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Strength Parameter Improvement of Weak Soil by Using Stone Quarry Dust

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***Abstract*—The phrase "expansive soil" refers to soils with the ability to shrink and expand in response to changes in water content. Swelling will put enormous uplift stresses on foundations built on expansive soils, and these forces can cause several structural difficulties. Expansive soil is prone to large volume changes (swelling and shrinking) that are directly related to changes in moisture. So the low bearing strength and high compressibility behavior of soil can cause severe damage to subgrade. In this research the enumeration of the strength of soil by adding different types of ground improvement materials like as Stone quarry dust in order to overcome such type of damages. The California Bearing Ratio (CBR) test is to determine the stability of subgrade soil by adding Stone quarry dust separately at different percentages. The objective of this paper is to study the combined effects of Stone quarry dust with expansive soil on Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Soaked CBR and Swelling pressure of expansive soil. The effects of molding water content and compaction delay, on soaked CBR of Stone quarry dust stabilized expansive soil have also been studied. CBR tests were performed with Stone quarry dust and separately at different percentage variations with the increment of 5% by weight in order to find out which one is most suitable for % stabilization of subgrade material. The results show that initially the optimum moisture content (OMC) of soil is 23% and for addition of Stone quarry dust separately up to 30%, it has become in decrease up to 19.2% respectively. Initially the CBR value of soil is 2.6%. For addition of bagasse ash up to 30% the CBR value of soil has become in increase up to 9.4 %. The UCS value initially was 18 Kg/cm^2 and then addition of stone dust increases up to 20% increases UCS value up to 22 Kg/cm^2 after then decreases.**

***Index Terms*—Expansive Soil, Stone quarry dust, Swelling Index, MDD, OMC, UCS, CBR.**

I. INTRODUCTION

1.1 Overview

Some clayey soils, even when partly wet, are very sensitive to changes in water content and exhibit excessive volume shifts. Expansive soils are defined as soils that expand in volume due to an increase in water content. Constructing using concrete has proven difficult due to cracking and deterioration in the foundation and slab-on-grade sections of structures as well as in the lining of channels and reservoirs. (Gromko, 1974; Wayne et al. 1984; Mowafy et al. 1985; Kehew, 1995)

In certain places, expanding soils have been the most expensive natural hazard, according to reports. There is a greater average yearly loss due to expanding clays in the United States than there is due to flooding and other severe weather events (Jones and Holtz, 1973). Expansive clay difficulties have been documented all over the globe, including the United States, China, Australia, India, and Canada, as well as portions of Europe. (Popescu,1986) If the long-term depletion of the world's resources and economy is taken into account, research on the topic of expansive soils become more relevant. (Cited in Ipek, 1998)

1.2 Review on Expansive Soils.

The phrase "expansive soil" refers to soils with the ability to shrink and expand in response to changes in water content. Swelling will put enormous uplift stresses on foundations built on expansive soils, and these forces can cause several structural difficulties. Large swelling stresses are also noticed when the soil is unloaded if the clay is saturated. The terms "active clays" and "swelling clays" have both been used to describe these types of soils. According to Chen (1988), swelling clays have been found in countries as far apart as Australia and Canada as well as the

United States. In Wibawa's (2003) words, this does not imply that these soils are not found elsewhere; in fact, they may be found almost everywhere.

Conventionally planned and constructed lightweight structures (damage to a lightweight structure is feasible when very little soil volume expansion occurs) will obviously be destroyed by heaving. Kehew (1995) said that Due to their inability to be affected by vertical displacement, highway embankments and highways are largely unaffected by expansive soils. (Mowafy and colleagues, 1985) A structure or pavement reduces the amount of surface evapotranspiration, which in turn reduces the amount of rain, floods, leaky water or sewage lines, or other sources of moisture. These soils' mineral makeup is the root cause of this issue. Many soils, particularly those rich in the clay mineral montmorillonite (a smectite), show signs of this kind of behaviour. Expansive soils and unsaturated soil mechanics must be studied in depth in order to understand and solve these issues.

