DISSERTATION

On

"STUDY OF SOIL STABILIZATION OF BLACK COTTON SOIL USING KOTA STONE DUST"

Submitted by-

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2K14/GTE/07

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CERTIFICATE

This is to certify that this report entitled **"STUDY OF SOIL STABILIZATION OF BLACK COTTON SOIL USING KOTA STONE DUST"** is an authentic report of the Major Project-II done by Mr.**Chetan Khandelwal**, Roll no:**2K14/GTE/07**. This is a bona fide record of students own work carried by him under my guidance and supervision in partial fulfillment of the requirement for the award of the Degree of Master of Technology in Civil Engineering(Geotechnical Engineering) by the Delhi Technological University of Delhi.

The matter embodied in this project has not been submitted for the award of any other degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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CHETAN KHANDELWAL

(2K14/GTE/07)

ABSTRACT

This project report shows the result of laboratory study to investigate Kota stone dust mixing with black cotton soil and its effect on index properties of black cotton soil. Black cotton soil is very weak soil to bear the load of the structure and contains swelling and shrinking and highly compressible properties whenever change in water content takes place. So it is required to make it suitable for construction activities. So that improvement of black cotton soil is required with the mixing of admixture like as Kota stone dust. The essence of this project is to check out the feasibility of Kota stone dust as soil stabilization material. Number of laboratory experiments is required to investigate the effect of Kota stone dust with black cotton soil with the different proportion of it with 0% to 30% in the interval of 5%. Test results represent a quite change in consistency limit or Atterberg's limit. Liquid limit decreases from 53.26% to 37.8%. Plastic limit changes from 29.76% to 29.12% with a very slight change in mixed proportion of soil. Liquid limit and plastic limit of black cotton soil decreases with increase in proportion of Kota stone dust. A big change is found in liquid limit but slight change in plastic limit takes place so overall plasticity index which shows plasticity behavior of soil also decreases up to a great extent. Plasticity index decreased from 23.5% to 8.68% with the addition of Kota stone dust from 0% to 30%. The differential free swell index decreased from 64.24% to 39.82% which shows that a reduction in swelling property of soil due to increase in the proportion of Kota stone dust which is a pozzolanic material and exerts friction in it due to coarser size particle of pozzolanic Kota stone dust. The unconfined compressive strength of soil is found maximum when Kota stone dust is mixed 10-20% with black cotton soil. The unconfined compressive strength of soil increases up to a certain limit after that it decreases. We found maximum UCS strength at the mixing of 15% Kota stone dust. Black cotton soil showed good UCS strength in the range of 10-20% Kota stone dust. When soaked CBR test was performed so that improvement in CBR value was found maximum within the range of 20-25% mixing of Kota stone dust, it gives maximum CBR value so it is desirable to mix Kota stone dust in black cotton soil with a proportion of 20-25% of mixing. CBR value mainly shows the soil behavior according to highway projects so Kota stone dust is useful in highway pavement design because it shows pozzolanic behavior of soil and frictional properties that causes good binding found in soil. Kota stone dust mixing with black cotton soil increases its maximum dry density in the range of 15-25% mixing of Kota stone

dust. We found that in the range of 15-25% Kota stone dust maximum compaction of soil occur So it is helpful to make the soil dense by providing proper compaction and maximum dry density of soil. Standard Procter test was performed with heavy compaction during experiments so that it was found that dry density of soil increases up to a particular proportion of Kota stone dust in the range of 15-25% but continuous increase in water content was found with increase in its proportion. So a range of 15-25% is batter to make a highly compacted and dense soil. So that lots of experiment has conducted during this project and results are positive to stabilize soil by mixing of Kota stone dust mainly in the range of 15-20%. This range shows best mixture of kota stone dust with black cotton soil because all the laboratory results are giving satisfactory improvement in the geotechnical.

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INTRODUCTION

1.1 Black cotton soil

Black cotton soil is a type of soil which shrinks and swells when change in water content takes place. It is an expansive clay which contains Montmorillonite mineral due to which it has high liquid limit, plastic limit and plasticity index. Black cotton soil consists of mineral montmorillonite which imparts expansive behavior in it. It is known as Regur soil in rural areas. Black cotton soil has high amount of iron, lime, calcium, magnesium, carbonate, alumina etc. When comes in contact with water so that it swells but with less water content soil shrinks. Due to these variations, settlement takes place below foundations, pavements, canal beds and residential buildings (Kalla et.al. 2006).

Black cotton soil has poor supporting capacity and high volume change characteristics so that it is difficult to construct a structure over it as per (Singh and Yadav, 2014). During summers moisture content of soil reduces so that large shrinkage cracks occur of 10 to 15 cm over ground surface and up to 2m depth below the ground surface. Due to these cracks foundation looses its support so that large settlement takes place. It is required to improve the soil properties by using admixtures so admixture will be mixed to stabilize the properties of soil. It will be mixed with various proportions of Kota stone dust so that black cotton soil may able to bear more load at various location of India as well as wastage of Kota stone dust can also be reused again. So that Kota stone hazardous effects will not affect environment by any kind of pollution like as air pollution, water pollution, soil pollution and due to air flow of dust it will not affect human life by disease like Periodontitis(Hussain et al 2013). So both the poor things mixed with each other and make a good rich mix of batter workability, compactible with index properties.

1.2 Kota stone

Disposal of waste material from stone industries causes various health issues due to air pollution, soil pollution, water pollution. Kota stone is a kind of very strong stone which is used in domestic as well as industrial point because of its high strength characteristics. It is used as floor material in houses and industries. In today time big requirement of it is found in the gulf countries, Australia and European countries and other part of the world. It found

basically between Kota to Jhalawad district at Ramganjmandi area in Rajasthan. It is also found in Suket, Chechat, Aroliya, Parolia and Julmi over a long length of 40km in southern part of Kota district joined with Jhalawar district. Kota stone processing units are found in five industrial areas i.e. Suket, Modak, Khudayala, Amarpur, Fatahpur etc. Kota stone deposits are part of Vindhyan range of sedimentary rocks, overlain by sand stone cappings. Basically it is a limestone of sedimentary rock origin and has calcium carbonate with high amount of silica content. In general Kota stone mining areas are free from sand stone coverings and the entire profile consists of different grades of lime stone beds. The floor grade limestone is available in a variety of different colors including blue, green, brown or spotted type. Color pattern is governed by the chemical composition where main players are iron, Titanium and Aluminium.

1.3 Kota stone slurry/dust/waste

The Kota stone waste is generated from long period of 50 years in the form of slurry and solid waste. It is estimated to 100MT in last 50 years of mining and was thrown over a length of 35km all around Modak and Ramganj mandi on fertile land or dumped along the road side and in river course, causing very much land degradation. Various wastes are generating in the quarrying and processing like as quarrying waste and processing waste. Kota stone dust is generated mainly during processing because processing consist dressing, cutting, polishing operations. During processing of Kota stone we found white slurry generation with water which came out during splitting of Kota stone that settle down in the pond near splitting unit and thrown in dumping yard outside the city after settled properly in the pond.(Hussain et. al. 2013)

Kota stone dust is a hazard over the environment from the last few years. Several issues are with this stone one of these are cutting and polishing of it. Its particles are of small size which spreads in the environment and effect it.

Figure 1.1: Kota Stone Slurry in Liquid Form

Figure 1.2: Slurry Pond to Settle Stone Dust

Some points regarding to Kota stone dust are as:-

i. Fine particles, less than 363 micron, cause air pollution.
ii. Slurry affects fertility of land and makes it barren land decreases porosity, water absorption and percolation.
iii. Due to long term deposition of slurry on land fill the voids and block the path of flow regime of aquifer and other ground water resources.
iv. Periodontitis is a disease found in the labor who work in such mines.

So that such kind of issue is with this stone. Due to Kota stone waste the environmental problem cropping up due to permanent loss of prime agricultural land, there is one more dimension to this activity i.e. formation of waste dumps over agricultural land. Due to which agriculture land is converted into barren land. Dumping of waste effects environment so its reuse can be done by mixed it with soil and make the soil stabilize then its use can be find in highway project, earthen dam, pavements, canal beds and residential areas. This wastage may be used in the stabilization of soil used as an admixture like as Kota stone dust (Lakhani et. al. 2014).

1.4 Chemical properties of Kota stone dust

i. A particular stone waste may have different physical and chemical properties depending on the method of generation of waste. It found that in cutting waste, calcium oxide (CaO) and in polishing waste, silicon di oxide (SiO2) is the main constituent.
ii. It can only be find out by using XRD AND XRF analysis of stone dust.

