The International Journal of Engineering And Science (IJES)
||Volume||2 ||Issue|| 3 ||Pages|| 111-115 ||2013||
ISSN: 2319 – 1813 ISBN: 2319 – 1805

A Field Study on Heave Reduction of Flooring Panels Resting on Expansive Soils Using Granular Anchor Piles and Cushions

[1,]Dr. P. Hari Krishna, [2,] Dr. V. Ramana Murty, [3,] J. Vakula,
[1,2,]Associate Professor in civil engg., National Institute of Technology, Warangal,
[3] Former PG Student, National Institute of Technology, Warangal

--Abstract--
The individual influence of cushions and granular anchor piles on heave control of structures resting on expansive soils was studied previously at NIT-Warangal by conducting field investigations. The present study is an attempt to understand the combined influence of these techniques in controlling the ground heave. For this, three flooring panels of 3 m x 3 m size were cast in the field with different treatment alternatives and their cyclic swell-shrink movements were monitored for four years. This study revealed that the heave is decreased by 26% and 92% for cushioned flooring panel and cushion-cum- anchored granular piled flooring panel respectively.

Key Words: *Expansive soil, Granular anchor pile, Cushions, Heave measurements, cyclic swell-shrink movements.*

Date Of Submission:25,Feb , 2013 Date Of Publication:15 March2013

I. INTRODUCTION

Expansive soils covered large tracts of land all over the world and undergo significant volumetric changes upon moisture fluctuations due to their peculiar mineralogical make-up [1,2 & 3]. Such volumetric changes threaten the stability of structures especially the lightly loaded ones resting on them [4,5,6, & 7]. Several investigators have attempted to understand the mechanisms of volumetric changes and devised several remedial techniques to combat the damages caused by them. However, most of the remedial methods are limited for their adoption in practice due to either technical difficulties or non-availability of suitable materials in adequate quantities such as for CNS layer or limited effectiveness [5 & 8]. Hence, efforts are still being made to search for the alternatives or modify the available techniques. CNS layer technique is being popularly used in India and in the recent years, investigations have been carried out to study the effectiveness of granular anchor piles to control heave of footings [9, 10, & 11] and their promising performance is reported [12, 13 & 14]. However, for area foundations or floorings, it is felt to combine the granular anchor piles along with CNS cushion so as to gain their combined influence to control ground heave /shrinkage. With this scope of investigation, 3 m x 3 m size of flooring panels were cast with different types of piles and pile – cushion systems in the field and their heave measurements were taken for four years under cyclic wetting and drying.

II. Experimental Programme

The present investigation was carried out at a site near the guest house of NIT-Warangal campus, where highly expansive clay bed is available upto a depth of about 2.4 m which is underlain by murrum stratum. The swell properties of clay are increasing with depth [15] and the properties are varying in the range of, Liquid limit = 70 - 110%, Plastic limit = 26 - 30%, Shrinkage limit = 15%; Clay content = 35 - 48%; Swell potential = 12 - 28 % and Swell pressure = 200 – 440 kPa. The moisture-density fluctuations at this site are limited to 1.5 m depth below G.L.

III. Materials Used

3.1 Granular pile material

The granular pile material used for the installation of the granular anchor piles and granular piles is a mixture of metal chips whose average particle size is 20 mm and coarse sand of size 2.4 – 4.75 mm in the ratio of 2,1.

Sand

Locally available Godavari sand is used for flooring panels.

3.2 Construction of model flooring panels

The following model flooring panels were constructed over the expansive clay bed.

a) **Flooring panel with CNS cushion**, In this case, the ground is leveled and a 0.5 m thick compacted CNS layer was placed. Over the compacted CNS layer, a 2.5 cm thick cement mortar is applied.

b) **Flooring panel with granular piles**, For this flooring panel, 9 boreholes of 200 mm diameter were made in the ground using an auger at 1 m center to center. Granular piles were formed by compacting granular material (2 parts of aggregate + 1 part of sand) in the boreholes with the help of the fabricated annular hammer of 20 kg weight falling from 0.60 m height. The granular pile material was compacted in lifts of 20 cm until the set per blow is negligible and for this, it was found that 35 blows were required for each lift. After the formation of granular piles, a 0.50 m thick compacted CNS cushion was placed and the flooring was laid of 2.5 cm thick cement mortar. The completed granular piles are shown in Fig.1.

c) **Flooring panel with granular anchor piles**, In this case, the construction of flooring panel is similar to the panel with granular piles except that the granular pile was provided with a central anchor having top and bottom pedestals.

d) **Flooring panel with granular piles and cushions,** In this case, the flooring panel was constructed over a group of piles and on the top of these piles 0.5 m thick CNS cushion was provided.

e) **Flooring panel without treatment**, In order to observe the relative performance of treated flooring panels, one flooring panel was constructed without any treatment. For this flooring panel, 100 mm thick murrum levelling course was compacted and plastered with 2.5 cm thick cement mortar. The constructed flooring panels were shown in Fig.2.

