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A Survey of Literature on Impact of Silica Fume (SF) and Saw Dust Ash (SDA) On Expansive Soil

Tiza Michael[1,] Sitesh Kumar Singh[2]
[1&2] Department of Civil Engineering, Career Point University, Kota, Rajasthan,India

Abstract - The quest to modify the engineering properties of weak or expansive soils seem to be unending as these expansive soils posse a huge challenge to construction of roads by Highway engineers due to their poor geotechnical properties. Many materials have been attempted with the aim of trying to determine how effective these materials will be in improving the strength characteristics of expansive soils, while many have been found very useful, a few have been found wanting. This review paper is aimed at trying to determine the general effect of Saw Dust Ash (SDA) Silica Fume (SF) and thus, their rate of acceptance or rejection judging from Laboratory experiments conducted by different researchers. It was discovered from the review that 100% of the research in this review recommend Silica fume as stabilizing agent while Saw dust Ash had 87.5% acceptance as stabilizing agent.

Key words – Expansive Soil, Silica Fume (SF), Saw Dust Ash (SDA), California Bearing Ratio (CBR), Atterberg's Limit.

I. INTRODUCTION

Pavement contruction on problematic soils does not only increase the cost of road or highway construction and unsafety but as well creates issues of quick deterioration of pavements which leads to failure even before their design life making an entire work considered as poorly done. It is because of this that construction of roads require expertise with due good experience and knowledge of soil inorder to avert disasters they may emanate as a result of poor construction practices. The numerous lives that are lost on road accidents are partly attributed to poor pavement conditions either due to poor construction practices , poor maintenance and or no maintainance at all. Thus execution of highway projects on soils that are very problematic like those containing high clay proportions which most have high level of disturbance due to a slight alteration due to variation in water content. Such soil needs to be improved upon with the motive of improving the geothecnical properties as good practice bnefore paving process is done. This practice is called soil stabilization.

II. SILICA FUME

Silica fume is a by-product from production of ferrosilicon or silicon alloys. It has very fineparticles, thus the reason it is also called micro silica fume. It is cementious in nature and extensively used in concrete technology due to its physical and chemical properties. It has been used in many areas of life however because its use is not exhaustive, it still possesses a high challenge of disposal since a large quantity of it comes out as waste products. Researchers have attempted to check its effect as stabilizing agent of expansive soils and some of the results obtained are as shown below.

Ishraq (2013) investigatedstudying some of the Geotechnical Properties of Stabilized Iraqi Clayey Soils. The experiments conducted were consistency limits test, specific gravity test, compaction test, unconfined compression test and California bearing ratio test. The optimal percentage of LSF combination was found to be (2.5%L+6.0%SF). Silica fume was thus considered for a modification agent of geotechnical properties of clayey soils.

Chhaya et al (2013) did a study on Effect of Silica Fume on Engineering Properties of Black Cotton Soil. It was indicated in the result the CBR had a significant increment and same as UCS.With increase in silica fume from 0% to 20% there was a decrease in differential free swell of the clay from 50% to 7%. There was a decrease in Proctor compaction results with increment in MDD and OMC. It was thus concluded that the silica fume posed the potential of stabilizing expansive soils. They also conducted a research on effect of Silica Fume on Index Properties of Black Cotton Soil also and found that the Liquid limit increased from 54% to 57% while PL decreased from 27.07% to 26.29% when there was an increment in Silica fume content from 5% to 20%. Plasticity Index was noticed to have increased from 26.93% to 30.71% and an increase in shrinkage limit from 7.55% - 12.70%, respectively. Differential Free Swell was observed to have decreased from 25% to 7%. Silica fume was thus recommended for use in modification of soil.

Chayan and Ravi (2014) studied Influence of Micro Silica Fume on Sub Grade Characteristics of Expansive Soil. Number of laboratory tests were conducted and it was proven that the material is good agent of stabilization of expansive soils for sub-grade

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

modification. Testslike Standard compaction test,MDD,OMC were carried out. Micro silica fume was increased at 5% each. The test was thus done in proportion of 5%, 10%, 15%, 20% and 25% respectively. It was noticed that 10% was optimum percent for soaked CBR which was same with unsoaked CBR as they both witnessed an increased.

