# Experimental study of stabilization of Expansive soil mixed with Sawdust and Marble dust

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## Abstract

This paper aims at studying the effects of marble dust powder and sawdust content as mixtures in clayey/expansive soil and its engineering properties. Expansive soils have high potential for shrinking or swelling. Due to this phenomenon, surface crack occur resulting in openings during dry season. The expansive soils have variable strength based on its moisture content and have large volume change leading it to unfit for the construction purpose. Based on Indian Standard guidelines CBR, UCS and Standard Proctor tests were conducted on the soil sample mixed with 2% to 10% sawdust and 2% to 15% marble dust powder to determine the maximum dry density and optimum moisture content at varied percentages of waste admixtures in the soil. The admixtures had an overall positive effect on the geotechnical properties of soil and they can be used as a measure to improve soil strength and contribute towards decreasing the environmental impact of waste materials on our surroundings and it also resolve the problem of waste disposal.

**Keywords:**- Black cotton soil, Specific gravity, Atterberg's limit, Sawdust, Marble dust powder, Unconfined compressive strength, Plasticity index.

## 1. Introduction

Black cotton soils in India, form a major soil category and cover approximately 20% of the absolute area and are most regularly accessible soil at all places. It is mostly found in central and western parts in India. Black cotton soils for the study were derived from Fatehpur, Baran Dist. Rajasthan The properties of high compressibility and plasticity, high shrinkage and swelling properties is classified as from medium to high. It is further seen that this soil possesses low strength and undergo excessive volume changes, making their use in constructions very difficult. The properties of the black cotton soil may be altered in many ways, mechanical thermal, chemical and other means. It especially involved as a construction material and for foundation purposes hence it becomes very important to investigate the physical and engineering properties associated with the black cotton soil especially In the present study, various

tests like grain size analysis, specific gravity, Atterberg's limits, standard proctor compaction and Unconfined compressive strength test and California bearing ratio test were conducted on the soil specimens. The solution of this soil is stabilization with appropriate stabilizing agent. Here we used waste material saw dust and marble dust & tested for strength, MDD, OMC, plastic limit, liquid limit, CBR and UCS.
For the study of behaviour of expensive soil, the sawdust is mixed in varied percentage of expensive soil. The mixture of expensive soil with different percentage of sawdust may improve the engineering properties of expensive soil. Further different percentage of marble dust powder has been used to strengthen the mix of expensive soil. The main objective of stabilization is to increase the strength or stability of soil and to reduce the construction cost by making best use of the waste materials.

## 2. Literature Review

Sachin N. Bhavsar et.al. (2014)[1] presented the effect of marble powder on engineering properties of black cotton soil has been studied by conducting series of tests. The Atterberg's limits were observed to be decreasing with the increase in the percentage of marble powder. The compaction test was performed which showed that the maximum dry density was increased and the optimum moisture content was decreased with the increase in the percentage of marble powder. The linear shrinkage is decreased with the increase in the percentage of marble powder. It was concluded that the marble powder is preferable for stabilization as it give positive result.
Parte Shyam Singh et. al. (2014)[2] studied the effect of marble dust on index properties of black cotton soil is investigated. Various laboratory experiments have been performed on black cotton soil samples mixed with 0% to 40% of marble dust by weight of dry soil. The test results of samples containing marble dust showed a significant change in consistency limits. The liquid limit decreased from 57.67% to 33.9%. The plasticity index was found to be decreased from 28.35% to 16.67% and shrinkage limit increased from 8.06% to 18.39% when added with marble dust from 10% to 40% of the dry weight of black cotton soil. Also the differential free swell index decreased from 66.6% to 20%, showing appreciable decrease in swelling behaviour. The differential free swelling has reduced from 66.6% to 20%. The degree of expansiveness reduced from very high to low which is indicated by the results of plasticity index, shrinkage limit and DFS.
A.Venkatesh et. al. (2016) [3]evaluated the effect of waste sawdust ash on compaction and permeability properties of black cotton soil has been studied.The dry density of the soil was increased from 1.40gm/cc to 1.46g/cc when 2% of waste sawdust ash was added. The density starts decreasing with the further addition of waste sawdust ash. The coefficient of permeability was found to be reduced from 0.18 to 0.08 with the increase in the percentage of waste sawdust ash. Omar Hamdi JASIM et. al. (2016) [4] discussed the effect of sawdust usage on the shear strength behavior of clayey silt soil is studied. A series of test has been conducted and it has been concluded that the addition of sawdust up to 5% decreased the liquid limit and plasticity index by 14.96% and 17.65% respectively and decreased the plastic limit by 13.16%. It has also decreased the maximum unit weight and optimum water content by 8.22% and 10.74% respectively. The unconfined compressive strength value and unconsolidated undrained shear strength were increased by 41.436% and 39.535% respectively, when