Fig. 1 Installed Granular piles below the flooring panel

Fig. 2. Flooring panels with treatment alternatives

IV. Discussion On Test Results

4.1 Heave measurements

The constructed flooring panels were cured for 10 days and flooded with water for 100 days by filling the shallow trenches made around the periphery of panels. The movements of flooring panels were measured with the help of an automatic levelling instrument to an accuracy of 1 mm by attaching the plastic scale to the leveling staff. After the maximum heave value is recorded, the panels were left for drying and the shrinkage movements were monitored. The seasonal movements of flooring panels were monitored for 4 years.

4.2 Influence of cushions on the heave of flooring panels

Fig. 3 shows the variation of heave with time for flooring panels provided with and without cushion. From this figure, it can be seen the heave of flooring panel is decreased by about 26% by the provision of CNS cushion when compared with the heave of flooring panel without any cushion. The time required for the maximum heave is decreased by about 25% for CNS cushioned flooring panel. This reduction in heave could be attributed to the gradual wetting and development of cohesive bonds that help to self-stabilize the clay bed against heave. The reduction in time for maximum heave of CNS cushioned flooring panel could be due to the decrease in the value of maximum heave.

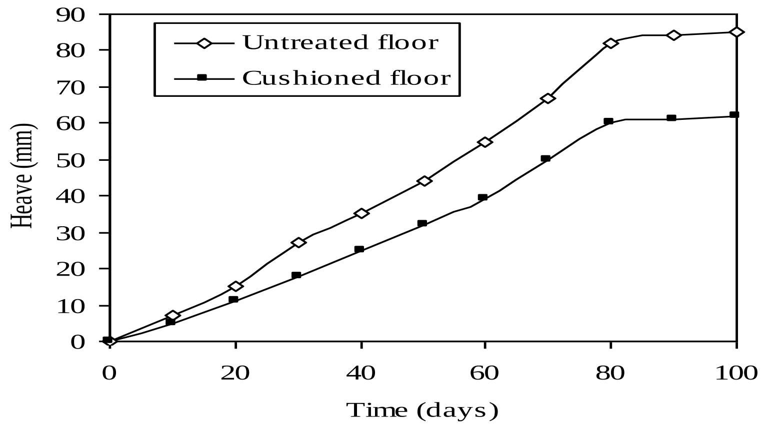

Fig 3 . Heave-time plots of flooring panels provided with and without cushion

4.3 Influence of granular piles on the heave of flooring panels

Fig. 4 shows the heave-time plots for flooring panels provided with and without granular piles. As can be observed from this figure, the efficacy of granular piles either anchored or not in the heave control of flooring panels is considerably higher when compared to the CNS cushion. The possible reason for heave control with granular piles could be due to a partial restraint to the initial movements that help to limit the overall ground heave. Similar mechanisms were explained by previous investigators also [15 & 16]. The reduction in heave is observed to be about 61% when the flooring panel is provided with granular piles whereas it is about 89% when the flooring is provided with granular anchor piles. This clearly indicates that the granular anchor piles are more effective than that of plain granular piles in controlling the heave of flooring panels resting on expansive soils which could be due to integrated action of the granular pile material.

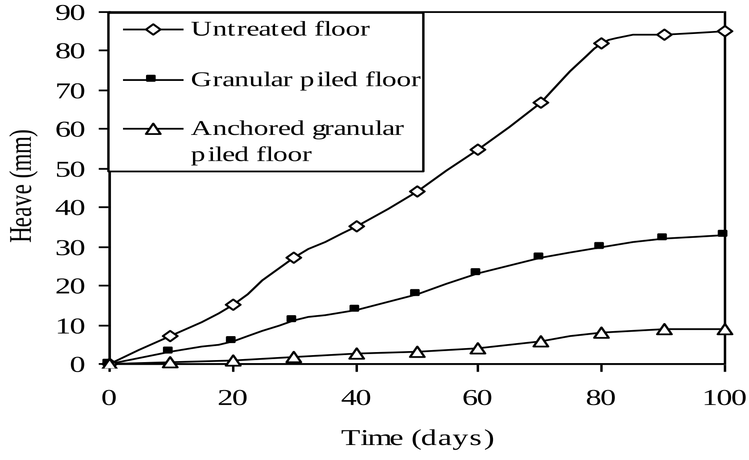

Fig. 4. . Heave-time plots of flooring panels provided with and without granular piles

V. Combined Influence Of Cushions And Granular Piles On The Heave Of Flooring Panels.

As can be seen from Fig. 5, the heave of flooring panels is further reduced when it was constructed over the CNS cushion and granular piled ground. The reduction in heave is observed to be about 68% when the flooring panel is provided with granular piles cum cushion whereas it is about 92% when the flooring is provided with granular anchor piles and cushion.

