Stabilization of Clayey Soil using Dunite Powder

K. Nikhilraaj, V.Janani

Abstract: ***Clayey soil is one of the problematical soil around the world which causes distress to the construction that is built over clayey soil. Construction on expansive soil for geotechnical application causes major problems due to its poor shear strength characteristics apart from this continuous variation in volume change. soil stabilization is the process for modifying the engineering properties of soil. It is one of the most standard techniques used for the improvement of poor soil and also to make cost-effective way by making the best use of the locally existing material. For quite a while, cement is the well-known binder in soil stabilization, but it emits a large amount of CO_2, and energy depletion has started using some other materials or by-products to exchange cement for soil stabilization in full or in part. The growing volume of greenhouse gasses such as CO_2 has also started explore into finding soil stabilization ecologically friendly resources. Dunite's have a high amount of MgO, Al_2O_3, SiO_2, and Fe_2O_3 could categorize this mineral as a soil stabilizing pozzolanic material. In present work experiment were conducted by addition of clayey soil with various percentage of Dunite powder (5%,10%,15%,20%) is added with the dry weight of soil. The unconfined compressive strength and California bearing ratio value is increased with the addition of Dunite power. The UCS value is increased from 198.88kPa to 247.29kPa over untreated soil as well as CBR value also increases from 4.61% for unstabilized soil to 8.86% for stabilized soil***

Keywords: CBR, Dunite power, Stabilization, UCS.

I. INTODUCTION

Many soils lack strength and dimensional stability in their untreated condition, making them unsuitable, wholly or partially, to the construction requirements. The engineer will then have the choice to accept the limitations imposed by the in-situ soil properties, replace the available soil with another soil that meets the specified requirements or improve the existing soil properties through stabilization to meet the design criteria. Many binder materials have enhanced applications that might be used to stabilize soil. Traditional available mixtures normally used high amount water to improve bearing capacity, reduce shrinking & swelling, decrease settlement and decrease permeability. Soil stabilization can be a method that was introduced a number of years ago with the key purpose of reducing soils that can meet specific engineering projects requirements. Well - established soil stabilisation techniques are usually used to find geotechnical properties that are reinforced by adding rigidity agents as Lime, asphalt and Portland cement. Cement is one of the most important and commonly used binders in soil stabilisation due to its high strength (Pourakbar and Pakbaz et al., 2015; Horpibulsuk et al.,2011). Cement production, however, consumes different types of fuel resulting in carbon dioxide (CO_2) being released into the air. While the cement production accounts for only about 5% of global CO_2releases, over the past decade, related carbon dioxide emissions from cement production have continued to grow by an average of 2·5%.per annum (Friedlingstein et al., 2014; Worrell et al., 2001). Recent ground improvement developments are sensitive to the need to use ecological materials or by - products to replace cement in a limited or complete manner as a result of important environmental effects (Basha et al.,2005; Cai et al.,.2015; Arulrajah et al., 2015; Jegand an et al., 2010).

Usually, Dunite is spread all over the Earth. According to a number of studies, Dunite carbonation breakdowns the chemical bond among silicon dioxide and magnesium oxide, with quartz being the key product (Dufaud et al., 2009; Daval et al., 2011).The rate of Dunite carbonation through this reaction depends on a number of factors, including pH, temperature carbon dioxide and water (Prigiobbe et al; Kwon et al.; 2009 Mazzotti, 2011). Dunite is atremendous source of magnesium oxide, the reaction of Dunite as a natural mineral basis and CO_2 makes magnesium carbonate more sensible. According to this reaction, serpentine and brucite are formed and all elements are kept in the rocks except water. (Okamoto et al., 2011). The Dunite formula $(Mg^{2+}, Fe^{2+})_2SiO_4$ is a magnesium ironsilicate. It is a predominant mineral in the Earth's subsurface and is commonly found inmafic's and ultramaficigneousrocks. It is originating some metamorphic rock alternatives and less frequently in marbles. The ratio of magnesium iron can vary in any percentage between pureMg_2SiO_4 (Forsterite) and pure Fe_2SiO_4(Fayalite). Dunite can be present with varying colours from olive green, reddish brown, greenish black and yellowish green. Dunite is the main source of magnesium oxide (MgO), which balances between 45% and 49%.

