International Journal of Research in Engineering, Science and Management
Volume-2, Issue-2, February-2019
www.ijresm.com | ISSN (Online): 2581-5792

Variation in Strength of CH Clay with the Addition of Olivine Activated with KOH

Ashika Menon[1], Twinkle Vinu Mohandas[2]
[1]*M. Tech. Student, Department of Civil Engineering, Marian Engineering College, Trivandrum, India*
[2]*Assistant Professor, Department of Civil Engineering, Marian Engineering College, Trivandrum, India*

***Abstract*: When olivine (Mg_2SiO_4) is activated with potassium hydroxide (KOH), it acquires the ability to improve the unconfined compressive strength of soil. This paper investigates the use of olivine for soil stabilization through alkaline activation by focusing on the role of different alkali activated olivine contents (5,10,15,20,25,30 wt%) in stabilizing native soil. It also studies the use olivine treated soil as a pavement material and liner. The impact of this work is far reaching and provides a new soil stabilization approach. Key advantages include significant improvements in soil strength with a lower carbon footprint compared with lime or cement stabilization. This achievement implies a tremendous effect of olivine on the strength behaviour of treated soil. These results provide essential information which is significant from an environmental perspective as it offers a low energy alternative to existing technologies, for soil stabilization.**

***Keywords*: Stabilization, Kaolinite, Olivine, Alkali Activation, KOH**

1. Introduction

A. General

Application of cement as binder in soil stabilization is a widely used method for ground improvement. However the high quantity of CO_2 released into the atmosphere is the main drawback of using cement. The cement industry produces 5% of global man-made CO_2 emissions. Beside the emission of CO_2, another by-product of cement production is NO_2. Most of these nitrogen oxides are produced in cement kilns, which can contribute to the greenhouse effect and acid rain. Several attempts involving the use of alternative methods or by-products as partial or full replacements of cement as stabilizers have been made to alleviate this. In this respect, binders based on alkali-activated materials have received a significant interest due to their sustainability advantages.

The alkali activation is a process in which, the aluminosilicate materials (industrial wastes and by-products) were dissolved through an alkaline activator such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) Alkali-activated materials may have low (e.g. fly ash class F and metakaolin) or high (e.g. ground granulated blastfurnace slag (GGBS) and fly ash class C) calcium contents. The formed geopolymeric gel can be viewed as an alkaline aluminosilicate base on amorphous Na+ or K+ aluminosilicate structure.

This report focuses on the use of olivine (Mg_2SiO_4) to provide a more sustainable approach for the preparation of alkali activated binders to be used in soil stabilization. Olivine is a magnesium silicate, whose deposits are globally located. It contains 45–49% magnesium oxide (MgO) and 40% SiO_2.

Si bonds leaves olivine susceptible to dissolution and subsequent chemical reaction. Its high SiO_2 and alkaline metal content makes this natural resource an ideal candidate for alkali activation. Due to its role as an effective source of MgO and SiO_2 with weak chemical bonds, olivine can be a good candidate for soil stabilization after being subjected to alkali activation. The aim of this study is to explore the use of olivine in the presence of KOH for the development of high strengths during soil stabilization. The behaviour of olivine treated soil was examined through UCS measurements and its effectiveness as pavement material was studied by conducting CBR test.

B. Olivine and its properties

Its weak nesosilicate structure and the absence of strong Si–O–S Olivine has a high affinity for the adsorption of CO_2 in the presence of water. Similarly, the hydration product of MgO, brucite can carbonate to produce magnesite or hydrated magnesium carbonates such asnesquehonite, dypingite, and hydromagnesite. The carbonation of olivine has been reported to improve the unconfined compressive strength (UCS) and ultimate bearing capacity of soil. Blencoe and Palmer [U.S. Patent No. 8,114,374 (2012)] reported the use of a strong base such as sodium hydroxide (NaOH) to break the chemical bond between MgO and SiO2. This leads to the production of $Mg(OH)_2$ and Na_2SiO_3. An intermediate step can involve the reaction of CO_2 with NaOH to improve the CO_2 adsorption potential. The reaction products are alkali-metal carbonate (Na_2CO_3) or bicarbonate ($NaHCO_3$) and silica in either a gelatinous or solid form (Blencoe and Palmer,U.S. Patent No. 8,114,374 (2012)). Due to its role as an effective source of MgO and SiO_2 with weak chemical bonds, olivine can be an ideal candidate for soil stabilization after being subjected to alkali activation and carbonation. Moreover, one of the great advantages of stabilizing soil using olivine as a binder in the presence of a strong alkali is that pretreatments, which are often energy intensive, are not required. This process can be induced by the introduction of NaOH to increase the carbonation potential of olivine.