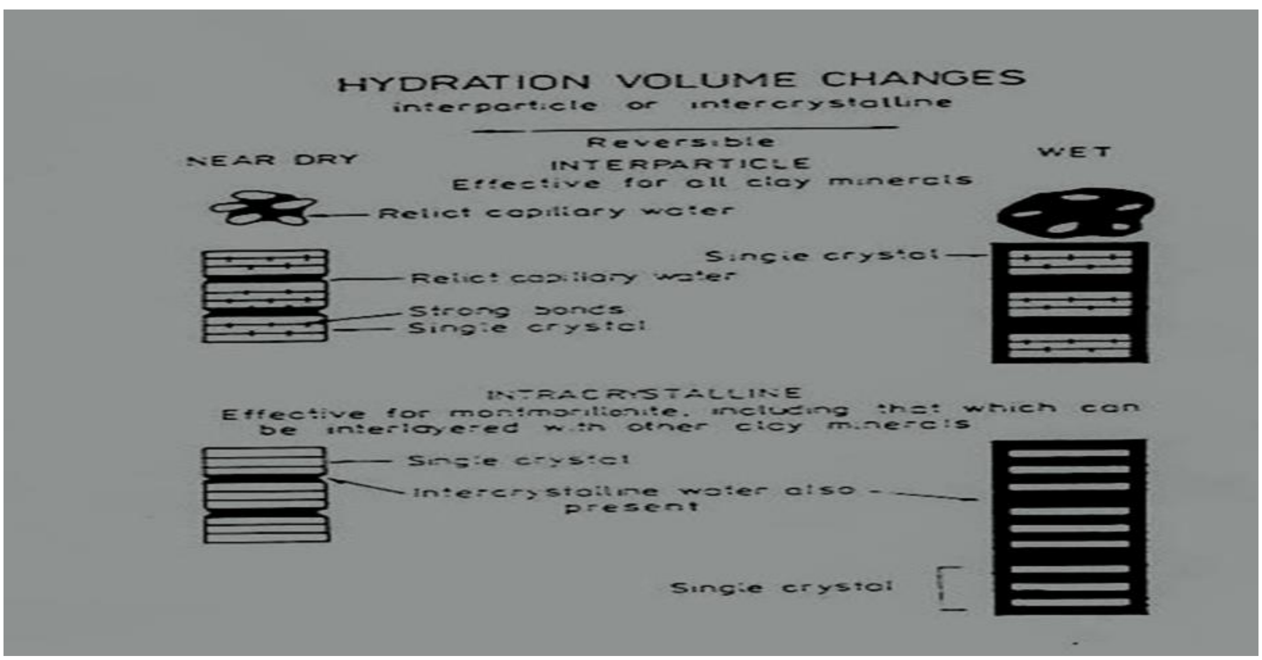
For finding potentially expanding soils, there are numerous relevant relationships. They may also be identified visually. It's possible that visual cues are (Wayne et al., 1984);

1. Dry-season wide and extensive shrinkage fractures; 2.
2. When dry, soil is brittle, but when wet, it becomes stiff and sticky.
3. Expansion of soil causes damage to nearby buildings.

1.3 Mechanism of Swelling

Swelling phenomena are caused by two primary causes:

A) Figure 1.7 illustrates interparticle or intercrystalline swelling, which is applicable to all clay minerals. Capillary forces keep the clay particles together in a nearly dry clay deposit. Once moist, the clay expands due to a release of capillary tension. The impact is the same whether the clay is in the form of particles or crystals, as illustrated in the image. Molecular forces suggest a strong connection between the clay crystal layers, as seen in the image by the short dashes.



II. MATERIALS AND METHODS

2.1 Material used

2.1.1 Black Cotton Soil:

In Lalitpur/Jhansi, black cotton soil was collected. Expansive soils are defined as soils that expand in volume due to an increase in water content. Constructing using concrete has proven difficult due to cracking and deterioration in the foundation and slab-on-grade sections of structures as well as in the lining of channels and reservoirs.

2.1.2 Stone Quarry Dust:
Haldwani in Uttrakhand, where there are numerous stone crushers and quarry dust was employed in our research. While quarry dust may be used as a partial substitute for fine aggregate in concrete, it poses significant environmental risks, thus it is worth mentioning. Approximately 200 metric tons of quarry dust are created in India alone each year.