Kalkan and Akbulut (2004) did studied the impact of silica fume on permeability, compactioncharacteristics, unconfined compression strength test and consistency limits, of clay soil. It was observed that silica fume addition leads to the reduction in Ps and permeability of soil while an increment was noticed in unconfined compression test values of the soilsample. It was thus recommended as modification agent of expansive soil.

Hasten et al (2013) studied stabilization of soft soil subgrade layers by using lime-micro silica fume mixture, Laboratory tests were conducted with addition of Silica fume in 3% proportions from 0% -12%. There was a considerable improvement in engineering characteristics of the soil.Liquid limit decreasedby 20% from 53% - 33% with L-MSF 12-0%, PL values increased14% with L-MSFby 9%, while PI values decreased by 24.79% with L-MSF 3%. The max dry density values decrease from 1.62gm/cm3 to 1.32 gm/cm3 with L-MSF 9-18%, OMC increased by 6.66% from 22% to 28.66% with L-MSF 12-0%. The CBR values was observed to have increased by 10.5% from 3% to 13.5 % with L-MSF 6-18%. They recommended that both lime and micro silica fume could be used in modification of black cotton soil for engineering use. They presented the chemical composition of Silica Fume as shown below.

TABLE.1. CHEMICAL COMPOSITION OF SILICA FUME*

Sr.No.	Chemical Composition	Chemical Composition (%)
1	Silica (SiO_2)	98.84
2	Alumina (Al_2O_3)	00.04
3	Calcium Oxide (CaO)	00.63
4	Iton Oxide (Fe_2O_3)	00.03
5	Potassium Oxide (K_2O)	00.07
6	Magnesium Oxide (MgO)	00.01

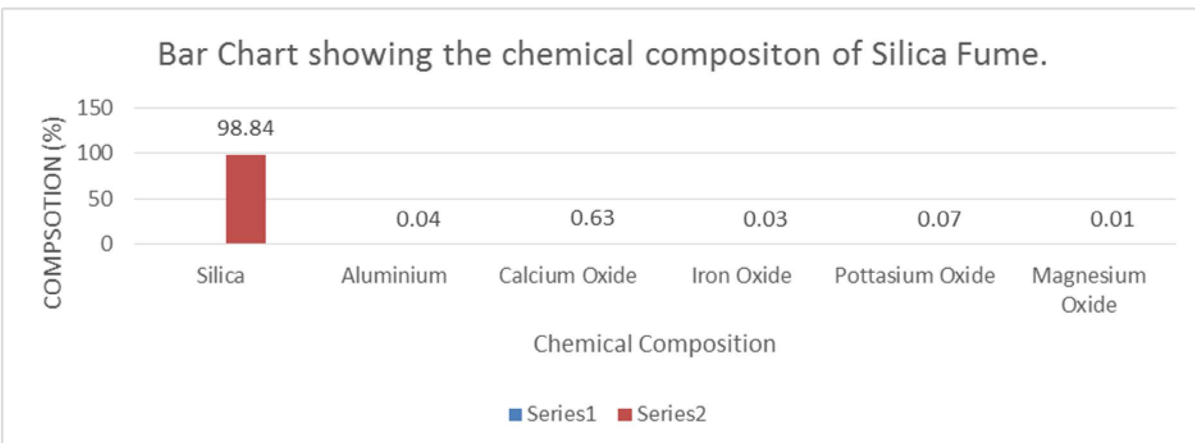

Fig.1.Bar chart showing chemical composition of Silica Fume*

*Source; Chaya and Ravi, (2014)

Mohhamed (2009) studied the effect of adding cement and silica fume with cement on compaction properties and shear strength of clayey soil. They used four different proportions of cement (2%, 4%, 6% and 8%) and three percentages for SF (2%, 4% and 6%). It was observed that addition of cement and silica fume decreased the MDD and increasedOMC. UCS was noticed to have increased after curing for a period of time.

Shivangi and Trivedi (2016) studied Impact of Micro Silica Fume on Engineering Properties of Expansive Soil. Laboratory tests were conducted on soil samples with increment in 5% proportion from 0%, to 15% of Silica Fume by weight of dry soil.LL increased by 17% from 50% to 67% and Plasticity Index increased by 7% from 24% to 31%. There was an increase in Shrinkagelimit, decrease specific gravity and differential free swell from 10.44% to 13.01%, 2.69% to 2.59%and 48.46% to 9% respectively indicating a fall in swelling characteristics of soil. It was thus recommended for use in stabilization of soils.

