Study on the performance of plastic drain board after soft foundation reinforcement by vacuum preloading method

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Abstract. Plastic drainage board has played an important role in transferring vacuum pressure, as a drainage channel for groundwater and preventing the loss of soil in the process of soft foundation reinforcement by vacuum preloading method. This experimental study shows that the plastic drainage board bear obvious bending deformation during the vacuum preloading process. Both filter fabric and core drain are attached with soil and clogged. When the plastic drain board was taken out on site, most deformation was obviously lost due to stress relief. Compared with the unused board, the masses of on-site used plastic drain board and filter fabric increased significantly, the water flux and vertical permeability coefficient of filter fabric were significantly reduced, but their tensile strengths changed little.

1. Introduction
The appearance of plastic drain board is very important for soft foundation reinforcement. The plastic drainage board combined with vacuum preloading soft foundation reinforcement method greatly improves the efficiency of foundation reinforcement[1]. As the negative pressure transmission channel and drainage channel of vacuum preloading reinforcement method, plastic drainage plate has a direct impact on the efficiency and effect of soft foundation reinforcement[2]. Therefore, the research of plastic drainage board is very important.

In the process of soft foundation reinforcement, plastic drainage board is transformed and clogged. Studies have shown that these changes will reduce the drainage efficiency of plastic drainage board and affect the reinforcement effect[3-5]. Through experiments, F. H. Ali[6] thought that the deformation of plastic drainage board had a significant impact on the water permeability. Y. Jeong and S. Lee[7] believed that the discharge capacity of plastic drainage board decreases linearly with the increase of bending times, and found that from 0 to 3 bends, the water flow decreases by 48%. J. C. Chai et al.[8-9] found that the drainage performance of plastic drainage board decreased significantly with time due to clogging.

2. Working principle of plastic drainage board in soft foundation reinforcement
When vacuuming, negative pressure is formed in sand cushion and vertical drainage channel, and pressure difference is formed between soil and drainage channel. Under the action of this pressure...
difference, the water in the soil is continuously discharged by the drainage channel, and the soil consolidate under the negative hydrostatic pressure. The role of plastic drainage board in this process is to transfer vacuum pressure, discharge channel and prevent soil particle loss.

The plastic drain board is inserted vertically into the foundation. In the process of reinforcement, the soft foundation has a large vertical settlement. Due to the side friction between plastic drainage board and surrounding soil, the deformation of plastic drainage board is coordinated with the deformation of the soil to produce bending deformation. The final plastic drainage board is shown in Figure 1.

![Figure 1. On-site used plastic drain board](image1)

Microscopically, under the action of negative pressure, water seepage from the foundation enters the filter fabric of the plastic drainage board and is discharged along the groove of the core plate. Soil particles are concentrated around the filter fabric. The soil particles which are larger than the opening size of filter fabric are blocked outside the filter fabric. Because of molecular thermal motion, inertial effect, diffusion, entrapment, cohesion function and electrostatic, soil particles which are smaller than the opening size of filter fabric are partially adhered to the fabric surface, partially embedded in the pores of the filter fabric, and partially entered the filter fabric. Soil particles entering the filter membrane are either discharged with water or deposited on the core plate. Clogging of filter fabric and core plate is shown in Figure 2.

![Figure 2. Clogged filter fabric and core plate](image2)

### 3. Sampling
After pressure relief, removed the plastic drain board from the foundation. Sampling was very difficult. The section was excavated with an excavator and then the samples were gouged out manually. The
sampling depth was 3.5m below the surface. As shown in Figure 3, Plastic drainage board had very obvious folds and bends, which were basically perpendicular to the plastic drainage board longitudinal.

Figure 3. On-site used plastic drain board sampling

4. Test and result analysis

4.1 Test

After plastic drainage board were taken out of the foundation, the stress was relaxed, the fold was stretched, and the shape in the foundation was obviously changed. As shown in Figure 4, the folding deformation had been basically relaxed, but the creases were still clear.

The quality test, tensile test, water permeability test and water flux test were carried out on the plastic drainage board samples, and the particle analysis test was carried out on the soil particles in the core plate.

Figure 4. Stress relaxed on-site used plastic drain board

4.2 Performance of plastic drain board after the soft soil reinforcement

The test results of plastic drainage board after reinforcement and its initial value are shown in Table 1.

