ISSN 2349-0292
Impact Factor (PIF): 2.365

Global Journal of Advance Engineering Technologies and Sciences

SWELLING BEHAVIOR OF EXPANSIVE SOIL USING GRANULAR PILE TECHNIQUE

Kundan Meshram* and P.K. Jain**
*Research Scholar, **Professor (CE) & Proctor
Department of Civil Engineering
Maulana Azad National Institute of Technology Bhopal-462051 (M.P.)

ABSTRACT

Granular Pile is one of the innovative technique, which is increase the load carrying capacity and decrease the swell-shrinkage properties of expansive soils. The installation of granular pile has been proved successful in improving soft marine clays, which are very poor strength and compressibility criteria. The technique of granular pile has applied in expansive soil too, to reduce its swelling behavior. Granular piles are the most natural and ecologically neutral foundation system in existence. Granular piles consist natural material like river sand, gravel, stone or stone chips with sand etc.

Keywords: Granualr pile, Expansive soil, Swelling, Clay Minerology

INTRODUCTION

Any soil which exhibit significant volume change when its moisture content is changed is termed as an expansive soil. If the moisture content increases the soil swells and likewise when the moisture content decreases the soil shrinks. Thus, in general, the term "expansive" is used to define any clay soil which contains clay minerals of the expanding lattice type. These are problematic to Engineering structures because of their tendency to heave during wet season and shrink during dry season (Mishra et al. 2007, Mokhtari and Dehghani 2012; Shukla et al 2014; Kumar, 2014). Light structures such as highways, railroads, runways, and other lifeline structures, constructed over expansive soils may be severely damaged due to high swell-shrinkage behaviour of these soils owing to fluctuating water content. The study of expansive soils in the field of soil mechanics and soil science have generated an ever increasing worldwide interest due to the fact that many new findings are still being discovered and new problems need to be understood. This universal interest arises from the fact that considerable geotechnical problems are associated with the occurrence of these soils.

In geotechnical engineering, clays are defined as those soils, which are composed predominantly of clay minerals. These clay minerals, which are nothing but hydrous alumina silicates, belong to a larger mineral family called phyllosilicates. There are different classes of clay minerals such as 2-layered clay minerals (ex: kaolinite mineral), 3-layer clay minerals (ex: montmorillonite mineral), 4-layer minerals (ex: chlorite mineral) and so on The unit cell of montmorillonite mineral consists of an alumina octahedral sheet sandwiched between two silicate sheets. The bonding between the adjacent unit cells of montmorillonite mineral is through very weak van der Waals' force which is more water absorbance capacity cause high swelling, swelling pressure and low strength (Shridharan 2014).

In India, expansive soils are popularly recognized as black cotton soils and are found extensively in Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamilnadu. The Indian black cotton soils have liquid limit values ranging from 40 to 100 percent, plastic limit ranging from 20 to 65 percent, shrinkage limit from 6 to 18 percent and differential free swell from 20 to 100 percent, CBR (soaked) from 1.2 to 4.0, optimum moisture content from 20 to 35 percent, proctor density from 13 to 16 kN/m^3 and the swelling pressure from 50 to 1000 kN/m^2 (Solanki, 2009). Many methods have been used to ground improvement/soil stabilization for improvement in engineering properties of such soil but their limited applicability.

So construction of granular pile in expansive soil have been new technique and given satisfactory results. It is improve strength and also reduce swelling-shrinkage of these soil.

CONCEPT OF GRANULAR PILE ANCHOR

The behavior of foundation anchored to Granular Pile Anchors (GPA) depends on the uplift capacity of the GPA. The granular pile-anchor foundation must be designed such that it resists the upward force in the foundation and does not fail in

ISSN 2349-0292
Impact Factor (PIF): 2.365

pullout. The resistance to upward force and safety against pullout depend upon the swelling pressure, the surface area of the GPA and the relative density of the granular pile material (Rao et al. 2007).
Fig. 1 shows the concept of a granular pile anchor GPA and the various forces acting on the foundation. The uplift force PUplift acting on the base of the foundation in the vertical direction is due to the swelling pressure Ps of the expansive soil. This uplift force is resisted by the weight of the granular pile W acting in the downward direction. The friction mobilized along the pile-soil interface also resists the upward movement of the foundation. This friction is generated mainly because of the anchor in the system. The upward resistance is further augmented by the lateral swelling pressure ksps, which confines the granular pile anchor radially, increases the friction along the pile-soil interface, and prevents
it from being uplifted.