III. SAW DUST ASH

Saw dust ash is a by-product of wood industry. It originates as a result of wood which is been sawn, Particles of sawn wood come out in very large quantities which constitute environmental challenges. Efforts have been made by highway engineers to convert this waste into a useful material for the purpose of strengthening the subgrade and sub base found in weak or expansive soils. The result of the research done by many researchers is discussed below.

TABLE.2. CHEMICAL COMPOSITION OF SAW DUST*

Sr.No.	Chemical Composition	Chemical Composition (%)
1	Silica (SiO_2)	86.00
2	Alumina (Al_2O_3)	02.60
3	Calcium Oxide (CaO)	03.60
4	Iton Oxide (Fe_2O_3)	01.80
5	Loss in ignition	04.20
6	Magnesium Oxide (MgO)	00.27

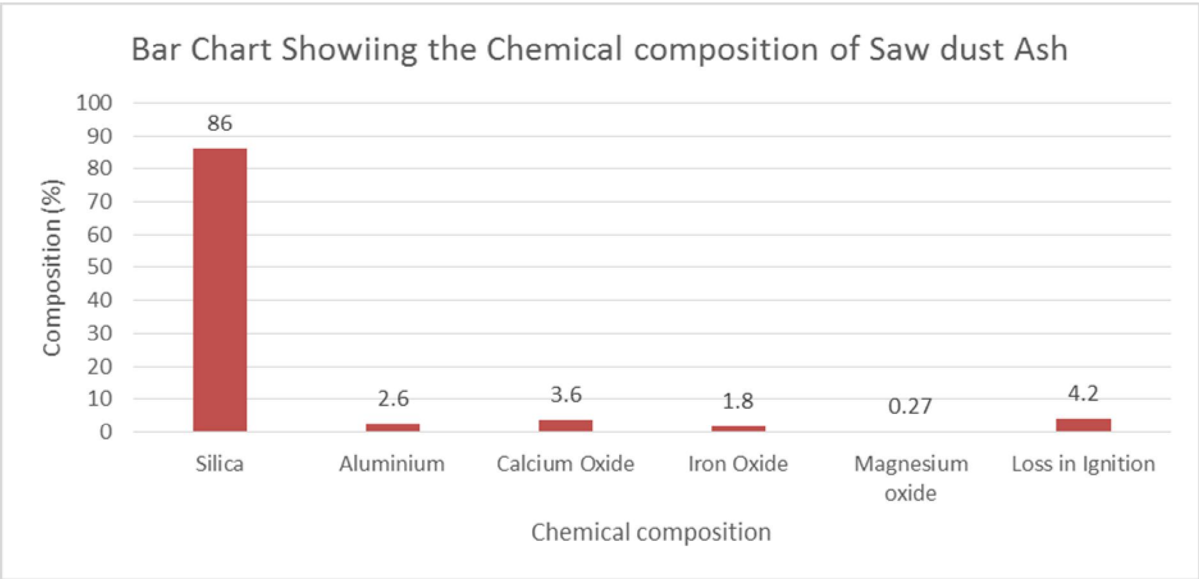

Fig.2. Bar chart showing chemical composition of Saw dust*

*Source; Koteswara (2012)

Adetoro & Adekanmi (2015) investigated on Potency Of Palm Kernel Shell And Sawdust Ashes in Stabilization Of soil that was already graded as Excellent in Gbonyin Local Government Area in west Africa, Nigeria precisely and found that the addition of stabilizing agents at 0%, 2%, 4%, 6% and 8% proportions increased the index properties of soil used it was thus deduced that the increase in stabilizing agents only increased the clay content of the soil thus, reducing the potency of the soil in use in highway construction.

Khan & Haziq (2016) studied on Improving the Mechanical behaviour of soil using Waste dust ash,permeability and shear tests were conducted on the soil and it was found that the optimum percentage of saw dust ash on the soil was 12 % as most of the engineering characteristics soil was found improved on the soil. It was thus recommended for use as admixture to soil or stabilizing agent of expansive soils.

