International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
ISSN (Online): 2347-601X
www.ijemhs.com

REAPPRAISAL OF LIME STABILIZATION OF SOILS

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Abstract: Lime for the most part works on the presentation of soils. Be that as it may, a few cases revealed an antagonistic impact. To foster a comprehension of the basic instruments, a methodical report covering a wide scope of versatility and mineralogy of soils was completed. Six distinctive soil tests were reconstituted utilizing two limit kinds of soils, as such, a montmorillonite rich broad soil and a silica-rich non-far reaching soil. The impact of lime adjustment on these dirts was assessed through assurance of geotechnical properties like fluid cutoff, plastic breaking point, enlarge, compressive strength, mineralogy, and microstructure. An ideal lime content past which the strength improvement diminished was found. This wonder is all the more noticeably saw with silica-rich soils that structure silica gel. As the silica gel is exceptionally permeable, when shaped in huge scope the strength acquire from cementation is generously countered by the strength misfortune from gel pores, leading to a noticeable decrease in by and large strength. Moreover, the gel materials hold a lot of water, prompting expanded versatility and enlarging. Subsequently, unreasonable lime treatment ought to be kept away from for silica-rich soils.

CE Database subject headings: Soil stabilization; Lime; Evaluation.

Author keywords: Soil stabilization; Lime; Evaluation.

Introduction

Lime, or CaO or Ca OH $_2$, the burned byproduct of lime stone ($CaCO_3$), is one of the oldest developed construction materials, and humans have been using it for more than 2,000 years, when the Romans used soil-lime mixtures to construct roads. However, its utility in modern geotechnical engineering applications was limited until 1945, mostly because of lack of proper understanding of the subject (Herrin and Mitchell 1961). Today, lime stabilization of soils is widely used in several structures such as highways, railways, airports, embankments, foundation base, slope protection, canal linings, and others. (Anon 1990; Wilkinson et al. 2010). This prevalent use of lime is primarily because of its overall economy and ease of construction, coupled with simplicity of this technology that provides an added attraction for engineers. Several research studies highlighted the beneficial effect of lime in improving soil performance.

An important phenomenon reported by many researchers is the ability of lime to change the plasticity of soils. Both the liquid limit and the plastic limit indices, where the plastic limit indicate the plasticity of soil, are influenced by lime, which affects the thickness of the diffuse hydrous double layer surrounding the clay particles. Whereas the liquid limit of clay soils is found to decrease with increased lime content (Wang et al. 1963; Bell 1988), the plastic limit generally shows an increasing trend (Herrin and Mitchell 1961; Barker et al. 2006). A greater amount of clay results in a higher, lime-induced increase in the plastic limit (Hilt and Davidson 1960).

Correspondingly, the plasticity index, the mathematical difference of the liquid limit and the plastic limit that quantifies the plasticity of soils, is generally found to decrease with lime amendment (Herrin and Mitchell 1961; Bell 1988), making the soil more friable and therefore more workable.

High plastic soils generally contain clay minerals such as mont-
morrilonite, which has large affinity for water. Therefore, such soils undergo large swelling, leading to severe distress and damage to the overlying structures (Petry and Little 2002). Through physico- chemical modifications, lime can effectively control the swelling of soils (Mateos 1964; Bhasin et al. 1978). Correspondingly, the swell pressure and, hence, damage and distortion of the superstructure substantially decreased (Wilkinson et al. 2010).

Apart from modifying the plasticity and swelling characteristics,
lime can stabilize the soils through cementation, giving rise to vis- ible increases in strength and stiffness (Bell 1996; Rajasekaran and Rao 2000; Consoli et al. 2011). The cementation is primarily attrib- utable to pozzolanic reactions and can significantly improve the long-term performance of the stabilized soils (Rogers et al. 2006; Khattab et al. 2007). Several case studies highlighted the applica- tion of lime stabilization in improving the performance of problem- atic soils (Joshi et al. 1981; Petry and Little 2002; Wilkinson et al. 2010).