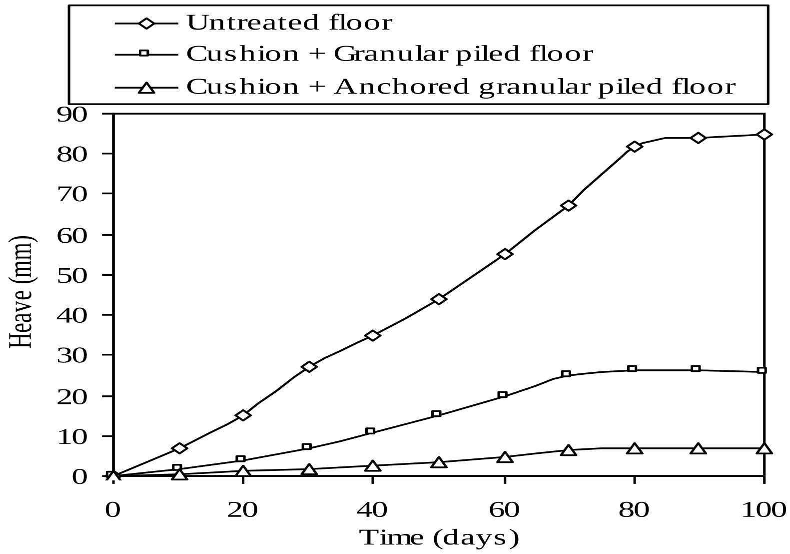

Fig. 5. Heave-time plots of flooring panels provided with and without granular piled cushions

VI. Cyclic Swell-Shrink Movements

The cyclic swell-shrink movements of flooring panels were measured for about 4 years to observe the long term performance of the flooring panels and presented in Fig. 6. From this figure, it can be observed that the seasonal movements are decreased by 63% and 88 % for granular piled and anchored granular piled flooring panels respectively whereas for cushioned panel, the reduction is about 26%. The reduction in heave could be attributed to the mechanism of self stabilization of clay bed due to the initial restraint to heave by piles or gradual wetting by the presence of CNS cushion.

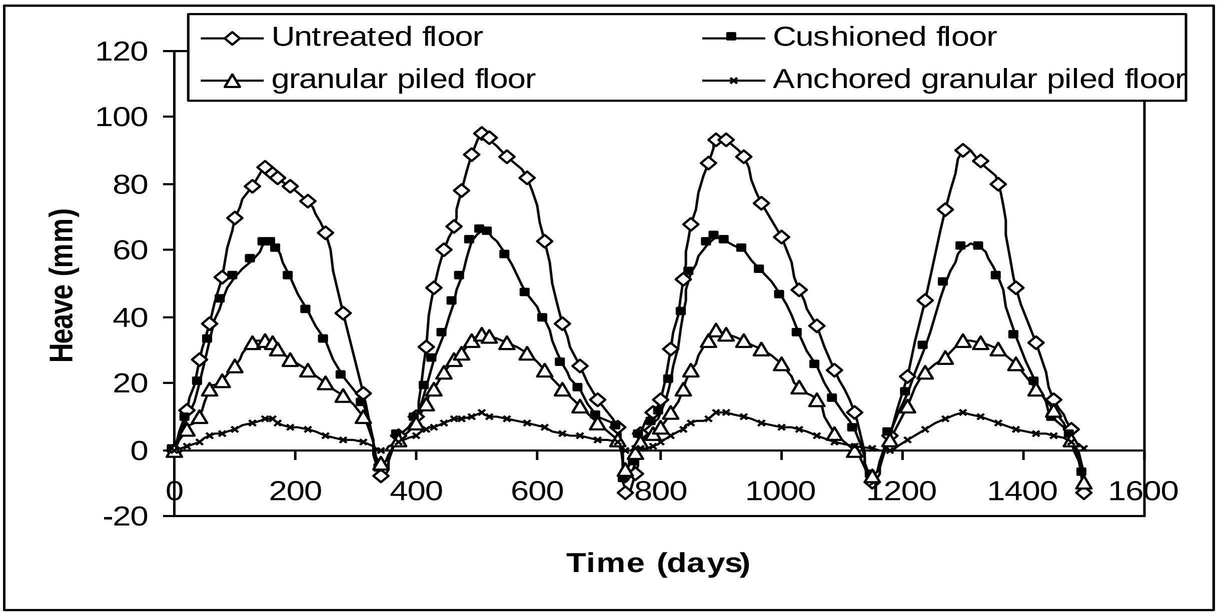

Fig. 6. Cyclic swell-shrink behaviour of flooring panels with treatment alternatives