2.2 SOIL STABILIZATION

There are many times when the soils at a particular location are not perfect for the intended use. In many cases, it would be logical to simply move the building or facility. However, the position of a structure is often determined by factors other than geotechnical ones, and the engineer is left with little choice but to work within the constraints of the available space. The geotechnical characteristics at the location may necessitate that the foundation be modified. In addition, it is possible to stabilise or enhance the soil's engineering qualities. This second strategy might be the most cost-effective one, depending on the situation. A variety of methods are utilised to stabilise, including mechanical and chemical. Thermal and electric stabilisation have also been discussed or implemented. (Craig, 1994)

Chemical stabilisation is one way to help expandable soils perform better. Chemical stabilisation entails adding chemicals to the soil, either by mixing or injection. Most chemical stabilising agents are made of Portland cement or lime or asphalt or calcium chloride or sodium chloride. Soil conditions, stabiliser characteristics, and building type all have an impact on how effective these chemicals are (i.e., houses, roads, etc.). There are several factors to consider while choosing an addition, including its cost, advantages, availability, and practicality.

Researchers from a wide range of disciplines have been working to find solutions to the difficulties caused by industrial waste in recent years. We could get rid of these trash by finding ways to use them. Recent studies have shown that good waste reuse may result in significant cost reductions in the construction of new buildings. (Kamon and Nontananandh, 1991)

2.2.1 Stone Quarry Dust Stabilization.
It may be necessary to combine lime with certain waste materials in order to acquire the requisite strength and improvement. Recent studies have shown that reclaimed soil and aggregate systems may benefit significantly from the addition of modest amounts of lime, fly ash, rice husk, and other such materials without becoming hard or sensitive to shrinkage. In most cases, the requisite strength and resilience modulus qualities may be reached by a sound mixture design procedure that incorporates lime and a waste material. (Muntohar and Hantoro, 2002) It has become more difficult to find solutions to environmental and resource issues in today's society. With an ever-increasing volume of industrial waste matter generated as a by-product of business operations, it is important to dispose of or recycle it for use in the building industry. Construction materials may be made from by-products if they meet the following criteria: 1. large quantities can be produced over an extended period of time. All of the necessary supplies may be found in any number of locations. Quality control is a matter of practicality. The materials are non-polluting to the environment.

Natural gravels cannot be used because of the difficulty in collecting them and the need to protect the environment. Crusher plants produce aggregate trash and rock powder as by-products. As previously stated, the materials employed in this investigation include rock powder and waste aggregates used in concrete. Stabilizing expansive soils may be done by using inactive and silt-sized elements like these. Swelling may be reduced by both ingredients. In Chapter 3, several of these materials' features are discussed.

III. EXPERIMENTAL WORK

3.1 Purpose

During this experiment, we'll look at the swelling potential and swelling rate of an expansive soil, as well as how lime, rock powder, and aggregate waste affect grain size distribution and Atterberg limits.

3.2 Materials

Black Cotton Soil:
In Lalitpur/Jhansi, black cotton soil was collected. The Tables 3.1 and 3.2 show Black cotton soil's

Index characteristics and normal range of chemical values.

Table 3.1: Index Properties of Black cotton Soil

Sr. No.	Description of Properties	Average range of values
1	Specific Gravity	2.51
2	Liquid Limit %	47
3	Plastic Limit %	20
4	Shrinkage Limit %	8-18
5	Plasticity Index %	27
6	Maximum Dry Density 9t/cu.m)	1.83
7	Optimum Moisture content %	23
8	Colour	Dark Grey
9	Free Swell Index %	87
10	UCS	18 Kg/cm^3

Table 3.2: Normal Range of Chemical Properties of Black Cotton/Clayey Soils

Sr. No.	Description	Formula	Range
1	Silica	SiO_2	48-58(%)
2	Alumina	Al_2O_3	13-22(%)
3	Lime	CaO	1-8(%)
4	Magnesium Oxide	MgO	1.8-5(%)
5	Ferric Oxide	Fe_2O_3	7.5-1.5(%)
6	Sulphates	SO_4	0.9-2.0(%)
7	Carbonates	CO_3	0.5-6.6(%)
8	Organic Matter	-	0.4-3.6(%)
9	Loss of Ignition	-	4.8-16.5(%)
10	PH	-	6.7-8.9

Stone Quarry Dust:

Haldwani in Uttrakhand, where there are numerous stone crushers and quarry dust was employed in our research. While quarry dust may be used as a partial substitute for fine aggregate in concrete, it poses significant environmental risks, thus it is worth mentioning. Approximately 200 metric tonnes of quarry dust are created in India alone each year. Tables 3.3 and 3.4 show the Stone Dust's Physical and Chemical Composition.