II. MATERIALS AND PROPERTIES

Clay soil is an expansive soil have low bearing capacity. So it must be stabilized to reduce the settlement of the structure. Clay soil is collected in the lake near kallakurichi at the depth of 1.2m from ground level. The several laboratory tests were conducted on virgin soil sample as per IS 2720 and to determined the basic propertiesof soil as shown in table1. It is a predominant mineral in the Earth's subsurface and is commonly found in igneous rocks, may be in metamorphic rocks. (Mg_2SiO_4) is a magnesium-rich mineral found in igneous rock. Dunite is as ustainable martial to not only cancapture CO_2 from atmosphere through the high amount of MgO, but also the chemical composition of Dunite will put this mineral as a pozzolanic material for soil stabilization because of the high amount of SiO_2, Al_2O_3 and Fe_2O_3.

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T**able 1.**PhysicalProperties of Virgin Soil

Properties		VALUES
Free Swell Index		91.66%
Specific Gravity		2.626
Grain Size Distribution	Silt And Clay	97%
	Sand	3%
Liquid Limit		88.5%
Plastic Limit		57.89%
Shrinkage Limit		5.77%
Standard Proctor Test	Dry Density	1.39g/cc
	OMC	25.91%
Ucc		198.88kPa
Cbr		4.61%
Soil Classification		CH (HIGH COMPRESSIBLE CLAY)

III. RESULTS AND DISSCUSION

3.1 Compaction characteristics of clay soil mixed with Dunite powder

The addition of Dunite powder into soil it makes optimum moisture content and the dry density is keep on increasing for increase percentage of Dunite powder. The increase in maximum dry density is due to higher density of Dunite powder then soil. The increase in optimum moisture content is due to water adsorption nature of Dunite powder

Table 2. Compaction Properties of Clay Soil with Sisal Fibre

MIXTURE	OMC%	MDD(g/cc)
0%	25.91	1.393
5%	26.08	1.403
10%	26.31	1.409
15%	26.42	1.413
20%	26.7	1.418

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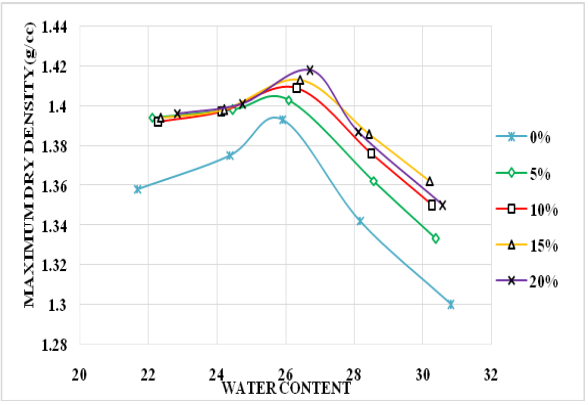

Figure 1. Compaction Characteristics Curve for Treated Soil Sample with Addition of Different Proportions of Dunite Powder

3.2. Unconfined Compression Strength Test

To determined Unconfined compressive strength of cylindrical (38 mm diameter and 76 mm length) specimens as per IS: 2720- Part 10, (1991).The cylindrical specimen was placed on the base plate and without any stress application on the specimen the load frame was fixed. It is the main.test recommended to determine the amount of additive requiredto beused in soil stabilization. The experimental setup consists of the compression device and dial gauges for load and deformation. To cast the UCC specimen, compaction results are taken from the dry density and moisture content, and stress and strain are determined in a graph. The test was carried out immediately after the sample preparation for virgin soil. Samples prepared were placed in polythene covers for soil treated with Dunite powder that were cured by covering them with wetted gunny bags. UCS variation with increase in Dunite powder from 5% to 20% and for curing days of 1,3,7,14 and 28 was considered and the results are shown in table 3.There was an increase in the UCS by adding Dunite powder to the virgin soil compared to the 198kPa UCS value noted for the natural soil.

Table 3.UCC Value for Soil Sample Treated with Dunite Powder Under Different Curing Periods

DUNITE POWDER %	UCS (kPa) CURING PERIODS (days)				
	1	3	7	14	28
5	216.86	218.94	219.94	227.66	239.25
10	216.96	219.01	220.18	228.49	240.93
15	217.08	219.23	220.33	229.63	243.73
20	217.92	219.35	220.6	230.46	247.29