Kota and Jhalawar districts of Rajasthan have been subsisted with about 100 million tonnes of Splitable type of decorative grade flooring limestone, better known as Kota stone. A typical chemical composition of Kota stone is given in table

Table.1.1: Chemical Composition of Kota Stone Dust (Lakhani et. al. 2014)

S. No.	Chemical Constituent	Percentage (weight)
1	Calcium Oxide	66.32
2	Magnesium Oxide	0.87
3	Sodium Oxide	1-2
4.	Potassium Oxide	0.20-0.35
5.	Aluminium Tri Oxide	3.26
6.	Ferrous Oxide	2.72
7.	Titanium Di Oxide	2.09
8.	Silica	22.69

1.5 Kota stone dust production

Stone dust production is done during the process of cutting Kota stone. Cutting operation is done with diamond blades. Water is thrown on blades to cool the blades and absorb the dust produced during cutting of stone. The amount of waste water is highly alkaline and it is not reuse to recycle. It is transferred into a pond where this stone slurry get settled and converted into thick layer and disposed in dumping yard and left to dry. After drying this powder effects environment and it is a cause of various types of pollution so reuse of this kind of dust is being searched by some university. Some studies has done by MNIT Jaipur and IIT Roorkee on the recommendation of Kota stone industries association and Centre for development of stones.

In specific to stone powder generation, there are two types of powder wastes coming out of Kota stone mining i.e.

i. Quarrying or sawing from the in-situ atone mines.
ii. Cutting and polishing wastes from polishing industries (Lakhani et. al. 2014).

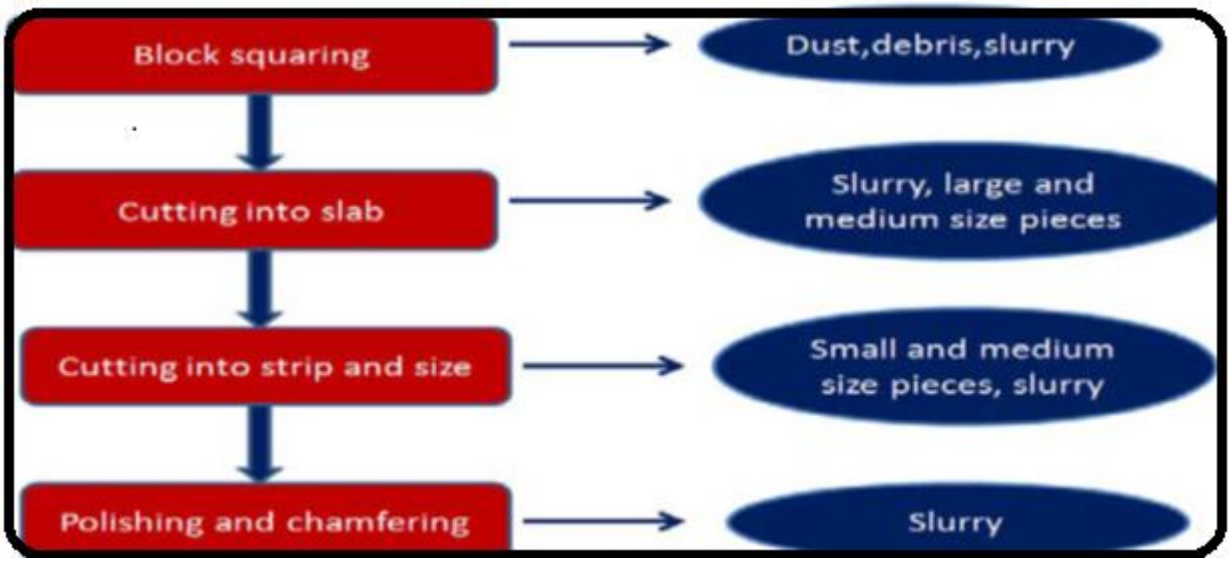


Figure 1.3: Kota Stone Slurry Generation Chart (Lakhani et. al. 2014)

Figure 1.4: Kota Stone Dry Dust near Splitting unit

Figure 1.5: Kota Stone Cutting Operation and Generation of Slurry

1.6 Index Properties of Kota Stone Dust

Table 1.2: Index Properties of Kota Stone Dust

S. No.	Index Properties of Kota stone dust	Results
1	Dry Density	16.72 KN/m^3
2	Color	White
3	liquid limit	N.A
4	Plastic limit	N.A
5	Specific gravity	2.62

1.7 Properties of Black Cotton Soil

Table.1.3: Index Properties of Black Cotton Soil

S. No.	Laboratory test	Result
1	Grain Size Distribution	57.75% fine
2	Specific Gravity	2.62
3	Gravel	1.60%
4	Sand	40.65%
5	Clay and Silt	57.75%
6	Soil Classification	CH
7	Liquid Limit	53.26%
8	Plastic Limit	29.76%
9	Plasticity Index	23.50%
10	Soaked CBR	2.29%
11	Unconfined Compression Strength	2683 KN/m^2
12	Differential Free Swell Index	64.24%
13	Optimum Moisture Content	12.62%
14	Maximum Dry Density	1.73 gm/cm^3

1.8 Objective of present study

The main purpose of this project is to stabilize the properties of black cotton soil with the use of Kota stone dust at different proportion from 0% to 30% at an interval of 5% so laboratory experiment is conducted over black cotton soil with the mixing of 0%, 5%, 10%, 15%, 20%, 25% and 30% Kota stone dust. Test which will be conducted liquid limit, plastic limit, plasticity index, standard Procter test, soaked CBR, unconfined compressive strength, differential free swell index test etc. This study is carried out to check the improvements in the properties of black cotton soil with addition of Kota stone dust in different percentages. So that the objective of this project is to evaluate the feasibility of Kota stone dust as soil stabilization material. To probe the effect of Kota stone dust on index properties of black-cotton soil that a series of laboratory experiments will be conducted on black-cotton soil samples mixed with 0% to 30% of Kota stone dust by weight of dry soil with an interval of 5%. The purpose of this study is to find the measures to reduce harmful effects of Kota stone dust over environment by utilizing it for stabilizing soil so it will not affect environment and easy disposal of it can be found. As we have studied that there is lots of harmful effects due to Kota stone dust as it affects environment by several ways like as Fine particles of it (less than 363 micron) cause air pollution, Slurry affects fertility of land and make it barren land so decreases porosity, water absorption and percolation, Due to long term deposition of slurry on land fill the voids and block the path of flow regime of aquifer and other ground water resources, Periodontitis is a disease found in the labor who works in such mines.so it is required to find the way to dispose Kota stone dust by stabilization in mixing with black cotton soil. So it will not affect environment and it will stabilize soil.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This chapter is based on the previous studies that are related to stabilization of black cotton soil with some admixture. The works carried out previously are mentioned in this chapter and their conclusions are also given. A brief review of current literature is given below.

2.2 Literature Study

Singh Shyam and Yadav R. K. (2014) presented a study on "Effect of marble dust on index properties of black cotton soil". They showed that liquid limit, plastic limit of Black cotton soil decreases and shrinkage limit increases so plasticity index of soil also decreases. They showed that differential free swell also decreased with a big amount. So a great improvement found after mixing stone dust in black cotton soil after mixing marble dust. According to them expansive soil make into more suitable for construction. Their objective was to make feasible industrial marble waste in soil improvement. They probed the effect of marble dust on index properties of black cotton soil with a proportion of 0-40% of marble dust. The test showed change in Atterberg's limit of samples containing marble waste. Liquid limit decreases from 57.68% to 33.92%. The plasticity index changes from 28.35% to 16.67% and also shrinkage limit goes up with 8.06 to 18.39% with proportion changes of marble dust from 10 to 40% of dry weight of black cotton soil. Appreciable decrease in differential free swelling properties was found here from 66.6% to 20.0%.from this experimental study it was found that marble dust obtained from the stone industries can be able to modify properties of black cotton soil. Expansive behavior of black cotton soil can be reduced by mixing of marble dust.