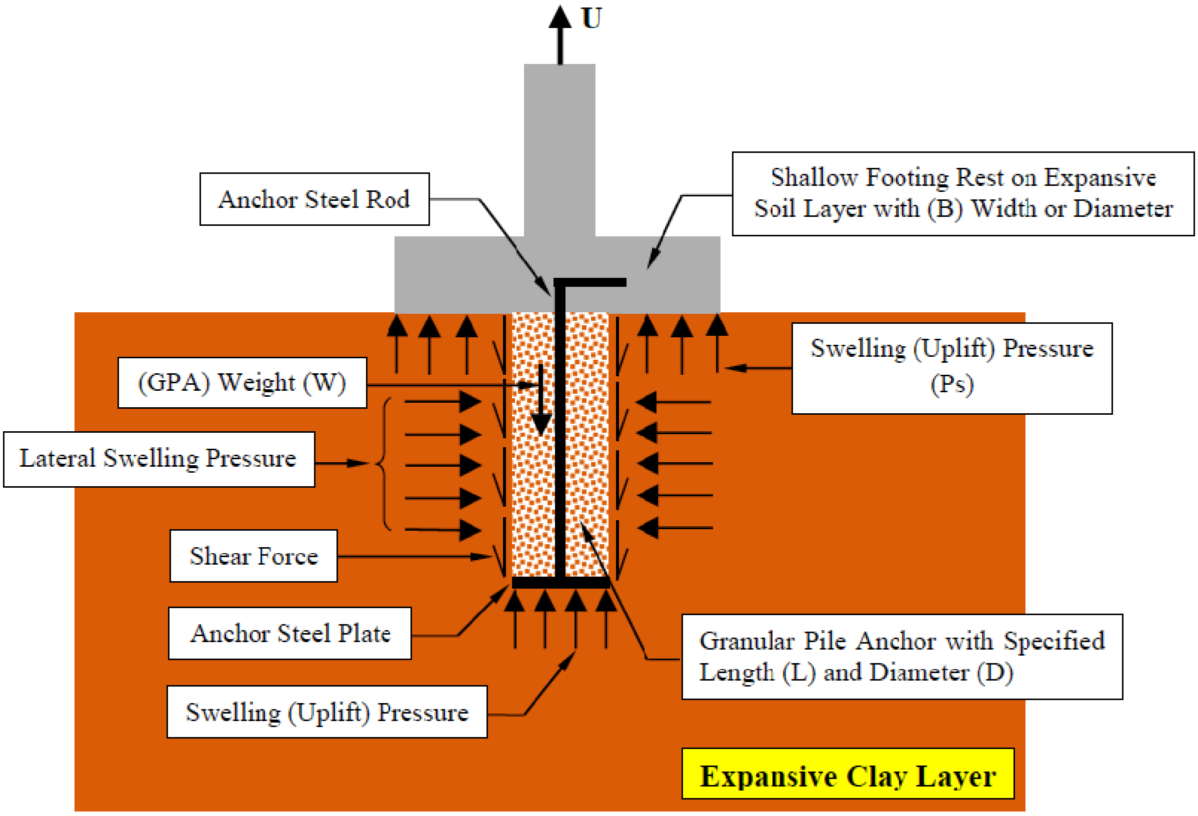

Fig. 1. Concept of granular pile anchor and forces acting on a granular pile anchor

APPLICATION OF GRANULAR PILE

Granular piles when installed in soft clays they improve the load carrying capacity, reduce settlement, swelling and swelling pressure . Granular pile have provided an economical method of support in compressible and fine-grained soils for low-rise buildings and structures such as liquid storage tanks, abutments, embankments, and factories that can tolerate some settlement (Kumar 2012).

LABORATORY WORK

Sharma and Phanikumar (2005) reported heave behavior of an expansive clay reinforced with geopiles, which are vertical cylindrical cells made of geogrid and filled with geomaterials. When a geopile is installed vertically in an expansive soil, heave is controlled because of the friction mobilized at the interface formed by the fill material, geogrid-expansive soil. The effects of diameter of the geopile and the type of the fill material on heave response have been investigated in this study. The results indicated that heave decreased with increasing diameter of the geopile and increase in the particle size of the fill material. Results are also presented from tests conducted on groups of geopiles using two and four geopiles together to investigate the influence of spacing on heave between the geopiles shown in Fig. 2. In the case of a group of geopiles, spacing between the geopiles was varied and its effect on heave studied. Heave decreased with closer spacing between the geopiles. No group effect of geopiles was observed when the spacing was more than four times the diameter of the geopile.