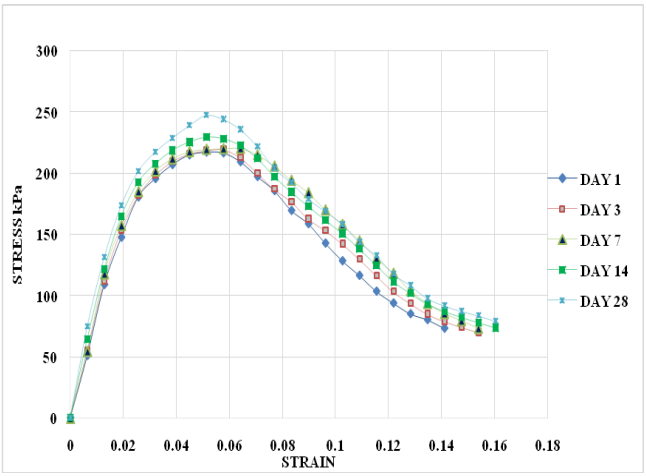

Figure 2. StressStrain Behaviour of Soil Sample Treated with 20% Addition of Dunite Powder at Different Curing Period.

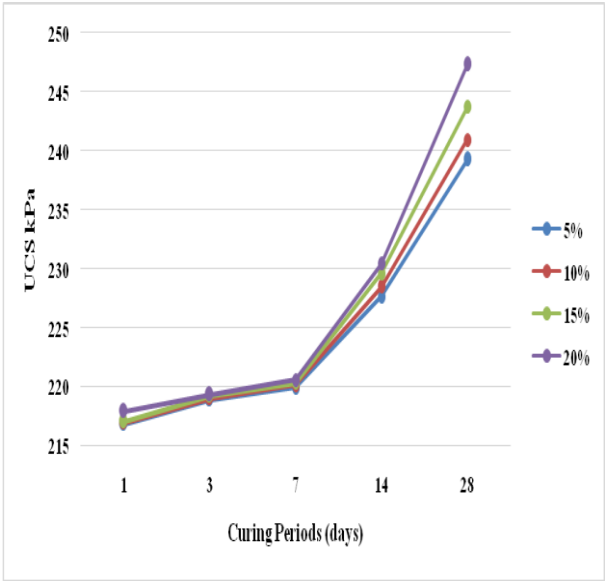

Figure 3.Effect of Curing Period of Soil Sample Treated with Varying Proportion (5, 10, 15& 20%) of Dunite Powder at Different Curing Period.

With the following addition of Dunite powder, the UCS values increase to their maximum at 20 percent. After 28 days of curing, the maximum recorded UCS value was 247.29kPa at 20% of Dunite powder. It is shown figure 1 and 2. These values are somewhat greater than the 198 kPavirgin soil UCS. Increase in value is due to high amount of Magnesium oxide content in Dunite powder a few chemical bonding is occurred. Furthermore,cementationoccurs because of crystallization and some pozzolanicreactions.

3.3. California Bearing Ratio Tests

California Bearing Ratio test is one of the most commonly used techniques for determine the strength of sub-gradesoil for pavement thickness design. To conduct the California Bearing Ratio test, the required volume of soil sample is compacted into 3 equal layers and 55 blows per 2.6 kg rammer were given to each layer. The sample was prepared and cured using soaked gunny bags and rice husk to avoid the difference in moisture content. The load was applied as a steady strain rate of 1.25 mm/minute. Also, the incremental ratio of the CBR value of the soil sample was increased based on the increment of the curing period was shown in the table 4. The load penetration curve for optimum percentage (20%) of Dunite powder at different curing period (1,3,7 days) and maximum strength attainment curve for a variable percentage of admixture (5, 10, 15, and 20%) were figure4 an5.

Table 4.CBR value for soil sample treated with Dunite powder under different curing periods

DUNITE POWDER %	CBR TEST(%)		
	CURING PERIODS (days)		
	1	3	7
5	7.52	7.82	8.41
10	7.59	7.89	8.56
15	7.67	7.89	8.71
20	7.74	8.04	8.86

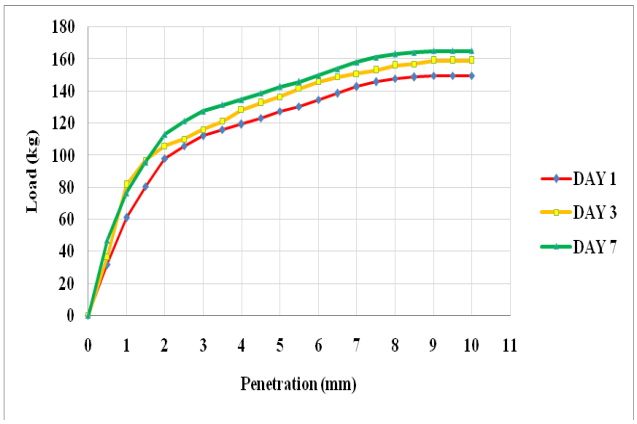

Figure 4. Load Penetration curve for soil sample treated with 20% addition of Dunite powder at different curing period.