Kumawat N. and Ahirwar S. K. (2014) presented a study on "Performance analysis of black cotton soil treated with calcium carbide residue and stone dust". These admixture transforms black cotton soil into workable, compactable, it was shown that the mixing of these admixture in equal amount of 10-10% controlling the swelling properties. According to him black cotton soil has tendency to shrink when soil become dry and when water content decreases but when water content increases then swelling of soil increases. In cutting and quarrying process wastage obtain is around 20-25% left of its production. According to him reuse of quarry dust could be done in geotechnical applications in back fill material,

embankments, sub base material. He uses calcium carbide residue (CCR) as to improve soil and to save money and time of construction. He found changes in workable, compactable, friable properties in clay. Also he said that chemical changes in unstable clay soil also occur in clay due to mixing of CCR. Due to mixing of CCR and quarry dust changes in expansive soil would be found in soil. He did laboratory experiments in standard proctor test, California bearing ratio test and unconfined compression strength test on black cotton soil. So he found that 10-10% of stone dust and CCR will control swelling behavior of black cotton soil and make more batter all other properties of it. He gives conclusion over the test that maximum dry density of soil reduces and optimum moisture content increases with CCR because its specific gravity is lesser then that of soil. But with increase in stone dust maximum dry density of soil improves which shows that increases packing effect and improve in strength development found as well as pozzolonic reaction also improve strength of soil. Also CCR increases the chemical bonding of the clay particles.

Udayshankar, Hakari D., Puranik S. C. (2012) presented a study on "Stabilization of black cotton soil using fly ash" from Karnataka university, Dharwad had stabilized the properties of black cotton soil using fly ash. They showed improvement in black cotton soil index properties, compaction and strength characteristics of black cotton soil. Liquid limit and plastic limit of the soil decreased with the addition of Dandeli fly ash. That fly ash improved unconfined compressive strength and CBR value of soil. According to them in the newly developing urban areas the steep increase in the building construction activities and required the implementation of infrastructure projects such as highways, railways, air strips, water tanks etc. these projects require quality earthen soil in a huge amount that would increase their bearing capacity of structure. In the Hubballi Dharwad region lots of challenges and hurdles found in construction activities. They improve black cotton soil with Dandelli fly ash and shows that fly ash improve index properties, compaction and strength characteristics of black cotton soil. The liquid and plastic limit of soil decreases with the addition of fly ash which indicates good changes in soil and soil gain shear strength at early stage than without mixing of fly ash in the soil. Plasticity of soil also going to decrease due to increase in workability found here. Also shrinkage limit increases which shows volume change behavior of soil when variation found in moisture content. Unconfined compressive strength of these soils increases with increase in fly ash. It will improve more batter when curing of soil and

fly ash mix occur for 28 days duration. CBR value increases up to a certain proportion of fly ash after that it becomes decreases. So It can be said that if it is used in bulk amount so it may be useful in road construction projects for the improvement of soil subgrade.

Bshara et al. (2014) showed results over poor soil with the mixing of stone dust. He performed test of California bearing ratio and maximum dry density of poor soil mixed with stone dust. He also showed liquid limit, plastic limit, plasticity index and optimum moisture content decreases due to mixing of stone dust. He said that stone dust contains pozzolanic as well as coarser grained particles so that it is more batter than fly ash to improve properties of poor soil. According to Basara California Bearing Ratio (CBR) is a test which is performed to assess the stiffness modulus and shear strength of soil sub-grade, however; if the CBR of available soil is poor so it should be improved. Soil stabilization and mixing of coarse grained soils are some methods of improving CBR of existing soils. fly ash and lime stones are useful for stabilizing the soil because they have the pozzolanic property but the drawback with these materials are that they don't have coarser particles in them, therefore some of the properties are left for modification. On the other hand mixing soil of coarser size particle in poor soil is also not the proper way because they do not possess cohesive nature and pozzolanic property in it. Therefore it was decided to use the material that possesses both property which can improve pozzolanic as well as friction property. They found that the stone dust is the material that has pozzolanic as well coarser particles in it and they are easily available. So that's why thy use it with poor soil. So black cotton soil which has high cohesion but less frictional properties can be improved by mixing of stone dust type of pozzolanic material For this aim their basic properties like percentage finer, Liquid limit, Plasticity index, particle size distribution, Compaction properties and California bearing ratio were determined with various relative proportion of 10%, 20%, and 30% by weight of raw soil were mixed with this poor soil., it may be concluded that the CBR of poor soil can be improved by mixing stone dust in it. Liquid limit can be decreased by the addition of stone dust while stone dust has less liquid limit. Similarly plastic limit may also be decreased. Both liquid limit and plastic limit drops with almost same amount. Plasticity index also reduces so that plasticity characteristics of soil will also decrease. So the soil used as highway subgrade material representing higher ranges of plasticity is not considered suitable for pavement and to bear heavy weight of soils.

Mehta A., Parate K., Ruprai B. S. (2013) they presented their study on the geotechnical properties of expansive black cotton soil of Maharashtra, India at various locations. According to them black cotton soil can be stabilize by fly ash. They used various proportions of fly ash and mix it with black cotton that means 0, 10, 20, 30, 40, 50 (%). All know that fly ash has no plasticity so if it mix with plastic soil so it will decrease soil plasticity and increase its workability by change in size of grain size particles and colloidal reaction. They mixed black cotton soil with fly ash and conducted CBR test soaked and unsoaked condition after that they conducted standard Procter test for this mixture. They found improvement in black cotton soil properties after mixing of fly ash. After test conducted it was seen that unsoaked CBR value was found maximum when black cotton soil mixed with 20% fly ash as compare to other mixing of fly ash with black cotton soil as well as dry density of black cotton soil also increased when it mixed with 20% fly ash. While at the other mix of fly ash not shown maximum dry density of soil. So according to them when 20% fly ash mix with black cotton soil so it may be useful in geotechnical applications. They said that low unit weight of fly ash makes it well suited for placement over soft or low bearing strength black cotton soil. They said that fly ash low specific gravity, freely draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties etc. can be used in the embankments, roads, reclamation of low lying areas, filling of retaining walls etc.

Mudgal M., Sarkar R. and Sahu A. K. (2014) during this study, he stabilized black cotton soil with lime. He mixed lime with black cotton soil after that found optimum value of lime when geotechnical properties of soil increased. After that he mixed up to 25% by weight of stone dust with an increment of 5%. Then he found California bearing ratio, unconfined compression strength and maximum dry density value. He concluded that maximum dry density of soil increases first of all after that it decreases when 20% stone dust increase. Same as unconfined compressive strength and California bearing ratio increases up to 20% after that it decreases.

Kalla P., Rotwal M. and Aggarwal G. (2006) of Indian road congress has done mixing of Kota stone dust with fly ash with different proportion of it and show results of liquid limit of black cotton soil reduces after mixing fly ash and Kota stone dust. Liquid limit, plastic limit

and plasticity index of soil reduces. They showed that soaked CBR, value increase up to particular amount of 18% of Kota stone and 3% of fly ash. Maximum dry density also decreases after mixing of both the admixture up to some extent but after that it reduces and optimum water content increases.

Lakhani R., Kumar R. and Tomar P. (2014) Stone waste use as a admixture, has received importance from last few years. It can be used as pozzolanic and non pozzolanic material for mortar, concrete and other use. This research paper tells the use of stone waste as a partial non-pozzolanic replacement for sand in mortar and concrete and in the containment of hazardous waste. This paper also tells the process to generation of stone waste and properties of it. They found its use in concrete and mortar. They concluded that stone powder can be used after mixing it with fly ash, rice husk ash and blast furnace slag for making a cheap cost building material as a replacement of sand. They also concluded that it can be used as thermal and acoustic insulation treatment of building so can be used to provide cooling in the building and this lime stone waste can be used to fill the gaps in the polymer matrices.

Agarwal N. (2015) he used stone dust as a material to mix it with soil of locally available with poor engineering properties. According to him each crusher unit generates 15 to 20% of stone waste which creates geo environmental problems such as landfill disposal problem, health and environmental pollutions. The best way to eradicate problem due to this waste is to mix it with local soil and improve its engineering properties. He did MDD, OMC, CBR and specific gravity test over soil mixed with 10%, 20%, 30%, 40%, 50% stone dust. After doing laboratory experiments he found satisfactory result for improvement of soil. He concluded after conducting tests that addition of 50% stone dust decreases optimum moisture content and increases maximum dry density and mixing 30% stone dust gives maximum CBR value. Specific gravity of soil also increases up to 30% mixing of Kota stone dust after that it decreases. Optimum specific gravity was found at 30% stone dust mixing of soil. It was cleared from this study that stone dust could improve locally available soil at greater extent.