ISSN 2349-0292
Impact Factor (PIF): 2.365

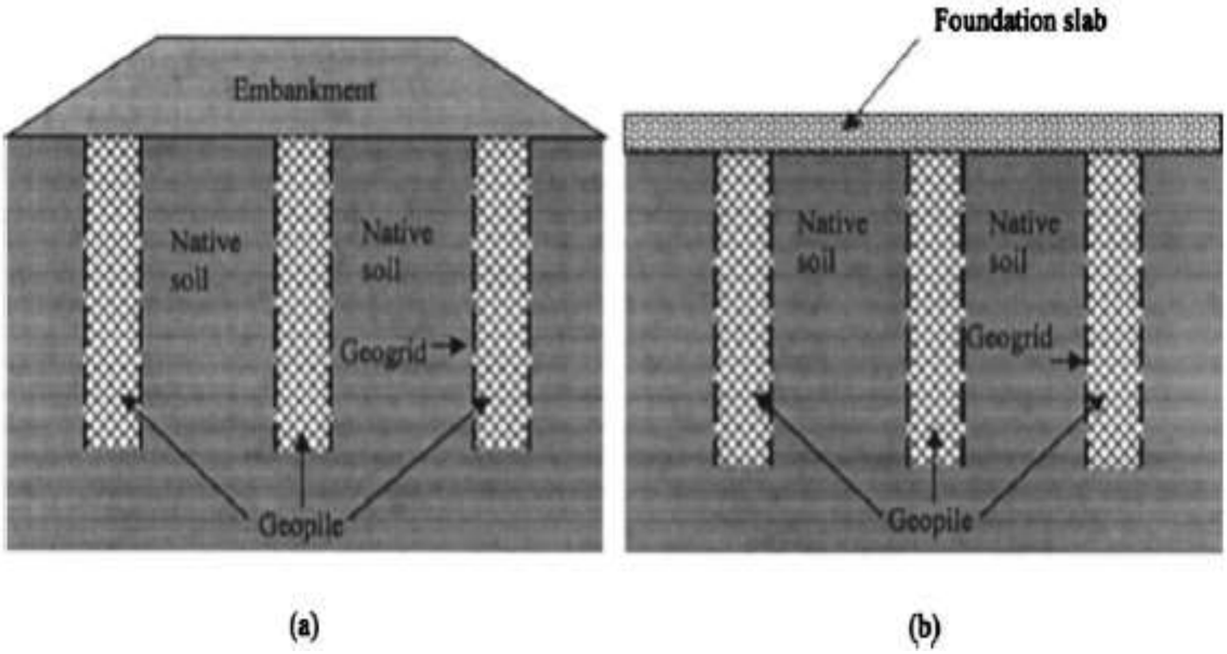

Fig.2 Illustrative use of geopiles for embankment and building foundations

Aljorany (2014) reported that laboratory tests have been conducted on an experimental model in which effects of different parameters, such as (GPA) length (L) and diameter (D), footing diameter (B), expansive clay layer thickness (H) and presence of non-expansive clay are studied. The results proved the efficiency of (GPA) in reducing the heave of expansive soil and showed that the heave can be reduced with increasing length and diameter of (GPA). The properties of expansive soil are shown in Table 1.

Table 1 Summary of physical, mechanical and chemical properties of expansive soil used

Test Name	Standard	Soil Property	Value
Specific Gravity	(ASTM D-854)	Specific Gravity (Gs)	2.73
Atterberg Limits	(ASTM D-4318)	Liquid Limit (L.L) %	59
		Plastic limit (P.L) %	23
		Plasticity Index (P.I) %	36
Grain Size Analysis Hydrometer	(ASTM D-422)	% Clay	51
		% Silt	42
		% Sand	7
		% Gravel	0
		Unified Soil Classification System (USCS)	CH
Standard Compaction	(ASTM D-1557)	Maximum Unit Weight (γ_{dry}), kN/m^3	16.3
		Optimum Moisture Content (O.M.C)%	21.5
		Initial Void Ratio (eo)	0.674
Unconfined Compression	(ASTM D-2216)	Unconfined Compressive Strength (q_u), kPa	165
Undrained Unconsolidated	(ASTM D-2850)	Undrained Cohesion (c_u), kPa	70

The heave of (GPA-Foundation System) is controlled by three independent variables these are (L/D) ratio, (L/H) ratio and (B/D) ratio. The heave can be reduced by up to (38 %) when (GPA) is embedded in expansive soil layer at (L/H=1) and reduced by about (90 %) when (GPA) is embedded in expansive soil and extended to nonexpansive clay (stable zone) at (L/H=2) at the same diameter of (GPA) and footing.