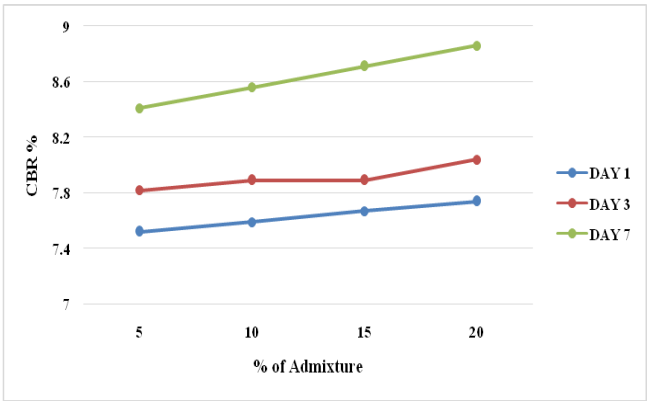

Figure5.Effect of Curing Periods on CBR of Treated Soil Samples At Different Curing Period.

The maximum CBR value increases from 4.61% for unstabilized soil to 8.86% for stabilized soil by adding 20 percent of Dunite powder after 7 days of curing. The improvement in CBRvalue may be attributed to bettercompaction and packingof the mix particles with addition of Dunite powderand the improvement in the strength can be related to the pozzolanic action of Dunite powder

IV. CONCLUSION

- A sequences of tests were conducted in this study to study the effect of Dunite powder on the strength characteristics of clay soil through varying curing periods. The

strength of the soil is predominantly increased due to the addition of Dunite powder to the clay soil.

- The addition of Dunite powder into soil it makes optimum moisturecontent and the drydensity is keep on increasing for increase in percentage of Dunite powder.
- It is Observed that the UCSvalue of clay soil has been improved from 198.88 kPa to 247.61kPafor 20% Dunite powder at the 28-day curing condition.
- It is Observedthat the CBRvalue of clay soil has been increased from 4.61% to 8.86% for 20% Dunite powder at the 7-day condition.
- Overall, it can be concluded that Dunite powder with 20% shows predominates increases in strength value with the increases in the curing period.
- The values are increased because of Dunite powder contains pozzolanic material. And it also contains the high amount of MgO content, it can be a soil - stabilizing sustainablematerial.
- To utilize the waste material effectively and economically. Then reduce the CO_2 content in environmental as an eco-friendly.

REFERENCES

1. Arulrajah A, Disfani MM, Maghoolpilehrood F (2015),"Engineering and environmental properties of foamed recycled glass as a lightweight engineering material". Journal of Cleaner Production, vol.94, pp.369–375.
2. Basha EA, Hashim R, Mahmud HB and Muntohar AS (2005) "Stabilization of residual soil with rice husk ash and cement". Construction and Building Materials, vol.19(6), pp.448–453.
3. Cai GH, DU YJ, Liu SY and Singh DN (2015) "Physical properties, electrical resistivity and strength characteristics of carbonated silty soil admixed with reactive magnesia". Canadian Geotechnical Journal, vol.52(999), pp.1–15.
4. Daval D, Sissmann O, Menguy N et al. (2011) "Influence of amorphous silica layer formation on the dissolution rate of Dunite at 90°C and elevated pCO_2". Chemical Geology, vol.284(1–2), pp.193–209.
5. Dufaud F, Martinez I and Shilobreeva S (2009) "Experimental study of Mg-rich silicates carbonation at 400 and 500°C and 1 kbar". Chemical Geology, vol.265(1–2),pp.79–87.
6. Friedlingstein P, Andrew RM, Rogelj (2014) "Persistent growth of CO_2 emissions and implications for reaching climate targets". Nature Geoscience, vol.7(10), pp.709–715.
7. Horpibulsuk S, Rachan R, Chinkulkijniwat A, Raksachon Y and Suddeepong A (2010) "Analysis of strength development in cement-stabilized silty clay from microstructural considerations". Construction and Building Materials, vol.24(10),pp.2011–2021.
8. Horpibulsuk S, Rachan R and Suddeepong A (2011) "Assessment of strength development in blended cement admixed Bangkok clay". Construction and Building Materials, vol.25(4),pp.1521–1531.
9. Kwon S, Fan M, DaCosta HFM and Russell AG (2011) "Factors affecting the direct mineralization of CO_2 with Dunite".
10. Okamoto A, Ogasawara Y, Ogawa Y and Tsuchiya N (2011) "Progress of hydration reactions in Dunite–H_2O and orthopyroxenite–H_2O systems at 250°C and vapor-saturated pressure". Chemical Geology, vol.289(3–4),pp.245–255.
11. .Pourakbar S, Asadi A, Huat BBK and Fasihnikoutalab MH (2015) "Stabilization of clayey soil using ultrafine palm oil fuel ash (POFA) and cement". Transportation Geotechnics, vol.3,pp.24–35.
12. Prigiobbe V and Mazzotti M (2011) "Dissolution of Dunite in the presence of oxalate, citrate, and CO_2 at 90°C and 120°C". Chemical Engineering Science 66(24): pp.6544–6554.
13. Worrell E, Price L, Martin N, Hendriks C and Media LO (2001) "Carbon dioxide emissions from the global cement industry". Annual Review of Energy and the Environment, vol.26(1): pp.303–329.