Indiramma P., Dr. Ch. Sudharani (2016) according to them soil stabilization was done to stabilize soil for construction of foundations and highways to improve compressibility, permeability and shear strength. They stabilize soil by mixing expansive soil with quarry dust

(a kind of low cost material). They found improvement in expansive soil by mixing it with various proportions of quarry dust. They conducted test as Atterberg limits, compaction characteristics, differential free swell index, unconfined compressive strength from the tests on expansive soil at different proportion of quarry dust. After performing test they concluded that liquid limit, plastic limit, plasticity index are decreased with mixing of different proportion of quarry dust. Maximum dry density increases and water content decreases with the increase of quarry dust. Unconfined compressive strength increases with the increase of quarry dust and differential free swell decrease with the increase of quarry dust. So it was become helpful to improve property of black cotton soil. They observed that with increase in quarry dust proportion compressive strength of soil will increase and maximum dry density increases from 19.14KN/M^3 to 19.58KN/M^3 and optimum moisture content decrease from 12% to 9.5%.

2.3 Conclusion of literature review

According to the above literature study we concluded that black cotton soil is changes its geotechnical properties after mixing admixture in it. Therefore positive changes found in black cotton soil after mixing of admixtures like as stone dust, fly ash, quarry dust, calcium carbide residue etc. According to them mixing of admixture should be in the range of 0-40% and those test should be conducted which shows plastic, compaction, strength, swelling behavior of soil at different proportion of admixture. According to them plasticity, swelling behavior of black cotton soil decreases and strength, compaction nature increases. This project contains Kota stone dust as admixture so its effects over black cotton soil will be concluded during the project work.

CHAPTER 3

EXPERIMENTAL INVESTIGATIONS

3.1 Material location

This project objective is to stabilize black cotton soil with the help of Kota stone dust. So material for this project was taken from near Kota district in Rajasthan. Kota stone dust was taken from Kota stone cutting industry B.S. Industries main Jhalawar road near city mall, Kota and black cotton soil was taken from Kota-Baran NH-76 road near Palayatha town.

3.2 Mix proportion

The black cotton soil is mixed with Kota stone dust passing through 4.75mm sieve from 0% to 30% at an increment of 5%. Total seven sample was prepared of Kota stone dust and black cotton soil with a proportion of Kota stone dust as 0%, 5%, 10%, 15%, 20%, 25%, 30% by weight where 0% Kota stone dust sample will give only black cotton soil test result. The test was conducted as per IS code 2720 to determine soil plasticity, swelling, strength and compaction behavior with increase in Kota stone dust proportion. Test conducted during this project are grain size distribution, liquid limit, plastic limit, CBR, standard Procter test with heavy compaction, unconfined compression strength test, differential swelling index test.

3.3 Method of mixing

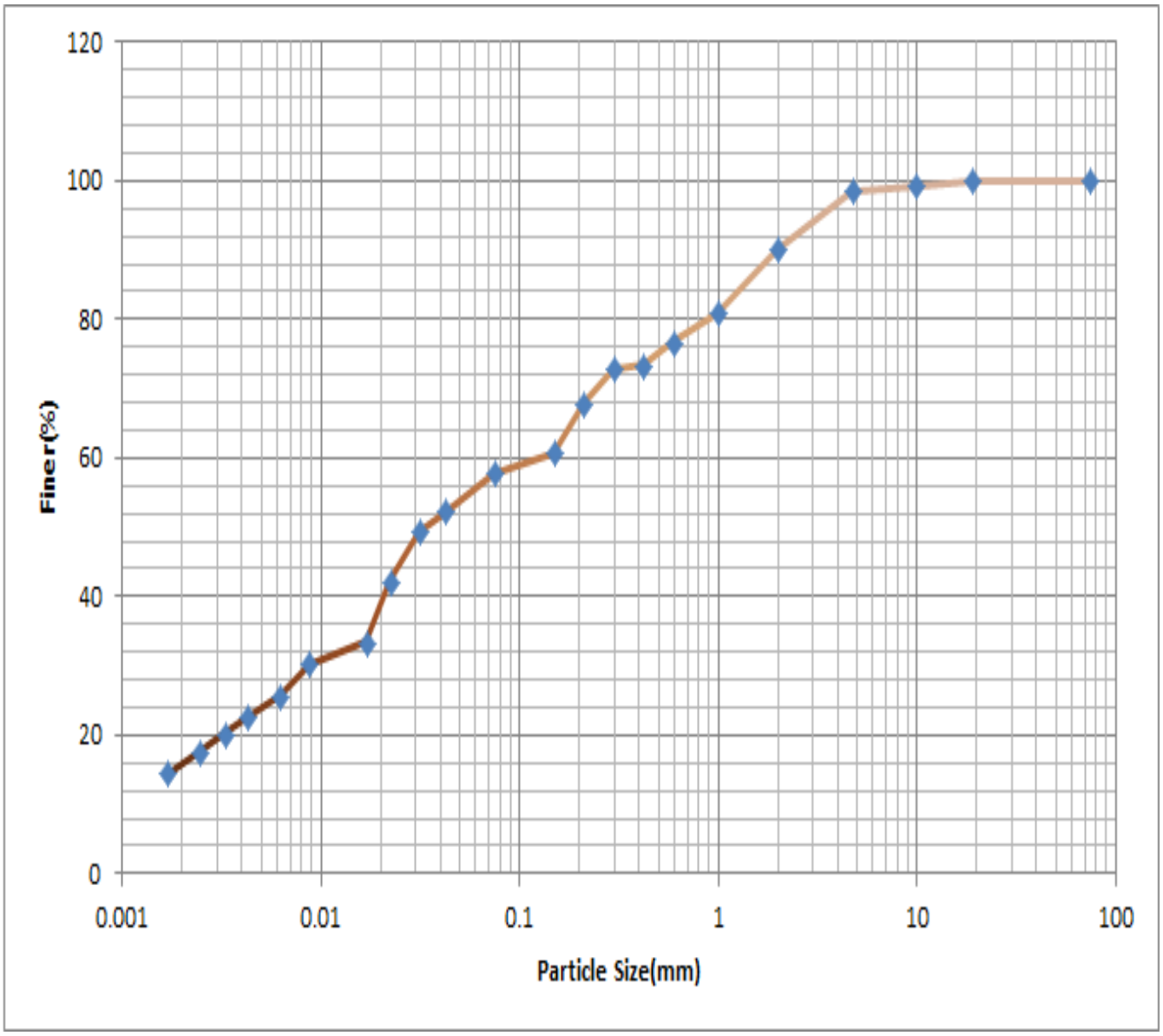
Mix of black cotton soil and Kota stone dust was a dry mix used after oven drying. Sample contains size of particle finer than 20 mm IS sieve as per IS 2720 recommendation for heavy compaction test, CBR test and for unconfined compressive strength test. Size of particle used in liquid limit test, plastic limit test and free swell index was passed through 425 micron sieve. During test procedure dry mixing of both the material took place. Optimum moisture content found from heavy compaction test was used to make sample in CBR test and in unconfined compressive strength test. The water content mixed to prepare sample in CBR test and in unconfined compressive strength test was taken as the maximum water content found during heavy compaction. The material used in the test was mixed uniformly.