Field Investing

Zheng et al. (2009) were analysing that engineering problems with expansive soils in subgrades complicate highway construction in expansive soil areas of China. To research and solve the engineering problems, a Chinese research group carried out extensive research as part of the construction of a highway in Ningming Basin, a typical expansive soil area in China. The research on Ningming expansive soils is presented, including laboratory studies of soil properties, modified California bearing ratio tests for evaluating the bearing capacity, and wet compaction tests for obtaining the parameters to control field compaction when using expansive soils as embankment fill. The field investigations of slope failures also are introduced, including analysis of the investigations. New techniques for using expansive soils in embankments, and stabilizing cut slopes consisting of expansive soils, were developed and applied into the trial sections of the highway by the research group, based on their research and investigations. The measures proved successful and were used to solve the technical problems related to the NanYou Highway subgrade construction. The outcomes of the research also may prove useful in the construction of such projects as railway and hydraulic works.

Chen et al. (2012) A stretch of State Highway (SH) 6 in Texas has been experiencing poor ride quality problems caused by continuous pavement swelling and heaving. Because of this, the Texas Department of Transportation (TxDOT)Waco District annually spent hundreds of thousands of dollars to overlay the pavement to keep it smooth. This study is motivated to identify the root causes and solutions to the critical problem. During the forensic study, a systematic approach is employed, which includes nondestructive and destructive tests. On the basis of the overall test results, it is revealed that the problem was initiated within the lower portion of the pavement structure (i.e., subgrade) rather than in the upper pavement structure (i.e., asphalt concrete and flexible base). It was further found that the major factors contributing to the subgrade problem include (1) swelling soils, (2) water penetrating into the expansive clay soils, (3) high organics content in the soil, (4) loss of strength of the lime stabilized layer, and (5) high levels of sulfates in the soils. Performance surveys of various potential treatments for remediating the problem associated with swelling subgrade soil and increased moisture were conducted. These performance histories provide input and guidance for the selection of the pavement rehabilitation strategies. On the basis of the past performance histories, a variety of short-term and long-term strategies were recommended to the Waco District office for solving the problem.

Du et al. (1999) In this paper, the swelling–shrinkage properties of the compacted expansive soil in the Huaiyin Section of the Ning- Lian Highway are introduced, and swelling–shrinkage mechanisms are discussed based on changes in soil water content, dry density, material composition and fabric. The improvement of the compacted expansive soil by lime is also discussed briefly. It is concluded that careful attention should be paid to this type of compacted expansive soil.

CONCLUSION

The application of granular pile technique to improve the performance of foundation on expansive soil is relatively new area. The swelling and shrinkage aspect is equally important. swelling aspect of expansive soil reinforced with granular piles reduces swelling and swelling pressure. Therefore, to build confidence in applying the technique of granular pile in minimising the problems of foundation performance in such soils, the study would be useful.

REFERENCES

1. Aljorany, A. N., Ibrahim, S. F., Al-Adly A. I. (2014). "Heave Behavior of Granular Pile Anchor-Foundation System (GPA-Foundation System) in Expansive Soil", Journal of Engineering, Number 4, Volume 20, pp. 1-22.

2.Chen D. H., Scullion T., Hong F., and Lee J. (2012). "Pavement Swelling and Heaving at State Highway 6", J. Perform. Constr. Facil. 2012.26:335-344.

3.Du, Y., Li S., and Hayashi, S. (2009) "Swelling–shrinkage properties and soil improvement of compacted expansive soil, Ning-Liang Highway, China", Engineering Geology, 53 (1999) 351–358.

4.Kumar, R. (2014). “A Study On Soft Ground Improvement Using Fiber-Reinforced Granular Piles”, PhD thesis , Maulana National Institute of Technology Bhopal.

5.Rao, A.S., Phanikumar, B.R., Babu, R.D. and Suresh, K. ,(2007). "Pullout Behavior of Granular Pile Anchors in Expansive Clay Beds In-situ", Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. (133), No. (5): 531–538

6.Sridharan A. (2014). “Soil Clay Mineralogy and Physico-Chemical Mechanisms Governing the Fine-Grained Soil Behaviour”, Indian Geotechnical Journal, 44(4):371–399.

7. Shukla, Rajesh Prasad, Parihar, Niraj Singh, Tiwari ,Rajendra Prasad, and Agrawal, Bal Krishna (2014). "Black Cotton Soil Modification using Sea Salt", EJGE, Vol. 19, pp. 8807-8816.

8.Zheng , J. L., Zhang, R., and Yang, H.P. (2009). "Highway Subgrade Construction in Expansive Soil Areas", Journal Of Materials In Civil Engineering © ASCE , J. Mater. Civ. Eng. 2009.21:154-162.