George & Braide (2014) studied Stabilization of Nigerian Deltaic Laterites with Saw Dust Ash.Some physicalcharacteristics and geotechnical characteristics which were studiedincluded Atterberg's limits, Moisture content, compaction characteristics, unconfined compressive strength (UCS) and California Bearing Ratio (CBR). The test showed that sawdust ash is appropriate material for improving deltaic lateritic soils and was thus recommended for use even as it is economical for use. The California Bearing ratio (CBR) was found to be within the permissible limits of recommendationsby the Asphalt Institute for subgrade and sub base materials in highway.

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Ogunribido (2012) investigated the Geotechnical Properties of Saw Dust Ash Stabilized South-western Nigeria Lateritic Soils. The study wasconducted with the aim of evaluating the impact saw mill waste ash on the engineering behaviour of soil from south-western part of Nigeria in three different locations in Nigeria. Tests conducted were compaction, specific gravity, consistency limits, California bearing ratio, shear strength and unconfined compressive strength. All these tests were conducted by addition of 2, 4, 6, 8 and 10% of saw dust ash. Results from the tests showed that Saw Mills Ash also called saw dust ash improved the engineering properties of the soil specimen used. It was observed that maximum dry density(MDD) increased from 1403 to1456 Kg/m3 and 1730 to 1785kg/m3, optimum moisture content(OMC) increased from 23.6 to 28.2% and 26.2 to 29.2%, unconfined compressive strength - from 101.4 to 142.14 and 154.97, shear strength - from 50.92 to 71.07kN/m2 and 77.49 to 105.99kN/m2 for all samples. It was concluded that saw dust was found appropriate for use in stabilization lateritic soils.

Ilori and Udo (2015) studied on improving engineering properties lateriticsoil using saw dust ash as the stabilizing agent. The lateritic soil was found to be in the classification A-7-6 lateritic soil. The following laboratory tests were conducted Maximum Dry Density (MDD), Atterberg's limits, and 7-day water cured unconfined compressive strength test. The increment of saw dust ash content the liquid limit showed a progressive increase up to 8% and then decreased, the plastic limit was found to have increased in value, subsequently dropped and then levelled off; maximum dry density(MDD) was found to have decreased, while optimum moisture content OMC) increased. Unconfined compressive strength (UCS) showed an initial decrease then subsequently increased then later dropped. Saw dust Ash was thus recommended for use in Highway construction purposes.

Naranagowda M., et al (2015) had studied the impact of saw dust and flyash on expansive soil stabilization the tests that were conducted the natural soil sample collectedwere consistencylimits, specific gravity, California bearing ratio (CBR), compaction, differential swell indexand UCC. Further these tests were repeated on addition of saw dust ash with soil by adding 5, 10, and 15% ofboth saw dust ash and fly ash.The result showed that saw dust ash was very appropriate for soil stabilization of lateritic soil.

Koteswara etal (2012) did a study on the stabilization of marine clay using saw dust and lime. It was noticed that the liquid limit of the marine clay had decreased by 15.43% on addition of 15% Saw Dust Ash (SDA) and then reduced further by 27.50% on addition of 4% of lime. It was noticed that the plastic limit of the marine clay had improved by 4.08% on addition of 15% Saw dust ash (SDA) then further improved by 11.50% at 4% addition of lime. The plasticity index of the marine clay decreased by 26.47% when 15% Sawdust was added and decreased by 49.57 % on further addition of saw dust ash (SDA). Optimum Moisture content (OMC) of the clay was observed to have decreased by 15.37% when 15% Saw dust ash was added then further increase in saw dust caused a decrease by 17.91%. The Maximum dry density (MDD) of the soil was noticed to have improved by 1.96% when 15% ofSawdust was added and on further 4% increase, there was a further improvement by 1.10% on addition of 4% lime to the soil.The general result showed that Saw dust ash is appropriate for use in stabilization and as well very economical for low volume roads especially in developing countries.

IV. DISCUSSION

As shown in fig.3, research conducted on Silica fume (SF) as reported in this work has 100% acceptance that Silica fume is effective in stabilization of expansive soils.

Use of Saw Dust Ash is considered to have an acceptance rate in percent of 87.50% as a stabilizing agent or material as shown below in Fig.4.