sawdust content was between 0 to 3%. Further addition up to 5% decreased the values. The shear strength of the clayey silt soil was found optimum at the addition of 3% sawdust.

Nidhi Gautam et. al. (2018)[5] investigated the effect on the properties of the expensive soil have been studied using marble dust and coir fibre. With the increasing percentage of marble dust in expansive soil the medium plasticity clay was found to be turned into low plasticity clay. The DFS of expensive soil is found to be decreased up to 93.44% when 40% marble dust was added. The optimum moisture content was found to be decreased and maximum dry density was increased. The CBR value was observed to be greatly affected as it was increased about 103.63% when 20% marble dust was added with expensive soil, further addition decreases the CBR value when 1.5% coir fibre was added to the mixture the CBR value was increase further with 214%. The unconfined compression strength value is increased with the increase in the percentage of marble dust till 20%. The value of swelling pressure was decreased to 0.11kg/cm$^2$ from 1.38 kg/cm$^2$ when 40% marble dust was added. From the study it is revealed that the combination of 20% marble dust and 1.5% coir fibre gave the best results.

## 3. Materials used

A. Black Cotton Soil

The black cotton soil for the present study was procured from Fatehpur, Baran district, Rajasthan India. The specimens were extracted from the ground with the help of Auger. Further, to avoid any change in moisture content arising due to increase or decrease in the atmospheric temperature, the specimens as derived were immediately placed in polythene covers.

**Fig 1**:- Black cotton soil

**Table 1**:- The various laboratory tests are mentioned in table as per IS code were conducted on the soil specimen.

| Test performed | IS Code used |
|---|---|
| Grain size analysis | IS:2720(Part 4)-1985 |

| | |
|---|---|
| Atterberg's limit test | IS:2720(Part 5)-1985 |
| Specific Gravity | IS:2720(Part 3)-1980 |
| Std proctor compaction test | IS:2720(Part 7)-1975 |
| UCS test | IS: 2720(Part 10)-1991 |
| California bearing Ratio test | IS: 2720 (Part 16)-1987 |

B. Marble Dust Powder

Waste marble dust produced from marble cutting and polishing of natural stones. The definition of marble is the metamorphic rock which is hardened and under hydrothermal conditions. The production of marbles dust produced from grinding and cutting of it has non-plastic and very fine particle size and almost well grated. For the stabilization of the soil the traditional techniques 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 can be utilized in the construction of canal lining, pavement structures and foundations. By using the marble dust, this work focuses to reduce the expansion of expansive soils and with the increase in the percentages of the soil sample it notice the change in index properties of soil samples.

**Fig 2**:- Marble Dust

C. Sawdust

It is defined as the by-product of cutting, drilling, grinding, sanding, or pulverizing wood or any other material with the help of saw or by other means of tools. It is also known as wood dust. It is composed of fine particles of wood. It can also be defined as the byproduct of certain animals, birds and insects i.e. which live in wood, such as the woodpecker and carpenter ant. It can be hazardous to manufacturing industries, especially in terms of its flammability. Sawdust is the main component of

particleboard. In this test the Sawdust which is used is of Teak (Sagwan wood) of Grade -I which is retained from the 4.75 mm sieve.

