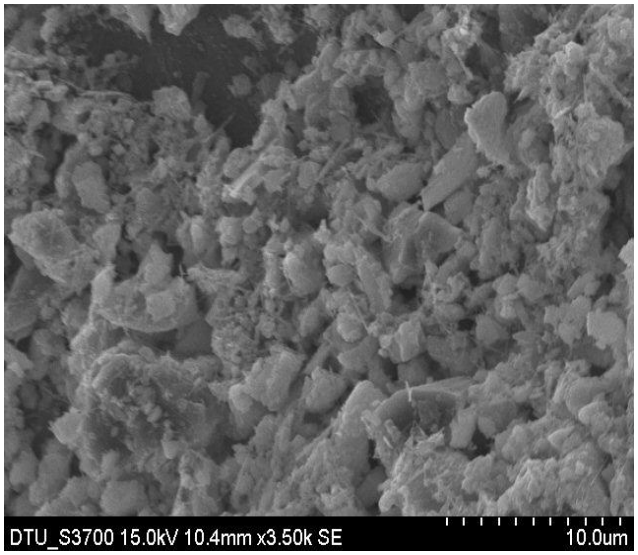

Fig-13: FS+10% MSD +6% L at 10 µm scale.

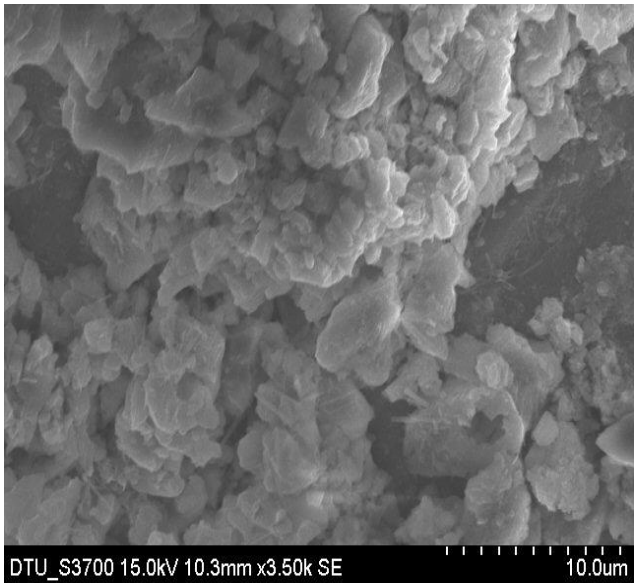

Fig -14: FS+10% MSD +9% L at 10 µm scale.