3.4 Test results and graphs (As per IS Code 2720)

3.4.1 Grain size distribution curve

Table.3.1: Grain Size Distribution Sieve and Hydrometer Analysis

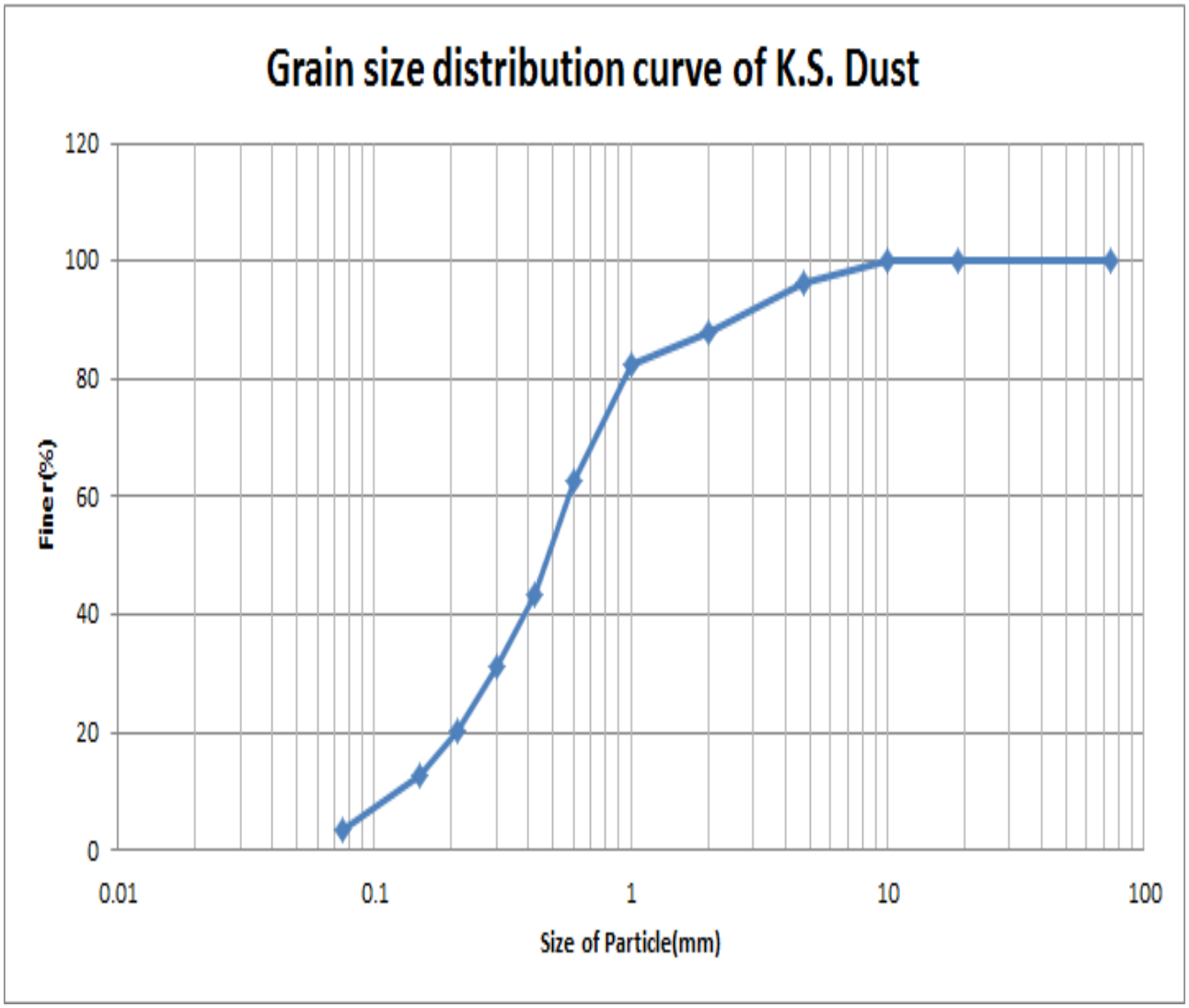
Grain Size Distribution of Black Cotton Soil		
S. No	**Particle size (mm)**	**%Finer(N)**
1	0	0
2	0.0017	14.44
3	0.0025	17.45
4	0.0033	20.03
5	0.0043	22.42
6	0.0063	25.55
7	0.0088	30.14
8	0.0171	33.23
9	0.0226	42.12
10	0.0314	49.31
11	0.043	52.17
12	0.075	57.75
13	0.15	60.68
14	0.212	67.77
15	0.3	72.65
16	0.425	73.23
17	0.6	76.62
18	1	80.89
19	2	89.91
20	4.75	98.4
21	10	99.2
22	19	100
23	75	100



Graph.3.1: particle size distribution curve of black cotton soil

Table.3.2: Grain Size Distribution sieve analysis of Kota Stone Dust

Grain Size Distribution of Kota Stone Dust	
Size of Particle (mm)	**% Finer**
0.075	3.45
0.15	12.66
0.212	20.12
0.3	31.39
0.425	43.42
0.6	62.7
1	82.63
2	87.79
4.75	96.4
10	100
19	100
75	100



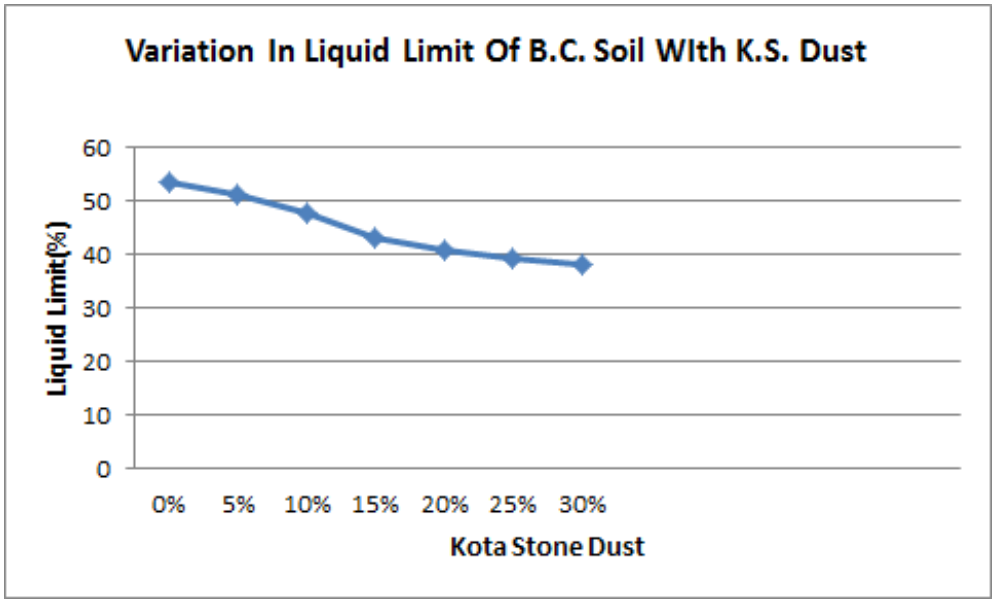
Graph.3.2: Grain Size Distribution Curve of Kota Stone Dust

3.4.2 Liquid limit test

Figure 3.1: Liquid Limit Test Apparatus after soil mixing

S. No.	Kota Stone Dust (%)	Liquid Limit of Black Cotton Soil mixed with K.S.D (%)
1	0	53.26
2	5	51.12
3	10	47.53
4	15	43.13
5	20	40.77
6	25	39.03
7	30	37.8

Table.3.3: Liquid limit of Black Cotton Soil with various proportion of Kota Stone Dust



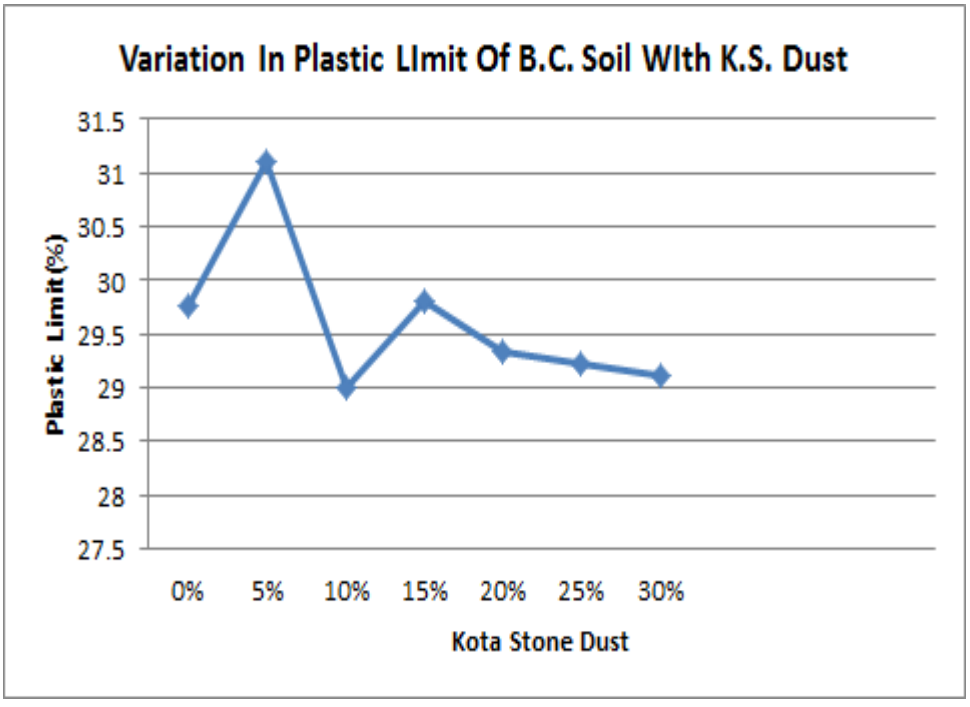
Graph.3.3: Variation of black cotton soil with Kota stone dust