Table 3.3: Results of Chemical Analysis of Kaolinite, Bentonite and Lime.

Sr. No	Description	Value
1	Specific Gravity	2.58
2	Liquid limit	Non-Plastic
3	Plastic Limit	Non-Plastic
4	Maximum Dry Density (T/M^3)	1.93
5	Optimum Moisture Content	7.2%
6	Colour	Grey

Table 3.4: Chemical Composition

Sr. No	Component	Percentage
1	SiO_2	63%
2	Al_2O_3	19%
3	Fe_2O_3	6.5%
4	CaO	5.5%
5	MgO	2.5%
6	K_2O	3.5%
7	TiO_2	0.9%
8	SrO	0.1%
9	ZrO_2	0.1%
10	Loss on Ignition	1.1%

IV. RESULTS OF EXPERIMENTS CONDUCTED

A. Experimental Results of Free Swelling Index

Table 4.1: Variation in free swell index with varying percentage of Stone dust/Stone quarry waste added to the soil.

Sr. No.	Percentage of stone quarry dust added	Free Swell Index
1	0	85
2	5	76
3	10	72
4	15	64
5	20	60
6	25	53
7	30	48

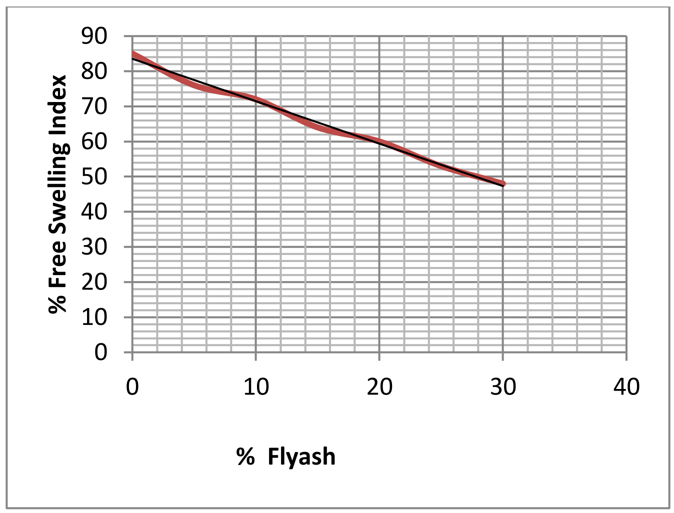


Figure-4.1: Percentage of Stone dust vs Free swell index.

B. Experimental Results of Atterberg's limits

Table 4.2: Experimental result for Index Properties

Sr. No.	Percentage of stone dust added	Liquid Limit	Plastic Limit	Plasticity Index
1	0	47	20	27
2	5	43	18	25
3	10	40	17	23
4	15	35	16	19
5	20	31	14	17
6	25	26	13	13
7	30	20	11	09