**Fig 3:-** Sawdust

## 4. Experimental Details

The soil sample collected from Baran district. These soil samples were classified according to Indian standard classification. Atterberg's limit test, Sieve analysis, Standard Procter Test, Unconfined compression test and California bearing ratio test were conducted. The consistency limit test includes liquid limit and plastic limit test of soil by using cone penetrometer apparatus. Five different percentages of saw dust; 0%, 2%, 4%, 6%, 8% and 10% were used and three different percentages of marble dust; 5%, 10%, 15%.

**Table2:-** Engineering characteristics of Black cotton Soil

| S.NO | Parameters | Test Values |
|---|---|---|
| 1. | Soil Classification | CH |
| 2. | Specific Gravity | 2.42 |
| 3. | Liquid Limit | 52.17% |
| 4. | Plastic Limit | 32.8% |
| 5. | Plasticity Index | 19.37% |
| 6. | Optimum Moisture content | 21.96% |
| 7. | Maximum Dry Density | 1.83g/cc |
| 8. | Unconfined Compression Strength | 11.6kg/cm$^2$ |

## 5. Results and Discussion

A. Grain size analysis

For the determination of the grain size, the Indian Standard guidelines is used and as per IS 2720 (Part 4) 1985 it can be determined. The percentage mass retained was determined for each and the percentage of sample passing each was determined from the data obtained. This was used to plot the graph of particle size distribution on semi log curve of the sample.

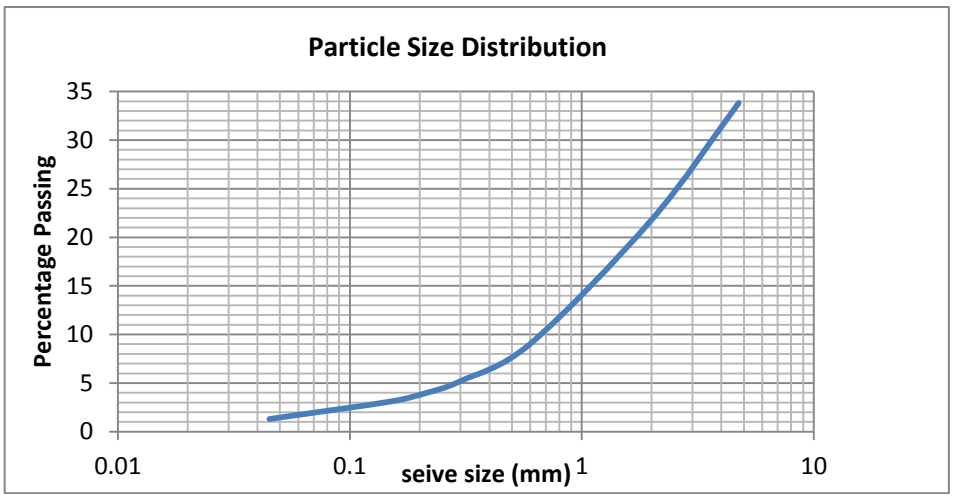


**Fig 4:-** Particle size distribution curve for black cotton soil.

B. Atterberg's limit

Atterberg's limit tests were conducted for the determination of liquid limit, plastic limit and plasticity index was shown in table. This test is conducted according to the IS: 2720(Part 5)-1985.