3.4.3 Plastic Limit Test

Figure 3.2: Thread Preparation during Plastic Limit Test

Table.3.4: Plastic limit of Black Cotton Soil mixed with Kota Stone Dust

S. No.	Kota Stone Dust (%)	Plastic limit of black cotton soil mixed with K. S. D. (%)
1	0	29.76
2	5	31.11
3	10	29
4	15	29.81
5	20	29.34
6	25	29.23
7	30	29.12

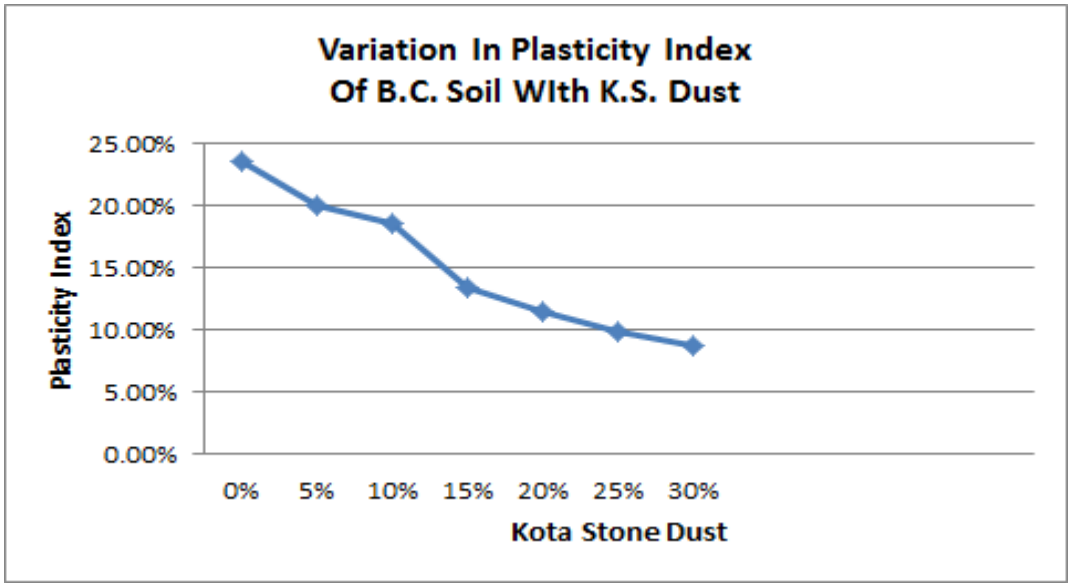


Graph.3.4: Variation of Plastic Limit of Black Cotton Soil with Kota Stone Dust

3.4.4 Plasticity Index

Table.3.5: Plasticity index of Black Cotton Soil mixed with Kota Stone Dust

S. No.	Kota Stone Dust (%)	Plasticity Index of Black Cotton Soil mixed with K.S.D (%)
1	0	23.5
2	5	20.01
3	10	18.53
4	15	13.32
5	20	11.43
6	25	9.8
7	30	8.68



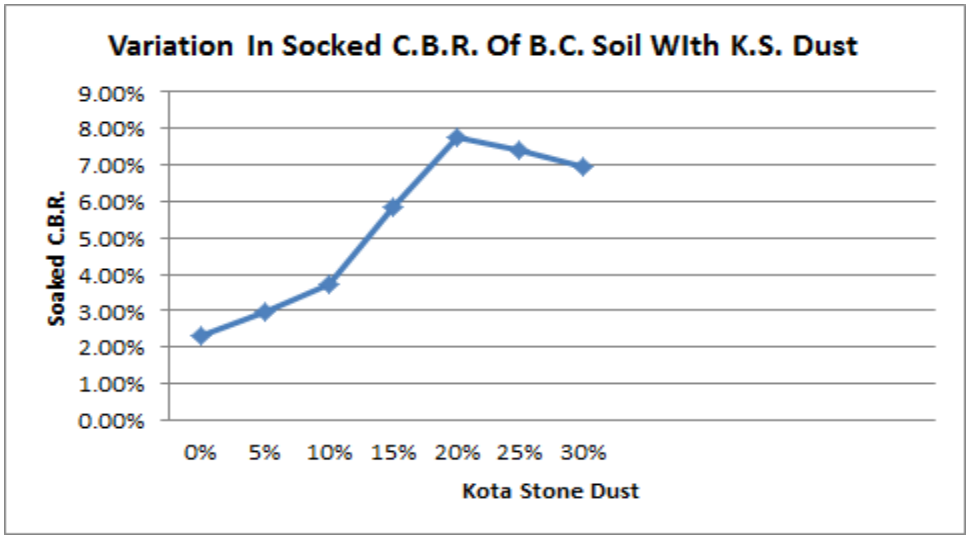
Graph.3.5: Variation of Plasticity Index of Black Cotton Soil with Kota Stone Dust

3.4.5 Soaked CBR Test

Figure 3.3: CBR Test Apparatus

Table.3.6: Soaked CBR of Black Cotton Soil mixed with Kota Stone Dust

S. No.	Kota Stone Dust (%)	Soaked CBR of black cotton soil mixed with K.S.D (%)
1	0	2.29
2	5	2.98
3	10	3.71
4	15	5.86
5	20	7.75
6	25	7.41
7	30	6.94



Graph.3.6: Variation of Soaked CBR of Black Cotton Soil with Kota Stone Dust

3.4.6 Standard Procter Test

Figure 3.4: Standard Procter Test Apparatus

Figure 3.5: Mould and Hammer used in Standard Procter Test

Table.3.7: Dry density of Black Cotton Soil mixed with Kota Stone Dust at different water content

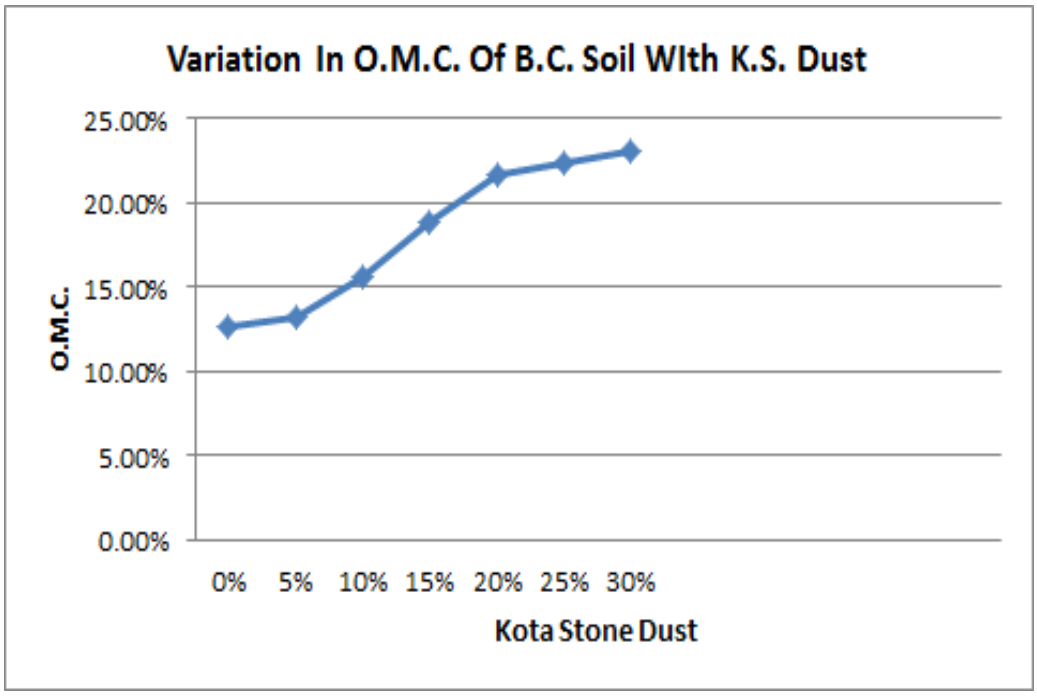
S. No.	Water Content (%)	Dry Density of Black Cotton Soil mixed with Kota Stone Dust(gm/cm^3)						
		0%	5%	10%	15%	20%	25%	30%
1	0	0.85	0.92	0.98	1.02	1.12	1.21	1.21
2	5	1.08	1.16	1.23	1.26	1.29	1.31	1.32
3	10	1.36	1.41	1.45	1.41	1.52	1.52	1.47
4	15	1.71	1.68	1.73	1.76	1.75	1.75	1.71
5	20	1.53	1.51	1.56	1.54	1.81	1.79	1.74
6	25	1.31	1.33	1.37	1.36	1.73	1.76	1.53
7	30	1.2	1.21	1.28	1.22	1.54	1.51	1.47