This study aims to explore the carbonation of alkali-activated olivine used in soil stabilization. The behavior of olivine-treated

International Journal of Research in Engineering, Science and Management
Volume-2, Issue-2, February-2019
www.ijresm.com | ISSN (Online): 2581-5792

soil was examined through UCS measurements before and after carbonation treatment.

2. Materials and methods

A. Clay

Clay used for the study was Amaravila clay. Various tests were conducted for determining the index properties of clay and it is shown in table 1.

B. Olivine

The olivine was taken from Navbhan Exporters, Bangalore. The soil was obtained in the original form itself and it is shown in table 2.

Table 1
Properties of Kaolinite

Properties	
Specific gravity	2.637
Liquid limit (%) (IS 2720 PART 51985)	52
Plastic limit (%) (IS 2720 PART 51985)	21.52
Plastic index (%) (IS 2720 PART 51985)	30.48
Shrinkage limit (%) (IS 2720 PART 51985)	17.65
IS Classification	CH
Optimum moisture content (%) (IS 2720 PART 7)	20
Maximum dry density (g/cc) (IS 2720 PART 7)	1.56
Percentage of clay (IS 2720 PART 4)	64
Percentage of silt (IS 2720 PART 4)	28
Percentage of sand (IS 2720 PART 4)	8
UCC strength (kg/cm^2) (IS 2720 PART 10)	0.485

Table 2
Properties of Olivine

Property **Chemical Composition (%)**	**VALUE**
MGO	49
SIO_2	41
FE_2O_3	9
AL_2O_3	0.5-2.0
3CAO	0.2
Melting Point	1600 ºC
Free Silica Content	<0.1%
Bulk Density (g/cc)	3.2-3.4

3. Results

A. Properties of Clay Sample

1) Atterbergs limit

The liquid limit, plastic limit, plasticity index was determined according to IS: 2720 PART 5. The values obtained are 52%, 21.52% and 30.48% respectively for liquid limit, plastic limit, and plasticity index. The soil is classified as CH.

2) Determination of grain size

For determination of grain size distribution, the marine clay was passed through an IS sieve having an opening size 75 µ. Sieve analysis was conducted for coarser particle as per IS: 2720 part (IV), 1975 and hydrometer was conducted for finer particles as per IS: 2720 part (IV). The percentage of clay is 64% percentage of silt is 28% percentage of sand is 8%.

3) Compaction characteristics of soil

The compaction characteristics of soil was found by using compaction tests as per IS: 2720 (Part VII)-1980. For this test, samples were mixed with required amount of water and the wet sample was compacted in proctor mould of 1000 cc volume in three equal layers using standard proctor rammer. The results obtained are Maximum dry density = 1.56 g/cc Optimum moisture content = 20%.

4) Unconfined compressive strength

Compressive strength of the soil was obtained by conducting unconfined compressive strength test. It was conducted according to IS 2720 (Part 10). Unconfined compressive strength of given sample was obtained as 0.485 Kg/cm^2 and which lies the range 0- 0.5 Kg/cm^2 so it can be informed that the soil sample was soft soil.

B. Addition of olivine activated with KOH

1) Compaction Characteristics

The compaction characteristics of soil added with different proportions of olivine by weight was found by using compaction tests as per IS: 2720 (Part VII)- 1980. For this test, samples were mixed with required amount of olivine activated with KoH and the wet sample was compacted in proctor mould of 1000 cc volume in three equal layers using standard proctor rammer. The results obtained are shown in table 3.

Table 3
Compaction Results

SAMPLE	MDD	OMC
5% OLIVINE +10M KOH	1.57	19.8
10% OLIVINE +10M KOH	1.58	19.5
15% OLIVINE +10M KOH	1.621	18
20% OLIVINE +10M KOH	1.64	17
25% OLIVINE +10M KOH	1.62	18
30% OLIVINE +10M KOH	1.69	18.6