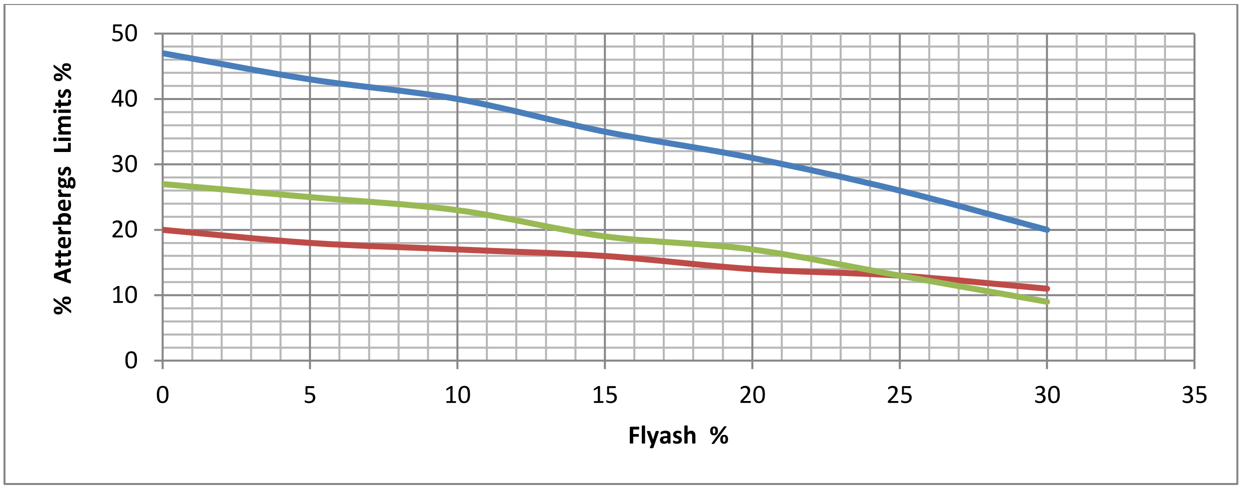


Figure-4.2: Percentage of Stone dust vs Atterberg's limits.

C. Experimental Results of CBR Value

Table 4.3: Experimental results for CBR value Test (Soaked).		
Sr. No.	Percentage of stone dust	CBR value
1	0	2.6
2	5	4.2
3	10	6.3
4	15	8.4
5	20	9.4
6	25	9.6
7	30	9.4

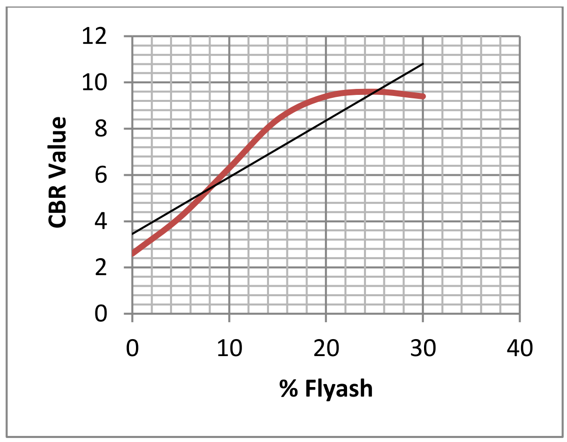


Figure-4.3: Percentage of Stone dust vs CBR.

D. Experimental Results of OMC & MDD (t/m3)

Table 4.4: Variation of OMC & MDD with varying % of stone dust			
Sr. No.	Percentage of stone dust	OMC (%)	MDD(t/m3)
1	0	23	1.83
2	5	22.1	2
3	10	21.2	2.1
4	15	20.8	2.3
5	20	19.6	2.41
6	25	19.4	2.4
7	30	19.2	2.38