Table.3.8: Optimum Moisture Content of Black Cotton Soil mixed with Kota Stone Dust

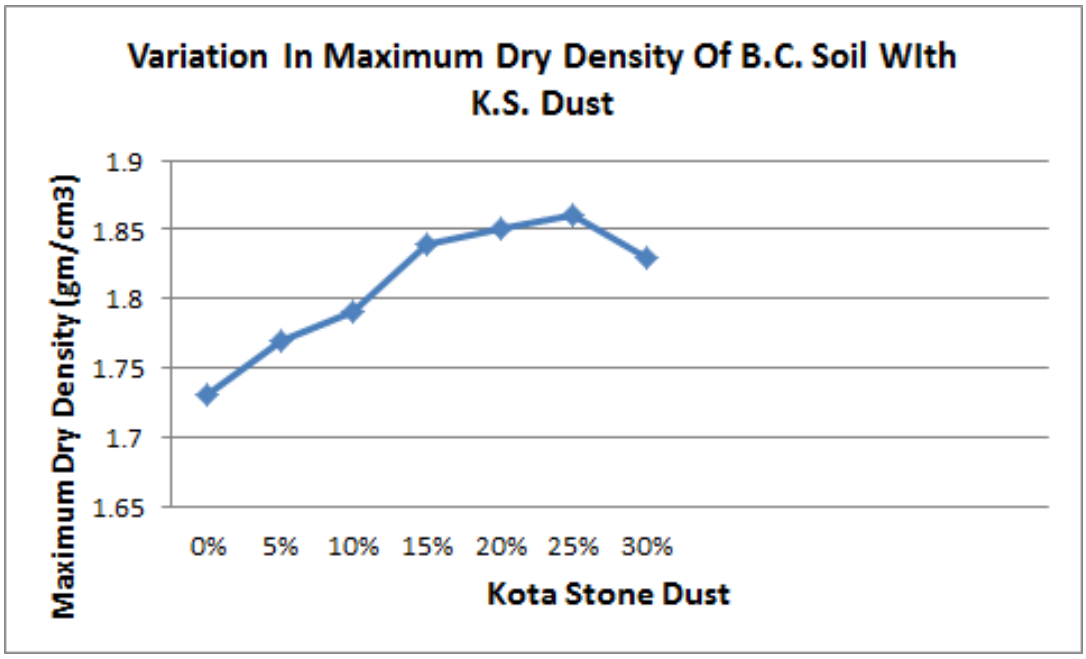
S. No.	Kota Stone Dust (%)	Optimum Moisture Content of Black Cotton Soil mixed with K. S. D. (%)
1	0	12.62
2	5	13.3
3	10	15.59
4	15	18.87
5	20	21.63
6	25	22.45
7	30	23.1

Table.3.9: Maximum Dry Density of Black Cotton Soil mixed with Kota Stone Dust

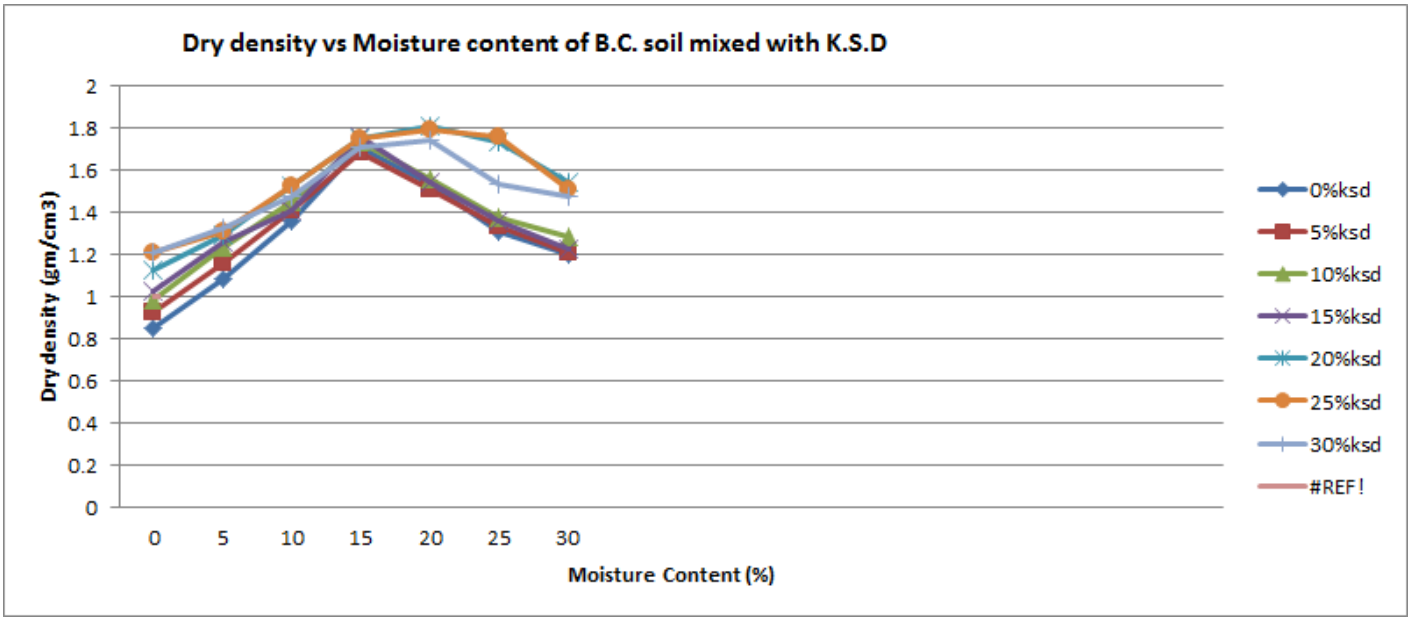
S. No.	Kota Stone Dust (%)	Maximum Dry Density of Black Cotton soil with KSD(gm/cm^3)
1	0	1.73
2	5	1.77
3	10	1.79
4	15	1.84
5	20	1.89
6	25	1.86
7	30	1.83



Graph.3.7: Variation of Optimum Moisture Content of Black Cotton Soil with Kota Stone Dust



Graph.3.8: Variation of Maximum Dry Density of Black Cotton Soil with Kota Stone Dust

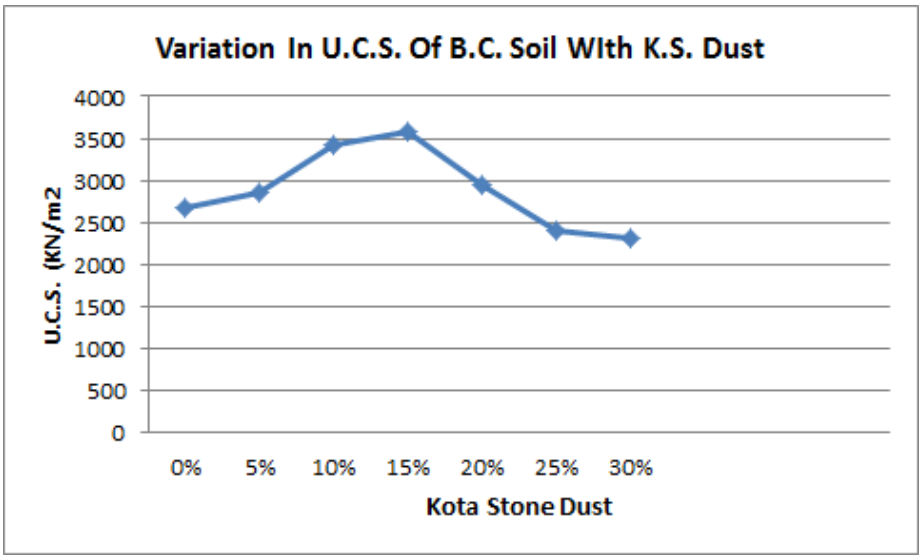


Graph.3.9: Plot of Maximum Dry Density vs Moisture content of Black Cotton Soil with Kota Stone Dust

3.4.7 Unconfined Compressive Strength Test

Table.3.10: Unconfined Compressive Strength of Black Cotton Soil mixed with Kota Stone Dust