**Table 3**:- Atterberg's limit test values of black cotton soil

| **Atterberg's limit** | **Values** |
|---|---|
| Liquid Limit | 52.17% |
| Plastic Limit | 32.8% |
| Plasticity Index | 19.37% |

C. Specific gravity

For the determination of the Specific gravity, the Indian Standard guidelines is used and as per IS: 2720 (part 3)1980 the specific gravity test is performed. Table 2 shows the value of specific gravity for the black cotton soil mixed with various percentages of sawdust. The specific gravity values of the samples are decreasing with the inclusion of sawdust. At 4% addition of the sawdust the specific gravity reaches to maximum and the value is 2.59. Specific gravity decreases with increasing percentage of the sawdust.

**Table 4:-** Specific Gravity of black cotton soil and sawdust

| Properties | Virgin soil | 2% | 4% | 6% | 8% |
|---|---|---|---|---|---|
| **Specific Gravity** | 2.42 | 2.35 | 2.59 | 1.78 | 1.82 |

D. Standard Proctor Compaction Test

The test has been conducted and the curve is plotted taking moisture content at x-axis and dry density at y-axis. The following result is interpreted by the figure shown. OMC was decreased by 0.77% at 2% sawdust. Further, 1.27% and 1.73% at 4% and 6%sawdust. At the addition on 8% sawdust the OMC is decreased by 2.82 and 4.18 at 10% sawdust.MDD was decreased by 0.33% for 2% sawdust. It is further decreased by 4.98% and 11.06% at 4% and 6% sawdust. At 8% sawdust it is decreased by 12.74% and 13.04% for 10% sawdust.OMC was decreased by 10.74% at 10% marble dust. Further it is decreased at 20% marble dust by 20.26%.
MDD of marble dust powder at 10% is increased by 2.18% and increased by 9.83% at 20% marble dust.

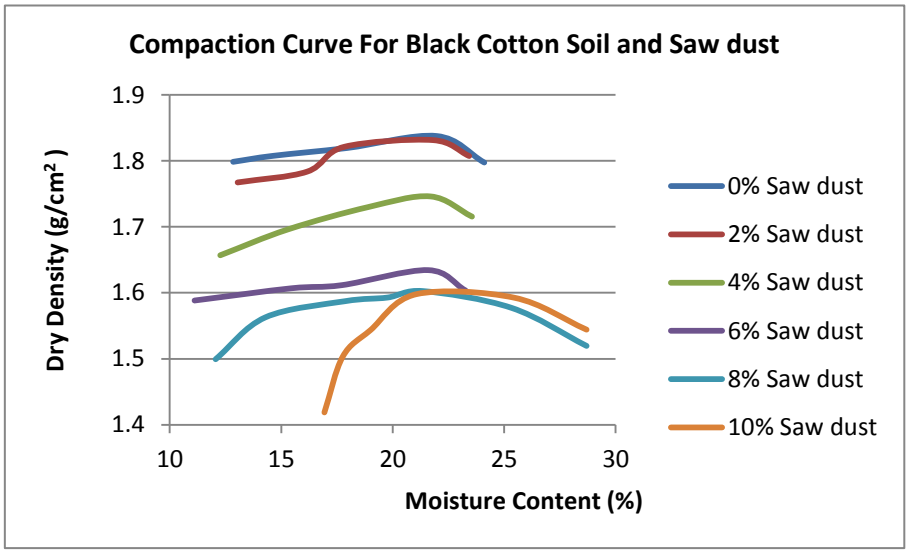


**Fig 5:-** Compaction test curve of black cotton soil with sawdust.

E. Unconfined Compression Test

The Unconfined compression test is performed as per the IS: 2720(Part 10)-1991. Stress-Strain curve is plotted which is shown in figure 7 taking stress at y-axis and strain value is taken on x-axis. From the figure the UCS value is increased by 2.12% at 10% marble dust and 4.78% at 20% of marble dust.