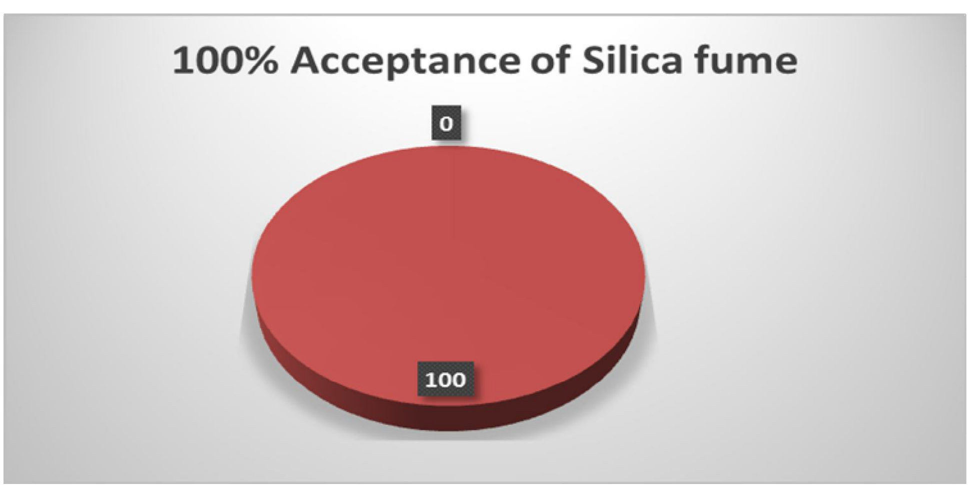

Fig. 3 100% acceptance of Silica fuel

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

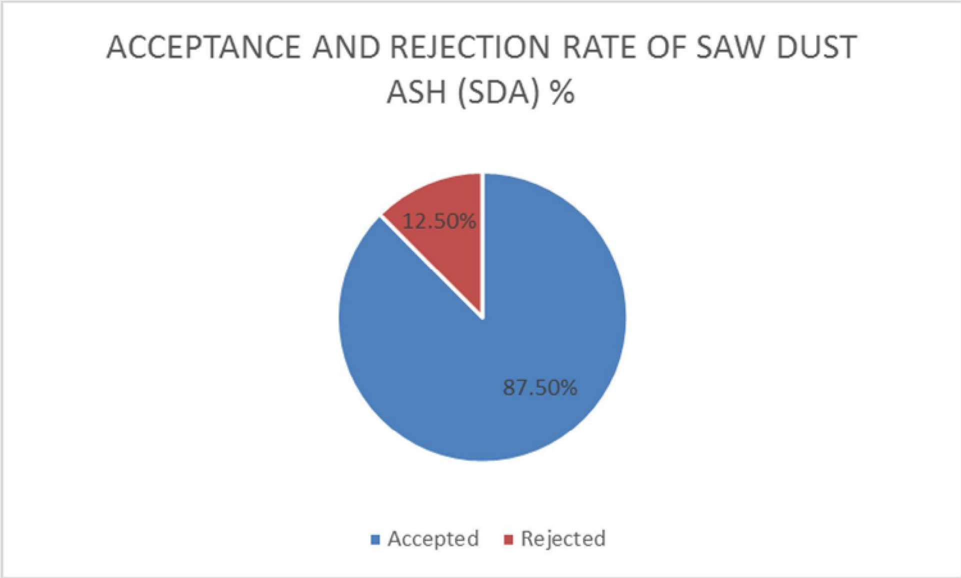

Fig.4. Acceptance and rejection rate of saw dust ash (SDA) %

V. CONCLUSION

The production of wastes from industries still posse a challenge to the environmental surrounding due to disposal of these wastes that are most times done indiscriminately which saw dust and Silica fume are not exemptions of wastes emanating from silicon industries and wood industries respectively.

As shown in the figures 3 and 4 above, although Saw dust ash seemed to fail in some aspects as indicated by some research conducted on it experimentally, it could be blended with other stabilizing agents to obtain a good efficacy. While Silica fume has 100% acceptance, it could as well be attempted on checking it efficacy on soils that are rich in sulphate which are as well expansive in nature.

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