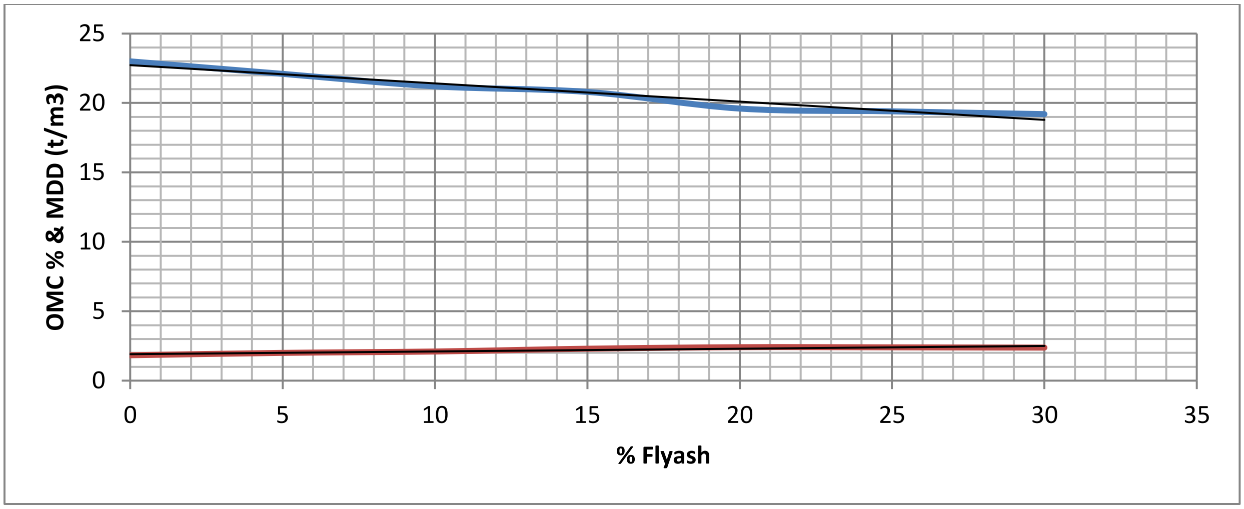


Figure-4.4: Percentage of Stone dust vs OMC & MDD (t/m3)

Table 4.5: Experimental result for unconfined compressive strength.		
Sr. No.	**Percentage of stone dust**	**UCS (Kg/cm2)**
1	0	18
2	5	19.3
3	10	20.1
4	15	21.5
5	20	22
6	25	21.8
7	30	21

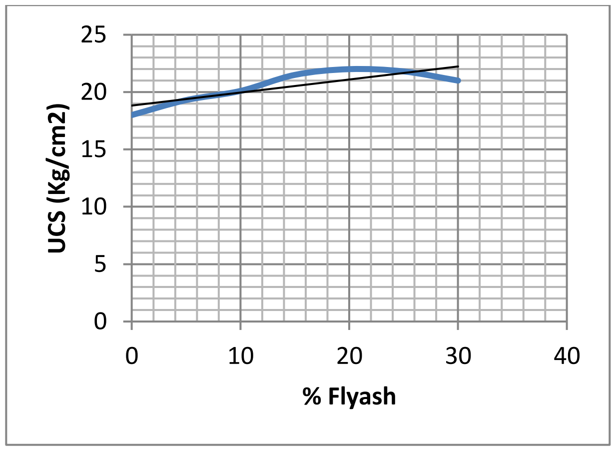


Figure-4.3: Percentage of Stone dust vs UCS.

V. DISCUSSION

The objective of present study was to improve the swelling and shrinkage characteristics the expensive soil by using cheap and locally available waste material i.e. stone dust. With various proportions of this additive i.e. 5%, 10%, 15%, 20%, 25% & 30%, expansive soils is stabilized.

1. The result shows that with addition of stone dust (upto 30% of wt) to the clayey soil decrease in plasticity index of the expansive soil.
2. The result shows that the addition of stone dust (upto 30% of wt) to the clayey soil reduces the swelling potential and then increases.
3. The result shows that the addition of stone dust (upto 25% of wt) to the clayey soil with increase in CBR value after then decreases.
4. The result shows that the addition of stone dust (upto 20% of wt) to the clayey soil increases its shear strength property and after that decreases.
5. The result shows that the addition of stone dust (upto 20% of wt) to the clayey soil increases Maximum Dry Density and then decreases.
6. The result shows that the addition of stone dust (upto 30% of wt) to the clayey soil reduces the optimum moisture content and then increases.

VI. CONCLUSION

After the result analysis the optimum percentage of stone dust is up to 20% for the given soil sample. The shear strength of the stabilized soil is about 122% of the original shear strength.

VII. FUTURE SCOPE

There is always room for growth in whatever we do in this world, and that is especially true in academia and research, where we often hear the adage "Perfection belongs with God alone," and that is certainly true of this project as well.

All elements of soil improvement have been researched thoroughly, but the stability and long-term durability of improved soil needs to be investigated further.

It takes at least four to five years of research to get to a definite judgment on the stability and sustainability of any improvement approach.

Even though it has been shown that the material under consideration has an additive enhancement and that its mechanism is evident, the work remains incomplete until more stability and durability investigations are carried out.

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