S. No.	Kota Stone Dust (%)	Unconfined Compressive Strength of Black Cotton Soil mixed with KSD (KN/M^2)
1	0	2683
2	5	2858
3	10	3430
4	15	3571
5	20	2950
6	25	2412
7	30	2321

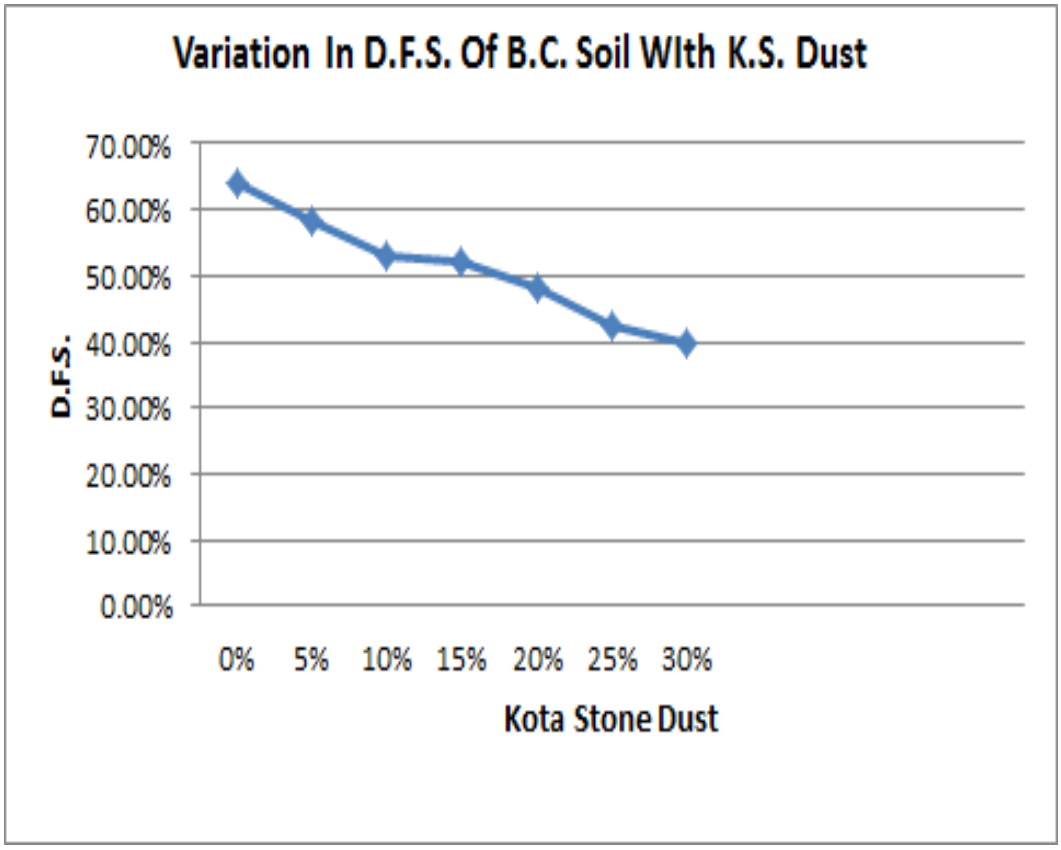


Graph.3.10: Variation of Unconfined Compressive Strength of Black Cotton Soil with Kota Stone Dust

3.4.8 Differential Free Swell Index Test

Table.3.11: Differential Free Swell Index of Black Cotton Soil mixed with Kota Stone Dust

S. No.	Kota Stone Dust (%)	Differential Free Swell Index of Black Cotton Soil mixed with K.S.D (%)
1	0	64.24
2	5	58.29
3	10	53.13
4	15	51.97
5	20	48.18
6	25	42.36
7	30	39.82



Graph.3.11: Variation of Differential Free Swell Index of Black Cotton Soil mixed with Kota Stone Dust

CHAPTER 4

Analysis and discussion

4.1 Effect of Kota Stone Dust on Liquid Limit, Plastic Limit and Plasticity Index of Black Cotton Soil

Liquid limit of black cotton soil is decreasing with increase in the proportion of Kota stone dust. So we can say from result obtained that liquid limit is decreased so it shows that Kota stone dust considerably stabilized black cotton soil. Similarly plastic limit and plasticity index of black cotton soil after increasing Kota stone dust is decreased so that it is a benefit for black cotton soil to become a stabilize soil.

4.2 Effect of Kota Stone Dust on California Bearing Ratio of Black Cotton Soil

As we know the California bearing ratio is the ratio of load carried by specimen at standard penetration of 2.5mm to that of load carried by standard crushed stone at standard penetration so here load carrying capacity of specimen increases with the mixing of Kota stone dust in black cotton soil will increase in CBR result with increase in Kota stone dust up to a particular limit of 20% Kota stone dust after that CBR again decrease. So if Kota stone dust mixed with black cotton soil in the range of 20% or near 20% so it will stabilize black cotton in a good way.

4.3 Effect of Kota stone dust on Unconfined Compressive Strength of Black Cotton Soil

Unconfined compressive strength of black cotton soil with the mixing of Kota stone dust increases up to a certain limit then after it is going to reduced. When Kota stone dust 15% proportion mixed with black cotton soil it will give maximum unconfined compressive strength that shows that it can be used for stabilize black cotton soil in the range of 15% or near to 15%. If Kota stone dust more than 15% or less than 15% would provide so that it will decrease unconfined compressive strength of black cotton soil.

4.4 Effect of Kota Stone Dust on Compaction Properties of Black Cotton Soil

Maximum dry density of black cotton soil mixed with Kota stone dust at a 20% of mixed proportion is quite good but optimum moisture content of soil is also going to increases with it so as according to the result obtained maximum dry density of soil at a certain amount of Kota stone dust so that it is a useful characteristic which can make black cotton soil to be a stabilize soil.

4.5 Effect of Kota Stone Dust on Differential Free Swell Index of Black Cotton Soil

Differential free swell of soil is decreased with increase of Kota stone dust proportion in black cotton soil as according to the result obtained. So it shows that mixture of Kota stone dust with black cotton soil has positive impact over soil swell characteristic by reducing soil swell behavior.

CHAPTER 5

CONCLUSION

Conclusion is based on the practical work which was done in laboratory through experiment. Are as follows:-

1. Kota stone dust which is a waste produced from the cutting and polishing industry of Kota stone at Ramganj mandi near Kota district is a hazardious pollutant in the environment which effect soil, water and air and it effects human being health. It can be disposed by using it in the civil engineering project such as road subgrade stabilization in that area where black cotton soil is found.
2. Kota stone dust mixing with black cotton soil increases its maximum dry density in the range of 15-25% mixing of Kota stone dust. So it is helpful to make the soil dense by providing proper compaction at a suitable mixing of Kota stone dust. Standard Procter test was performed with heavy compaction during experiments so that it was found that dry density of soil increases up to a particular proportion of Kota stone dust in the range of 15-25% but continuous increase in water content was found with increase in its proportion.so a range of 15-25% is batter to make a highly compacted and dense soil.
3. Liquid limit and plastic limit of black cotton soil decreases with increase in proportion of Kota stone dust. A big change is found in change in liquid limit but slight change of plastic limit takes place so overall plasticity index which shows plasticity behavior of soil also decreases up to a great extent.
4. When soaked CBR test was performed so that improvement in CBR was found with the mixing of Kota stone dust in the range of 20-25% mixing it gives maximum CBR value so it is desirable to mix Kota stone dust in black cotton soil with a proportion of 20-25% of mixing. CBR value judged the soil behavior according to highway projects, it is useful in highway pavement design because it shows pozolanic behavior of soil and frictional properties that causes good binding found in soil.
5. Unconfined compressive strength of soil is found maximum when Kota stone is mixed 10-20% proportion with black cotton soil.
6. As we know black cotton soil contains swelling properties with the variation of water content in it so through this project differential free swell index continuously

decreases. So it is very helpful for black cotton soil to reduce its swelling property. Because due to this property settlement is found in the building, roads etc.

7. The differential free swell and plasticity index reduction shows that expansive properties of soil as swelling and shrinking will get reduced.
8. It can be said Kota stone dust is able to stabilize black cotton soil and it may possible to stabilize sub grade of pavement in highway projects, embankments, filling of retaining walls, improve bearing capacity of soil below residential building foundation in black cotton soil affected areas.

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