However, in some cases, lime is reported to produce adverse effects on the performance of soils. Increases in the liquid limit and plasticity index (Clare and Cruchley 1957; Prakash et al. 1989; Bell 1996) indicate that lime increased the plasticity of the soils that it treats. This result is suggested from the action of hydroxyl ions modifying the water affinity of the soil particles. Moreover, increase in lime content beyond a certain limit was found to decrease the strength gain (Hilt and Davidson 1960; Herrin and Mitchell 1961; Bell 1996; Kumar et al. 2007). Because lime itself has neither appreciable friction nor cohesion, excess of lime is postulated to reduce its strength. However, soil-lime stabi- lization is dependent on several factors such as soil type, its min- eralogy, lime content, and curing period, and is a complex problem that needs careful reevaluation.

Conclusions

Lime generally improves the engineering performance of soils. However, in some cases, lime has been reported to have an adverse effect. To develop an understanding of the possible mechanisms involved, a series of experiments through careful variation of differ- ent parameters were carried out, based on which the following conclusions are drawn.

The liquid limit of soils initially decreases with an increase in lime content. This result is attributed to a reduction in the thickness of the double layer attributable to increased electrolyte concentra- tion in the pore fluid. In the process, the charge concentration of the pore water increases. As a result, the viscosity of the pore water increases and it offers higher resistance against interparticle movement, leading to an increased plastic limit. However, beyond approximately 5% of lime content, the consistency limits no longer change, indicating that the workability of the soils cannot be im- proved further. However, for silica-rich soils at relatively higher content of lime and prolonged curing period, both the liquid limit and plastic limit have exhibited phenomenal increases and the soil turned to be increasingly plastic. This phenomenon occurred be- cause lime produces calcium silicate gel upon reacting with silica, and the gel is a viscous material that holds a large amount of water onto itself and therefore enhances soil plasticity.

Correspondingly, the swell potential of soils initially decreases with increased percentage of lime to a practically negligible value, beyond which it once again increases as lime content increases. The lime content at which swelling begins to increase is approximately 5% for fine-grained soils and approximately 9% for coarse-grained soils. With coarse particles, the intergranular voids are larger. Therefore, the cementatitious gel formed is initially contained within the void space and does not contribute to swelling. Only with a higher percentage of lime is the gel formed sufficiently large in quantity to fill the intergranular voids, then the external swelling begins. Hence, apart from plasticity characteristics, the grain size distribution also plays a significant role in the swelling behavior of the lime-treated soils.

The major cementitious compounds formed are gyrolite, calcium silicate hydrate, and calcium aluminum silicate hydroxide hydrate, which significantly improve the strength and stiffness of the soil. However, beyond certain limits, further addition of lime reduced improvement in strength, more prominently in case of silica-rich soils. This reduction in strength is attributed to the excess formation of silica gel, a highly porous material. The increased *d*-spacing of the compounds establishes the formation of such porous structure. As a result, the strength gain from cementation is substantially undermined. Therefore, in such soils, excessive lime treatment should be avoided.

References

ASTM. (2006a). "Standard test method for unconfined compressive strength of cohesive soil." *D2166* West Conshohocken, PA.

ASTM. (2006b). "Standard practice for classification of soils for engineer- ing purposes (Unified Soil Classification System)." *D2487*, West Conshohocken, PA.

ASTM. (2005). "Standard test method for liquid limit, plastic limit and plasticity index of soils." *D4318*, West Conshohocken, PA.

ASTM. (2007). "Standard test method for pH of soils." *D4972*, West Conshohocken, PA.

Barker, J. E., Rogers, C. D. F., and Boardman, D. I. (2006). "Physio- chemical changes in clay caused by ion migration from lime piles." *J. Mater. Civ. Eng.*, 18(2), 182-189.

Bell, F. G. (1988). "Stabilization and treatment of clay soils with lime, Part 1—Basic principles." *Ground Eng.*, 21(1), 10-15.

Bell, F. G. (1996). "Lime stabilization of clay minerals and soils." *Eng. Geol.*, 42(4), 223-237.

Bhasin, N. K., Dhawan, P. K., and Mehta, H. S. (1978). "Lime requirement in soil stabilization." *Bulletin No. 7*, Highway Research Board, Washington, DC, 15-26.

British Aggregates Construction Materials Industry. (1990). *Lime stabili- zation manual* London.