(a) (b)

**Fig 6:-** (a) Unconfined compression testing machine. (b) UCS Sample

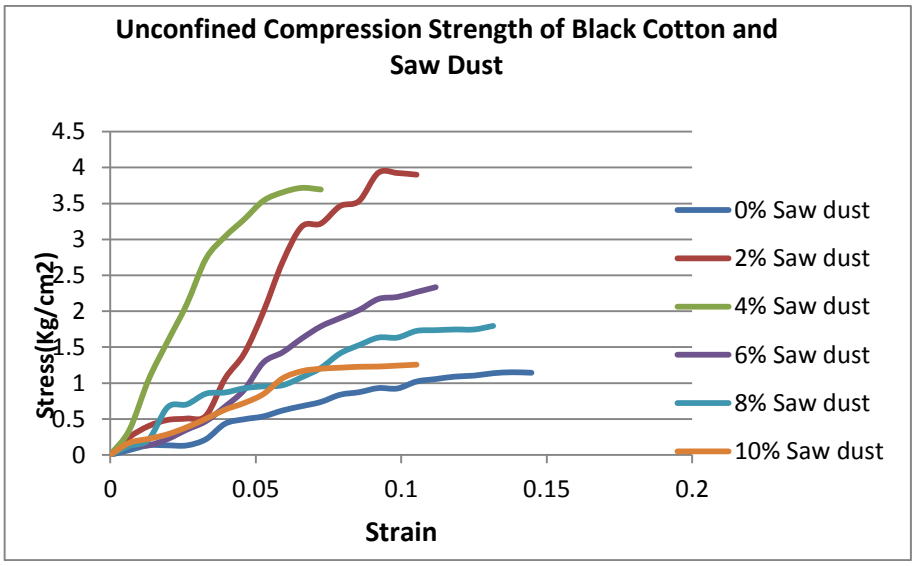


**Fig 7**:- Unconfined Compression strength of black cotton soil with sawdust.

F. California Bearing Ratio Test

1. California Bearing Ratio is performed as per the IS: 2720 Part 16. This test is conducted with different percentages of sawdust with the black cotton soil.

**Fig 8:-** California Bearing Ratio

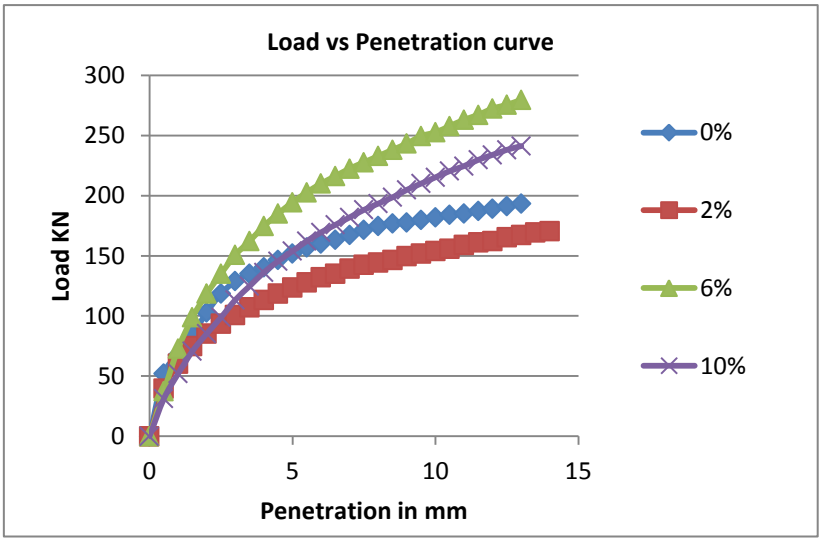


**Fig 9:-** California Bearing Ratio test of black cotton soil with sawdust

The load versus penetration curve is plotted taking load on y-axis in KN and penetration on x-axis in mm which is shown in figure 9. Further from the curve we can interpreted that the C.B.R. value of black cotton soil improves considerably to 10.16% on 6% Sawdust content. The figure shown above consists of virgin soil i.e. 0%, 2%, 6% and 10% sawdust.