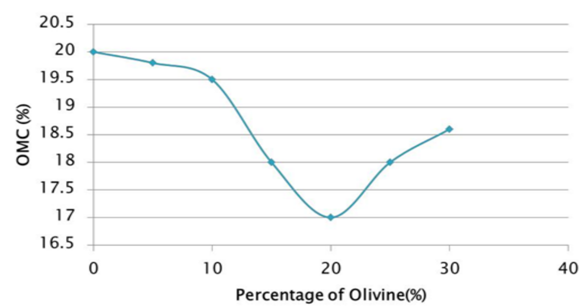

Fig. 1. Variation of OMC

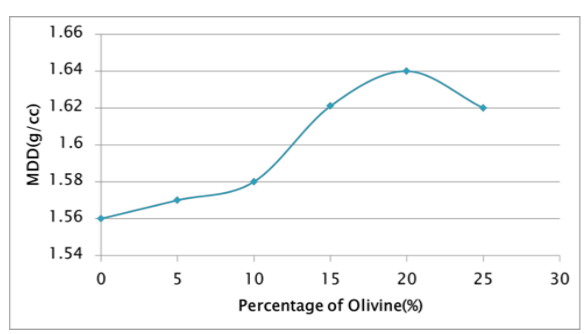

Fig. 2. Variation of MDD

2) Unconfined Compressive Strength

Unconfined Compressive test was conducted and the results are shown in table 4.

Table 4
UCS results

SAMPLE	UCS (Kg/cm^2)	SHEAR STRENGTH (Kg/cm^2)
5% OLIVINE +10M KOH	1.5	0.75
10% OLIVINE +10M KOH	1.8	0.9
15% OLIVINE +10M KOH	2.2	1.1
20% OLIVINE +10M KOH	2.6	1.3
25% OLIVINE +10M KOH	2.3	1.15
30% OLIVINE +10M KOH	2.15	1.08

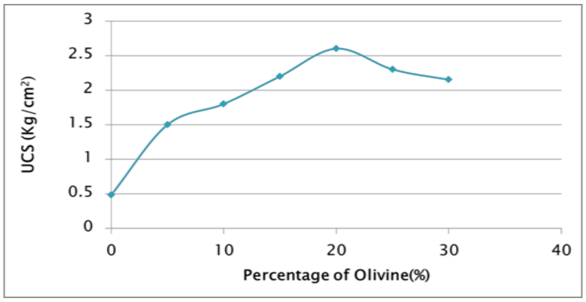

Fig. 3. Variation of UCS

4. Conclusion

This study investigated the potential of Olivine as a sustainable binder in improving the properties of clay. The following conclusions can be deduced from the study.

- Addition of Olivine increased the maximum dry density and reduced the optimum moisture content of the soil.
- Strength of Olivine treated soils was found to improve in the presence of an alkali activator.
- There was decrease in OMC upto 20% after which it increased.
- MDD of the soil increased uptp 20% addition of Olivine and marked a decrease after it.
- Based on strength improvement the optimum concentration of olivine was found to be around 20%.

References

[1] Maher, M. H. and Gray, D. H., (1990). “Static response of sands reinforced with randomly distributed fibers”, Journal of Geotechnical Engineering, Vol 116, 1661–1677
[2] Palomo, Grutzeck and Blanco (1999). “Alkali-activated fly ashes: a cement for the future”, Cement and Concrete Research, Vol 29, 1323–1329.
[3] Pourakbar, S., Asadi, A., Huat, B. B. and Fasihnikoutalab, M. H. (2015). “Soil stabilization with alkali-activated agro-waste”, Environmental Geotechnics, Vol. 2, 359–370.
[4] Cristelo, N., Glendinning, S., Fernandes, L. and Pinto, A. T. (2013). “Effects of alkaline-activated fly ash and Portland cement on soft soil stabilisation”, Acta Geotechnica, Vol. 8, 395–405.
[5] Mohammad Hamed Fasihnikoutalab, Afshin Asadi, Bujang Kim Huat, Paul Westgate, Richard J. Ball, Shahram Pourakbar (2016). “Laboratory scale model of carbon dioxide deposition for soil stabilization”, Journal of Rock Mechanics and Geotechnical Engineering.
[6] Nima Latifi, Amin Eisazadeh, Aminaton Marto, Christopher L. Meehan (2017). “Tropical residual soil stabilization: A powder form material for increasing soil strength”, Construction and Building Materials Vol 147, 827– 836.
[7] R. K. Sharma (2017). “Laboratory study on stabilization of clayey soil with cement kiln dust and fiber”, Journal of Geotechnical Engineering.
[8] Binod Singhi, Aminul Islam Laskar and Mokaddes Ali Ahmed (2017). “Mechanical Behavior and Sulfate Resistance of Alkali Activated Stabilized Clayey Soil”, Journal of Geotechnical Engineering.
[9] Hamdallah Bearat, Michael. J and R. W. Carpemter (2006). “Carbon Sequestration via Aqueous Olivine Mineral Carbonation: Role of Passivating Layer Formation”, Journal of Environmental Science and Technology Vol. 40, 4802-4808.
[10] Anil Pandey, and Ahsan Rabbani (2017). “Stabilisation of pavement subgrade soil using lime and cement: review”, International Research Journal of Engineering and Technology Vol. 04, Issue 6, 5733-5735.