Clare, K. E., and Cruchley, A. E. (1957). "Laboratory experiments in the stabilization of clays with hydrated lime." *Geotechnique*, 7(2), 97-111. Consoli, N. C., Lopes, L. S. Jr., Prietto, P. D. M., Festugato, L., and Cruz, R. C. (2011). "Variables controlling stiffness and strength of lime- stabilized soils." *J. Geotech. Geoenviron. Eng.*, 137(6), 628-632.

Greaves, H. M. (1996). "An introduction to lime stabilization." *Proc. Symp. on Lime Stabilization*, Thomas Telford, London, 5-12.

Herrin, M., and Mitchell, H. (1961). "Lime-soil mixtures." *Bulletin No. 304*, Highway Research Board, Washington, DC, 99-138.

Hilt, G. H., and Davidson, D. T. (1960). "Lime fixation on clayey soils."

Bulletin No. 262, Highway Research Board, Washington, DC, 20-32. Jackson, M. L. (1958). *Soil chemical analysis*, Prentice-Hall International, London.

Joshi, R. C., Natt, G. S., and Wright, P. J. (1981). "Soil improvement by lime-flyash slurry injection." *Proc. 10th Int. Conf. on Soil Mechanics and Foundation Engineering*, AA Balkema, Stockholm, Rotterdam, 3, 707-712.

Khattab, S. A. A., Al-Mukhtar, M., and Fleureau, J. M. (2007). "Long-term stability characteristics of a lime-treated plastic soil." *J. Mater. Civ. Eng.*, 19(4), 358-366.

Kumar, A., Walia, B. S., and Abjaj, A. (2007). "Influence of fly ash, lime, and polyester fibers on compaction and strength properties of expansive soil." *J. Mater. Civ. Eng.*, 19(3), 242-248.

Mateos, M. (1964). "Soil-lime research at Iowa State Univ.." *J. Soil Mech. and Found. Div.*, 90(2), 127-153.

Materials data manual. (1999). *Jade*. Livermore, CA, Copyrights, 1995-1999.

Neville, A. M., and Brooks, J. J. (2004). *Concrete technology. 4th Indian reprint*, Pearson Education, Delhi.

Petry, T. M., and Little, D. N. (2002). "Review of stabilization of clays and expansive soils in pavements and lightly loaded structures—history, practice and future." *J. Mater. Civ. Eng.*, 14(6), 447-460.

Prakash, K., Sridharan, A., and Rao, S. M. (1989). "Lime addition and curing effects on the index and compaction characteristics of a mont- morillonitic soil." *Geotechnical Eng., AIT*, 20(1), 39-47.

Rajasekaran, G., and Rao, S. N. (2000). "Strength characteristics of lime-treated marine clay." *Proc. Inst. Civ. Eng. Ground Improv.*, 4(3), 127-136.

Rogers, C. D. F., Boardman, D. I., and Papadimitriou, G. (2006). "Stress path testing of realistically cured lime and lime/cement stabilized clay." *J. Mater. Civ. Eng.*, 18(2), 259-266.

Sivapullaiah, P. V., Sridharan, A., and Bhaskar Raju, K. V. (2000). "Role of amount and type of clay in the lime stabilization of soils." *Proc. Inst. Civ. Eng. Ground Improv.*, 4(1), 37-45.

Sridharan, A., and Gurtug, Y. (2004). "Swelling behaviour of compacted fine-grained soils." *Eng. Geol.*, 72(1-2), 9-18.

Taylor, A. W. (1959). "Physico-chemical properties of soils—Ion exchange phenomenon." *J. Soil Mech. Found. Div.*, 85(2), 19-30.

Wang, J. W. H., Mateos, M., and Davidson, D. T. (1963). "Comparative effects of hydraulic, calcitic and dolomitic limes and cement in soil stabilization." *Highway Research Record Bulletin No.59*, National Research Council, Washingthon, DC, 42-54.

Wilkinson, A., Haque, A., Kodikara, J., Adamson, J., and Christie, D. (2010). "Improvement of problematic soils by lime slurry pressure injection: case study." *J. Geotech. Geoenviron. Eng.*, 136(10), 1459-1468.