INFLUENCE OF WETTING-DRYING CYCLES ON HEAVE BEHAVIOUR OF FIBER-REINFORCED EXPANSIVE SOIL SPECIMENS

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ABSTRACT: This paper is an experimental study on heave behaviour of fiber-reinforced remoulded expansive soil specimens subjected to wetting and drying cycles. Nylon fibers of length 15mm were used as random reinforcing inclusions in the samples. The diameter and thickness of the samples were kept constant at 100 mm and 33.33 mm (arbitrarily chosen). The samples were subjected to three cycles of wetting and drying for respective time periods of 10 days and 30 days. With increasing number of cycles of wetting and drying, swelling or heave decreased. The fibre content (f_c) was increased as 0%, 1% and 2%.

INTRODUCTION
Expansive soils are highly problematic by virtue of their innate capacity for undergoing volume changes corresponding to changes in moisture regime. They swell when they absorb water and shrink when water evaporates from them [1]. Because of this alternate swelling and shrinkage, lightly loaded civil engineering structures founded in these soils are severely distressed. It has been estimated that the cost of repair required is often more than the cost of original structures. In USA it is about 1000 million dollars and in the UK it is 100 million GBP per annum [2].

Many innovative foundation techniques have been devised to mitigate the problems posed by expansive soils. Some of them are physical alteration, chemical alteration, compaction control, pre-wetting, sand cushion [3], CNS layer technique [4], drilled piers and belled piers [1], underreamed piers [5] and granular pile anchors [6]. Of these techniques, granular pile-anchors (GPAs) are the latest and the most innovative technique. A GPA is a simple modification of the conventional granular pile. In the technique of a GPA, an anchor rod to which an anchor plate is attached at the bottom is incorporated in a granular pile, keeping the diameter of the anchor plate equal to that of the granular pile. Recent research showed that swell-shrink behaviour of expansive soils could be controlled through fibre reinforcement also [7, 8, 9, 10].

This paper is a work on fibre-reinforced remoulded expansive soil samples. Air dry expansive soil samples in remoulded state were compacted in unreinforced and fibre-reinforced conditions to study the heave behaviour.

EXPERIMENTAL INVESTIGATION
Heave tests were conducted on air dried remoulded expansive soil specimens. The tests were conducted on both unreinforced and fiber-reinforced soil samples. The samples were compacted in Proctor’s mould (dia = 100mm).The thickness of the samples was arbitrarily fixed at 33.33mm.

The soil used in the test programme was a highly expansive soil with a free swell index (FSI) of 250%. The soil, by virtue of its liquid limit and plasticity index, was classified as clay of high plasticity, having a symbol CH. The fibre used was nylon fibre having a high tensile strength. The diameter of the fibre was 1 mm. Fiber content (f_c) was varied as 0%, 1% and 2% by dry weight of the soil specimen. Length of the fibre was kept constant at 15mm, which meant that the aspect ratio (l/d) of the fiber was kept constant at 15. The number wetting-drying cycles (n) was varied as 1, 2 and 3. All the specimens were compacted at a dry unit weight of 13 kN/m³ and a water content of 0% (oven dry condition).

The samples, in both fibre- reinforced and unreinforced conditions, were inundated with water and heave was continuously monitored with dial gauges. After equilibrium heave was reached, the samples were allowed to dry and undergo shrinkage. After the samples have reached equilibrium shrinkage, they were once again inundated to heave. Thus, three cycles of wetting and drying were performed on unreinforced as well as fibre-reinforced samples.

RESULTS AND DISCUSSION
Figure 1 shows the rate of heave of unreinforced specimen for three cycles of wetting and drying. The data show, by comparison, the change of heave with time for the first, the second and the third cycles. Heave increased continuously with time during the 1st cycle. It can be observed from the figure that the samples showed increasing heave even after three days. However, when the samples were subjected to 2nd and 3rd cycles of wetting and drying, heave decreased significantly. Further, heave got stabilized in a lesser amount of time. While the first cycle showed an increase in heave up to the end of 3 days, the 2nd and 3rd cycles
showed that increase in heave stopped even before \( t = 10 \) minutes. For example, the amount of heave of unreinforced specimens in the 1\(^{st}\), 2\(^{nd}\) and the 3\(^{rd}\) cycles was respectively 23.4 mm, 9.05 mm and 3.65 mm (see Figure 4.1). The maximum amount of heave was reached in a lesser time with increasing number of wetting-drying cycles.

**Fig. 1** Variation of heave with number of cycles for unreinforced sample

The data shown in the figures indicate that heave reduced considerably when the samples were reinforced with fibre.

**Fig. 2** Variation of heave with number of cycles for fiber-reinforced sample (\( f_c = 1\% \); \( l = 15\text{mm} \))

Figure 2 shows the rate of heave for fiber-reinforced specimens (\( f_c = 1\% \); \( l = 15\text{mm} \)) subjected to wetting and drying cycles. Similar patterns were obtained for other fiber contents also. Final heave of fiber-reinforced specimens decreased compared to that of unreinforced specimens. Moreover, heave decreased further with increasing number of cycles. Upon reinforcing the specimens with fibre, heave got reduced to 23 mm, 7 mm and 3.25 mm respectively.

**Fig 3. Rate of heave for varying \( f_c \) (1\(^{st}\) cycle)**

Figure 3 shows the rate of heave fiber-reinforced specimens for varying fiber content (\( f_c \)) for the first cycle. Similar patterns were observed for other fiber contents and other cycles also. The data shown in the figures indicate that heave decreased considerably when the samples were reinforced with increasing fibre content. Further, heave decreased with increasing number of wetting-drying cycles.

**Fig 4. Variation of heave with number of cycles for \( f_c = 0\%, 1\% \) and 2\%**

For all the number of cycles, the heave of unreinforced specimen was more than that of the fiber-reinforced specimens. In both fiber-reinforced and unreinforced specimens, the amount of heave decreased significantly with increasing number of cycles. But as number of cycles increased, the difference between heave of unreinforced and fiber-reinforced samples decreased.
CONCLUSIONS
Amount of heave decreased with increase in the number of cycles for both fibre-reinforced and unreinforced samples. The introduction of fibres into the specimen reduced the swelling in comparison to unreinforced sample. As the number of wetting-drying cycles increased, heave decreased in both fiber-reinforced and unreinforced specimens owing to fatigue.

REFERENCES