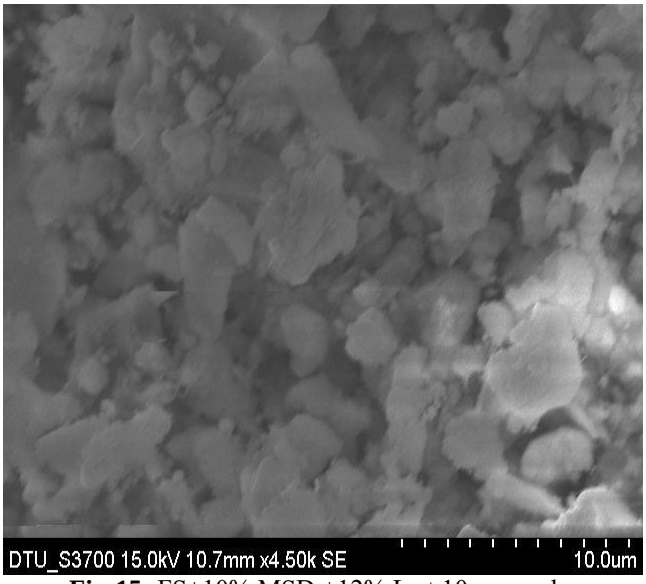

Fig-15: FS+10% MSD +12% L at 10 µm scale

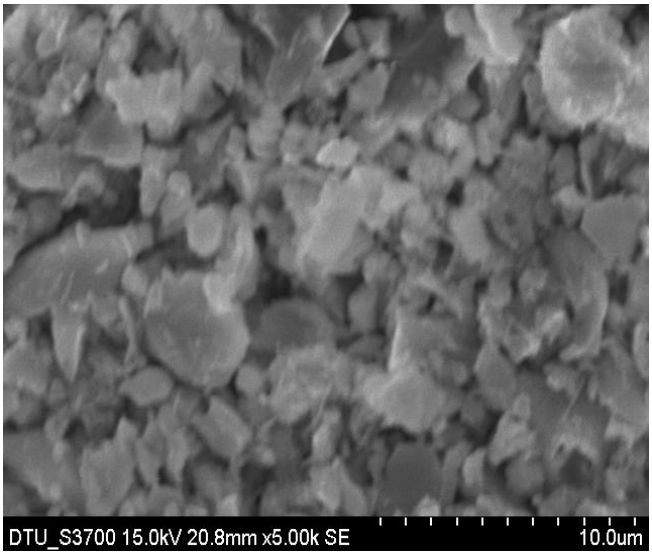

Fig-16: FS+15% MSD +3% L at 10 µm scale

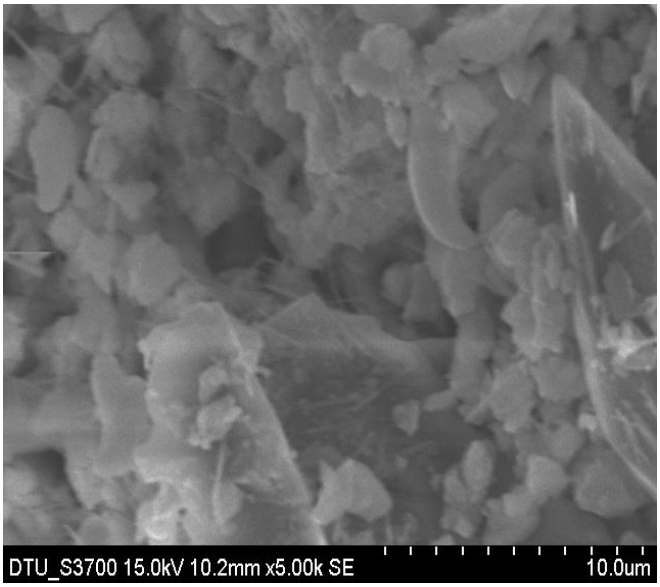

Fig-17: FS+15% MSD +6% L at 10 µm scale

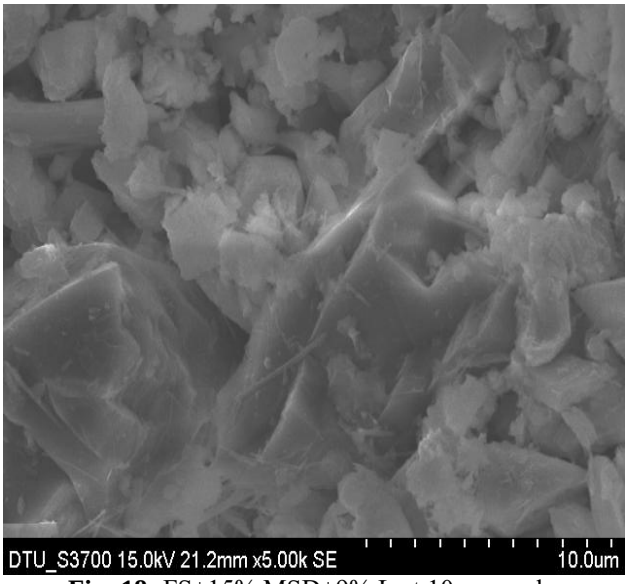