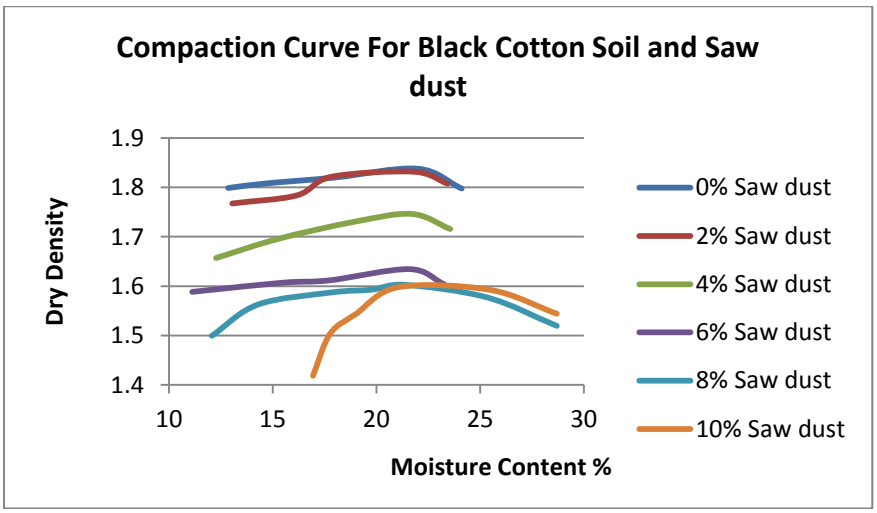


**Fig 10**:- Compaction Test curve for mixed sample

The test has been conducted and the curve is plotted taking moisture content at x-axis and dry density at y-axis. The following result is interpreted by the figure shown. OMC was decreased by 0.77% at 2% sawdust. Further, 1.27% and 1.73% at 4% and 6%sawdust. At the addition on 8% sawdust the OMC is decreased by 2.82 and 4.18 at 10% sawdust.MDD was decreased by 0.33% for 2% sawdust. It is further decreased by 4.98% and 11.06% at 4% and 6% sawdust. At 8% sawdust it is decreased by 12.74% and 13.04% for 10% sawdust.OMC was decreased by 10.74% at 10% marble dust. Further it is decreased at 20% marble dust by 20.26%.
MDD of marble dust powder at 10% is increased by 2.18% and increased by 9.83% at 20% marble dust.

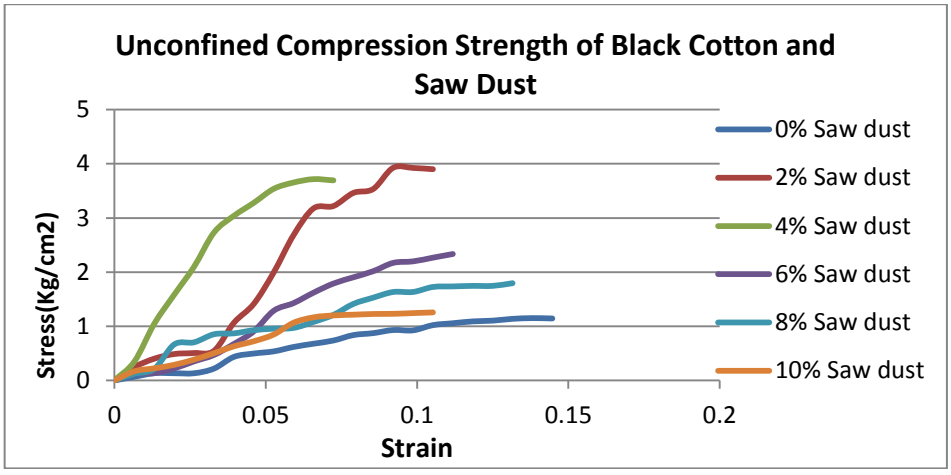


**Fig 11**:- Unconfined compression test values of a mixed sample

The Unconfined compression test is performed as per the IS: 2720(Part 10)-1991. Stress-Strain curve is plotted which is shown in figure 7 taking stress at y-axis and strain value is taken on x-axis. From the figure the UCS value is increased by 2.12% at 10% marble dust and 4.78% at 20% of marble dust.