Table 1. Test results of plastic drain board

| type    | width | thick | unit length mass | tensile strength (dry, when E.L is 10%) | E.L | vertical water (side pressure 350kPa) |
|---------|-------|-------|------------------|----------------------------------------|-----|-------------------------------------|
| narrow  | initial | 50 | 4.6 | 58 | 3.3 | 11 | 53 |
4.2.1 Physical properties

The width and thickness of plastic drain board did not change significantly. This indicates that the deformation of core plate is small and the tooth lodging and groove folding are not obvious. The unit length mass increased obviously, and the test results were very discrete. This is because many soil particles are blocked up on the filter fabric and core plate of the on-site used plastic drainage board, as shown in Figure 2.

The particle size distribution instrument was used to analyze the soil particles deposited on the core plate. The test results are shown in Table 2. The soil particles deposited on the core plate are less than 0.075mm, which are mainly silt and clay, and the effective aperture of fabric O₉₅ is less than 0.075mm, which mean that only soil particles less than the effective aperture of filter fabric can penetrate the filter fabric.

| Grain composition of soil on the core plate (%) | 0.25-0.075 | 0.075-0.05 | 0.05-0.01 | 0.01-0.005 | <0.005 | <0.002 |
|-----------------------------------------------|------------|------------|-----------|------------|--------|--------|
| mm                                            | mm         | mm         | mm        | mm         | mm     |
| 0                                             | 1.2        | 31.0       | 32.1      | 35.7       | 11.6   |

4.2.2 Tensile properties of the complex

The tensile properties of the composite of plastic drain boards showed no obvious variation, which are mainly determined by the core plate. It is shown that the tensile strength of the core plate of the plastic drainage board in this project had not been significantly reduced.

4.2.3 Drainage performance

During the water flux test, the soil deposited in the core plate flowed out with the current, and the water discharged was turbid, as shown in Figure 5. The stability time of plastic drainage board water flux test increased after reinforcement, and the dispersion of test results was large. The initial water flux of the plastic drainage board after reinforcement was obviously less than that of the new plate, and the stable water flux was also less than that of the new plate. The drainage performance of plastic drainage board was obviously decreased during the process of soft foundation strengthening. Due to the stress relaxation of plastic drainage board, deformation has a great degree of recovery, actual water flow will be smaller.
4.3 Performance of filter fabric

4.3.1 Physical properties

The test results are shown in Table 3. In the process of particles passing through the filter, some particles remain in the pore of the filter, as shown in Figure 6, which resulted in the increase of thickness and mass per unit area.

| type       | thick | mass per unit area | soil retention per unit area | vertical permeability coefficient |
|------------|-------|--------------------|-----------------------------|----------------------------------|
| narrow     | 0.35  | 84                 | -                           | -                                |
| on-site    | 0.37  | 134                | 50                          | -                                |
| used       |       |                    |                             |                                  |
| ordinary   | 0.67  | 100                | -                           | 0.106                            |
| on-site    | 0.73  | 167                | 67                          | 0.010                            |
| used       |       |                    |                             |                                  |

Figure 6. The on-site used filter fabric

4.3.2 Permeability

The permeability of filter fabric has an important effect on the drainage performance of plastic drainage board.

The test results are shown in Table 3. The permeability coefficient of filter fabric decreased obviously, because there were soil particles in the pores of filter fabric fiber, which clog part of the permeability path. Before the infiltration test, the soil particles adhered on both sides of the filter fabric samples were cleaned. While the plastic drainage plate on-site is affected by the soil particles adhered on the surface of the filter fabric and the soil particles adhered on the outside, its permeability coefficient will be smaller.

4.4 Performance of core plate

As shown in Figure 7, a lot of soil particles are adhered to the core of the plastic drain board after the work, and the groove part of the core board is filled with the deposited soil mass. When the flow velocity of the permeated water in the plastic drainage board is small, it is difficult to carry all the soil particles, thereby causing the deposition of soil particles in the core plate. In addition, a part of the longitudinal rib of the core plate is slightly inclined, and there is a slight longitudinal crease on the groove, which also causes a decrease in the water passing performance of the plastic drainage board after the work.
5. Conclusion and advice
When vacuum preloading is strengthened, the performance of plastic drainage board changes, and these changes will have an impact on the strengthening effect. The study found that the mechanical properties of plastic drainage board changes little after reinforcement. Due to the folding and bending deformation of plastic drainage board, and the retention of a large number of soil particles on the filter fabric and the core plate, the physical properties and hydraulic properties change greatly, the unit area (length) quality is significantly increased, the vertical water of the complex and the vertical permeability coefficient of the filter fabric are significantly reduced.

Since the stress relaxation after the removal of the plastic drainage board after the work, the bending deformation of the fold was largely restored, and the influence of the soil particles adhered on both sides of the filter on the permeability, drainage performance and vacuum suction transmission, was ignored. The actual performance of the board in the soft base was somewhat different. It is recommended to consider the above factors in future research.

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