Fig -18: FS+15% MSD+9% L at 10 µm scale

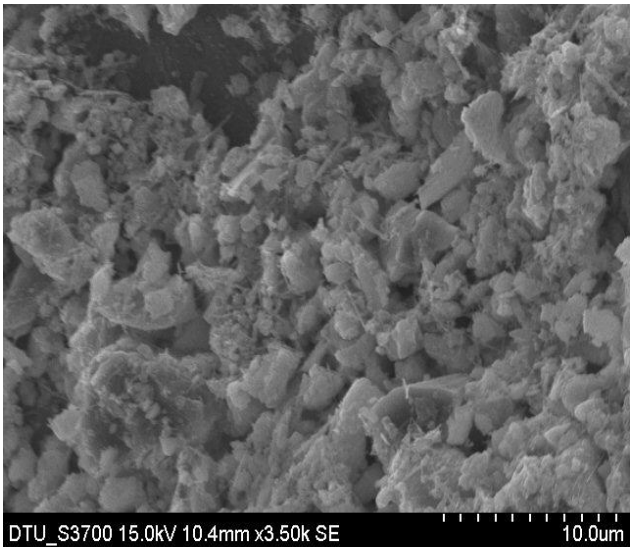

Fig -19: FS+15% MSD+12% L at 10 µm scale

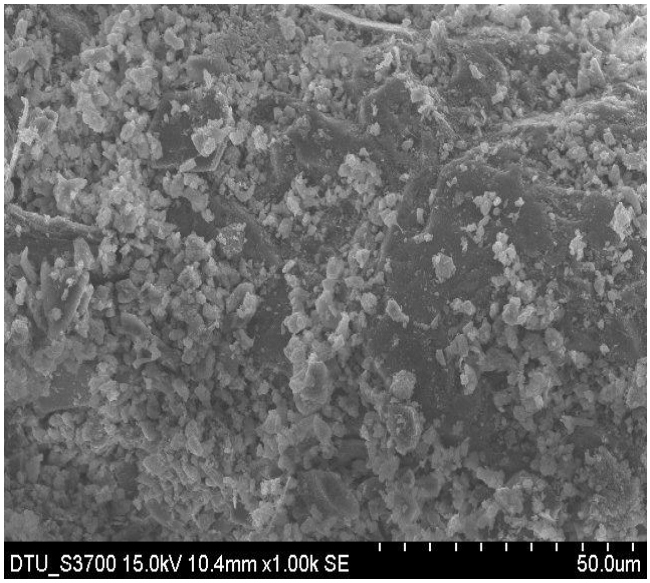

Fig-20: FS+20% MSD+3% L at 10 µm scale

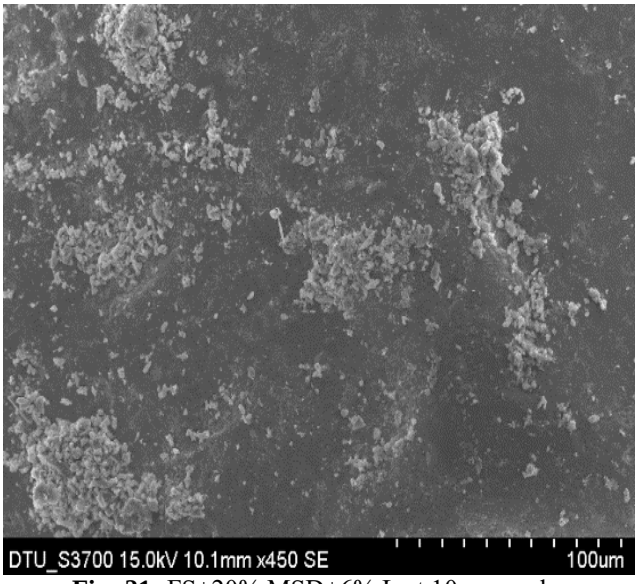

Fig -21: FS+20% MSD+6% L at 10 µm scale