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- with P.T.Ravichandran and Vinutha Mudengudi, "Strength Development on problematic soil stabilized with calcined clay", International Journal of Pure and Applied Mathematics, Volume 118 No. 20, 2131-2138, 2018.
- WithM.Ashni,"Experimental study on pull - out capacity of Helical pile in clayey soil", International Journal of Civil Engineering and Technology, vol 8, issue 4,pp 1514-1521,2017.
- withJ.Samson Paul Muller,"Influence of Tile Waste Powder on the strength and swell characteristics of Expansive soil", International Journal of Civil Engineering and Technology, vol 8, issue 4, pp 1860-1868, 2017.
- withA.Gowtham,"Study on the Effectiveness of Redmud on the Expansive soil", International Journal of Civil Engineering and Technology, Vol 8, issue 5,pp 378-385, 2017.
- withK.Divya Krishnan, P.T.Ravichandran,

C.Sudha&ManishaGunturi,"Utilisation of Phosphogypsum and fly ash in soil stabilization", Indian Journal of Science and Technology, Vol 9, Issue 33, pp 1-5, 2016.

- withN.Kamaraj, V.Janani, P.T.Ravichandran, D.Nigitha& K.Priyanga,"Study on improvement of soil behaviour by Bio-Stabilisation Method", Indian Journal of Science and Technology, Vol 9, Issue 33, pp 1-5, 2016.
- withDivyaKrishnan.K, P.T.Ravichandran, R.Annadurai, ManishaGunturi, "Effect of Phosphogypsum and flyash stabilization on the strength and micro structure of clay", The Indian Concrete Journal, Vol.89, Issue 7, pp.81-86, July 2015.
- withN.Kamaraj, K.Priyanka, P.T.Ravichandran , D.Sankari, "Study on Bio-stabilisation of problematic soils", The Indian Concrete Journal, Vol.89, No.7 Issue , pp.87-94, July 2015.
- withP.T.Ravichandran, DivyaKrishnan.K, R.Annadurai, ManishaGunturi, "Soil Stabilisation with Phosphogypsum and Fly ash – A Micro Level Study", International Journal of ChemTech Research, Vol.7,No.2, pp.622-628, Feb. 2015.
- withDivyaKrishnan.K, ,P.T.Ravichandran, R.Annadurai, ManishaGunturi, " Effect of Fly Ash and PhosphoGypsum on Properties of Expansive Soils", International Journal of Scientific Engineering and Technolog, Vol.3, Issue 5, pp. 592-596, May 2014.
- with DivyaKrishnan.K, R.Annadurai, ManishaGunturi, "Soil Stabilisation Using Phosphogypsum and Flyash", International Journal of Engineering Trends and Technology, Vol. 9, No. 14, May 2014, pp. 736-739

MEMBERSHIP

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ACHIEVEMENTS

- Best Paper Award Received along with DivyaKrishnan.K, P.T. Ravichandran, ManishaGunturi for the paper titled "Effect of Phosphogypsum and flyash stabilization on the strength and micro structure of clay", at International Conference on Sustainable Technologies in Building & Environment, Chennai, July 2015.

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