VII. Conclusions

The following conclusions are drawn based on the in-situ studies made on the behaviour of flooring panels provided with cushions and granular piles.

[1] Use of 0.5 m thick CNS cushion over the expansive clay bed could control the heave of flooring panel by about 26%.
[2] The heave of flooring panel is reduced by about 61% when it is provided with granular piles whereas it decreased by about 89% when it is provided with granular anchor piles.
[3] The heave of flooring panels resting on expansive soils could be controlled to about 92% by combining the techniques of cushion and granular anchor piles.
[4] From the cyclic swell-shrink studies, it is observed that the combined influence of both cushions and granular piles provided below floorings is found to be effective in controlling the flooring movements.

REFERENCES

[1] Katti, R.K. (1979), Search for solutions to problems in black cotton soils, First IGS Annual Lecture, Indaia Geotechnical Journal, Vol.9, pp.1-80.
[2] Panigrahy, B.K., Babushanker, N. and Nataraj, P. (1994), Clay Mineralogy and Swelling Behaviour of Selected Expansive Soils Around Warangal, India, Proc. of IGC-94, Warangal, India, pp.53-56.
[3] Erdal Cokca (2001), Use of Class C Flyashes for the stabilisation of an Expansive Soil, Journal of Geotechnical and Geoenvironmental engineering, Vol, 127, No.7, ASCE, pp, 568-573.
[4] Chen, F.H. (1988), Foundations on Expansive Soils, Elsevier Pub. Co.
[5] Subba Rao, K.S. (1999), Swell-shrink behaviour of expansive soils – Geotechnical challenges, 22nd IGS Annual Lecture, Indian Geotechnical Journal, 30(1), 2000, pp, 1-68.
[6] Puppala, Anand J., Napat Inthara Sambat and Rajan K. Vempati (2005), Experimental studies on ettringite – induced heaving in soils, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol.131, No.3, pp.325-337.
[7] Aly Ahmed(2009), Assessment of Drying-Wetting Cycles for Mitigation of the Potential of Expansive soil in Upper Egypt, Journal of Applied Science Research, Vol.5, No.12, pp.2277-2284.
[8] Katti, R.K. and Katti, A.R. (1994), Behaviour of Saturated Expansive Soil and Control Methods, Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.
[9] Donaldson G.W. (1967), The Use of Small Diameter Piles in Expansive Soil, Proc. of 4th regional conference for Africa on Soil Mechanics and Foundation Engineering, Capetown, South Africa, pp, 249-251.
[10] Ali Elfatih, M. and Abbadi Seif Eldawla, A. (1987), Design of Short Tension Piles in Expansive Soils, A Probabilistic Approach, Proc. of 9th Regional Conference for Africa on
[11] Soil Mechanics and Foundation Engineering, Lagos, pp, 307-311.
[12] Osama K. Nusier and Ahmed Shlash Alawneh (2004), Micropile Technique to Control Upward Movement of Lightweight Structures over Expansive Soils, Journal of Geotechnical and Geological Engineering, No.22, pp, 89 – 104.
[13] Cooke, R. W. and Price, G. (1973), Strains and Displacements around Friction Piles, Proceedings of 8th ICSMFE, Vol.2, Moscow, pp.53-60.
[14] Alawneh A. S., Malkawi, A.I.H. and Al-Deeky, H. (1999), Tension Tests on Smooth and Rough Model Piles in Dry Sand, Canadian Geotechnical Journal, Vol.36, pp.746-753.
[15] Pradeep Kumar (2002), Granular Anchor Pile System Under Axial Pullout Loads, Ph.D. thesis, I.I.T.-Roorkee.
[16] Ramana Murthy, V. (1998), A study on Swell Pressure and Methods of Controlling Swell of Expansive Clays, Ph.D. thesis submitted to Kakatiya University, Warangal.
[17] Hari Krishna, P. (2006), A study on the use of granular anchor piles to control heave of footings resting on expansive soil, Ph.D. thesis submitted to Kakatiya University, Warangal.