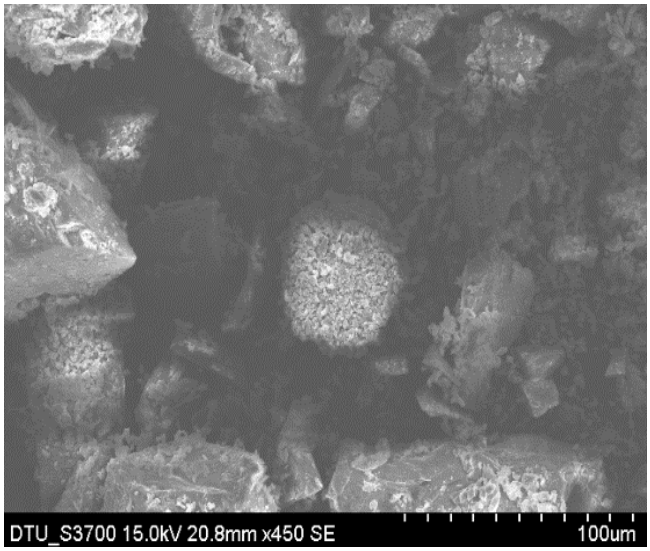

Fig-22: FS+20% MSD+9% L at 10 µm scale

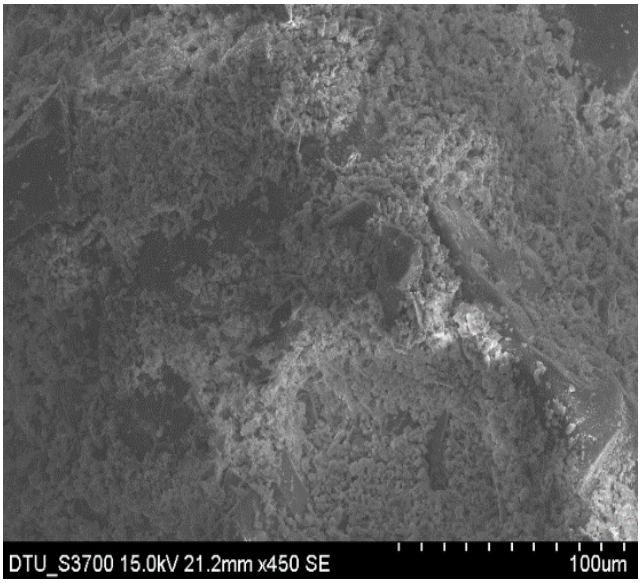

Fig -23: FS+20% MSD+12% L at 10 µm scale

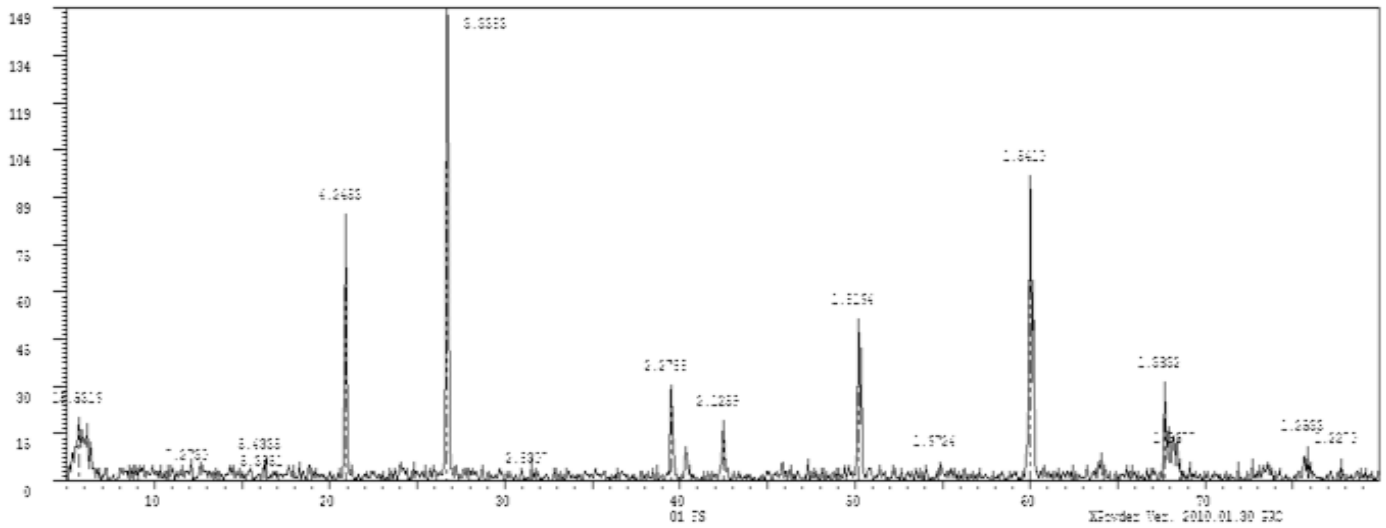

Fig -24: XRD pattern of fine sand particles (S. Gupta et al. 2013)