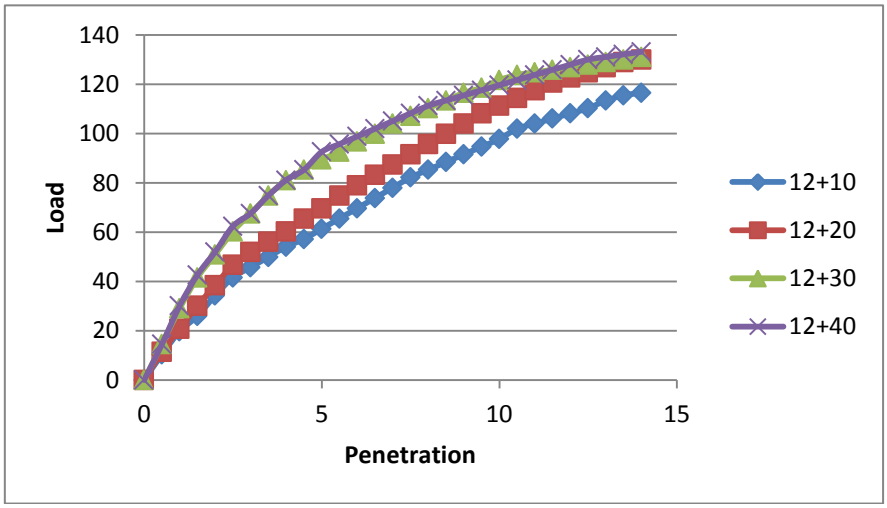


**Fig 12:-** California Bearing Ratio curve for mixed sample

The load versus penetration curve is plotted taking load on y-axis in KN and penetration on x-axis in mm which is shown in figure 9. Further from the curve we can interpreted that the C.B.R. value of black cotton soil improves considerably to 10.16% on 6% Sawdust content Apart from that the sawdust content is fixed taken as 12% and the cbr value is determined by changing the marble dust values i.e. 10%, 20%, 30%, and 40%.

## 6. Conclusion

Based on extensive laboratory tests conducted on black-cotton mixed with sawdust from 0% to 10% by weight of dry clay.

The following conclusions can be drawn:

1. The specific gravity values of the samples are decreasing with the addition of sawdust.
2. 4% addition of the sawdust the specific gravity reaches to maximum and its value is 2.59.
3. OMC was decreased by 0.77% at 2% sawdust. Further it is decreased by 1.27% and 1.73% at 4% and 6% sawdust. On the addition of 8% sawdust the OMC is decreased by 2.82 and 4.18 at 10% sawdust.

4. MDD was decreased by 0.33% for 2% sawdust. It is further decreased by 4.98% and 11.06% at 4% and 6% sawdust. When the 8% sawdust is added it is decreased by 12.74% and 13.04% for 10% sawdust.
5. OMC was decreased by 10.74% at 10% on the addition of marble dust. Further it is decreased at 20% marble dust by 20.26%.
6. MDD of marble dust powder at 10% is increased by 2.18% and it is increased by 9.83% at 20% marble dust.
7. The UCS value is increased by 2.12% on the addition of 10% marble dust and 4.78% at 20% of marble dust.
8. The C.B.R. value of black cotton soil improves considerably to 10.16% on 6% Sawdust content.
9. Wood dust accumulations create a number of safety and health hazards. Saw dust becomes a health problem when the wood particles become airborne and they are inhaled.

From the above laboratory investigation it can be concluded that the sawdust has a potential to modify the characteristics of expansive clay like black-cotton soil and to make it suitable in many geotechnical applications and strength will be increase due to marble dust.

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