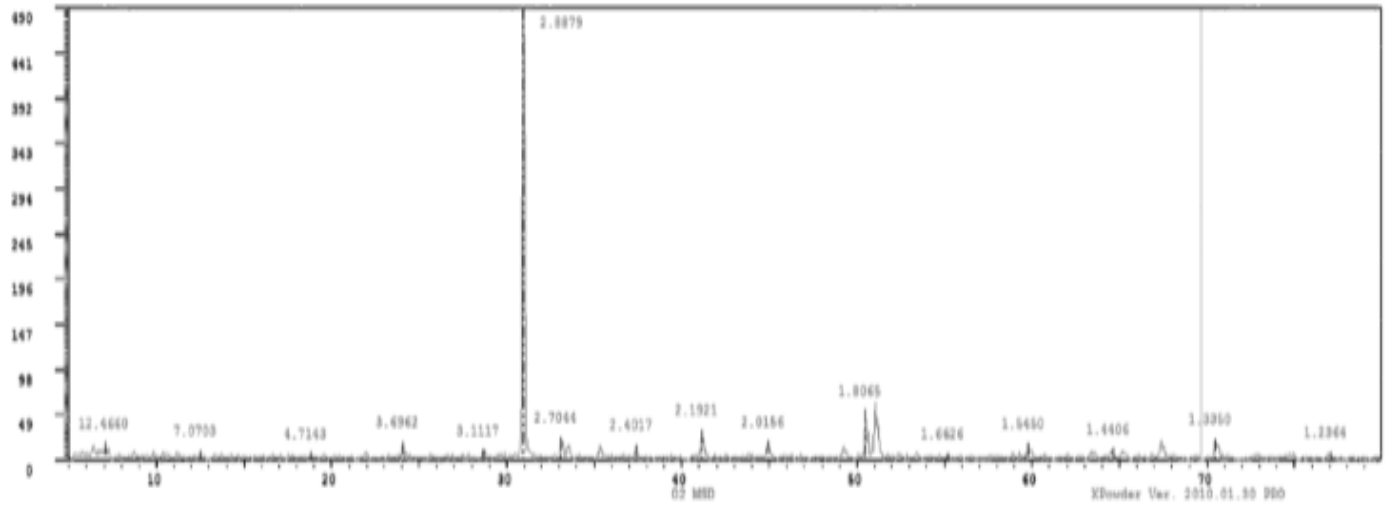

Fig -25: XRD pattern of marble slurry dust particles

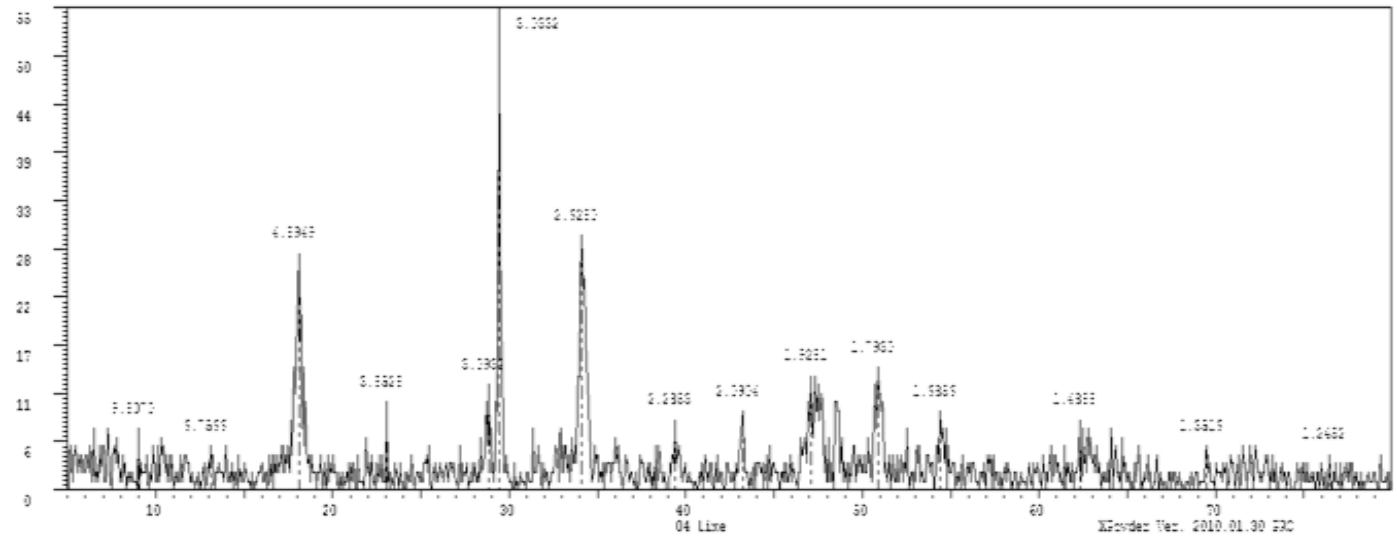

Fig -26: XRD pattern of lime (S. Gupta et al. 2013)

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