Experimental Study on Glass Sand Well

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Abstract. Aiming at the disposal of waste glass, our paper proposes a method of filling sand wells with glass sand formed by mixing waste glass and sand as a backfill material. In this paper, the basic properties of glass sand are studied by penetration test, consolidation test and consolidation bearing capacity test. The results show that the permeability of mixture is better than that of common sand well when glass particles are incorporated into sand. When bearing the same bearing capacity, the average bearing capacity of common sand well is smaller than sand well, and the bearing capacity of the soil in the upper part of the model box is greater than the bearing capacity of the lower soil. The sedimentation of clay with sand well is higher than that of common clay. Glass sand well can accelerate the consolidation of soil in soft soil foundation by utilizing the good permeability of glass and sand.

1. Introduction

What is believed to be one of the current disposal methods in real construction material when using waste glass as a building engineering material. The glass sand refers to a mixture of discarded and recyclable glass with sand at a certain mass percentage. Glass sand well means that glass sand soil is used as backfill material to fill the sand well, so that the soft soil foundation can be strengthened. The principle of drainage consolidation method of glass sand well is to carry out stacking load on the upper part of soft clay, forming the stacking system of drainage consolidation method. The drainage water body of glass sand well is installed on the lower part to shorten the drainage distance and increase the drainage path. The pore water of soft soil is discharged gradually, the pore volume of soil decreases, and the consolidation settlement of foundation soil occurs.

At present, many scholars have studied the sand wells consolidation theory [1], in which Chen et al. had deduced the consolidation governing equation based on the assumption of equal strain and taking into account the radial variation of horizontal permeability coefficient, and obtained the general solution [2-5].

In this paper, the basic properties of glass sand and the effect of glass sand well on soil consolidation are determined from two aspects. On the one hand, the basic properties of glass sand mixtures are determined by permeability tests; on the other hand, drainage consolidation tests are used to simulate the consolidation process of soft clay, and the consolidation test of glass sand well model box is used to determine the influence of glass sand well on soil consolidation.
2. Experimental Program

2.1. Materials and Specimens
According to the "Rules of Geotechnical Testing" [6], the sand in this test is natural sand with a content of less than 3%. The glass is discarded leftover material of shenyang yaohua glass factory, with particle diameter ranging from 5 to 25mm. The soft clay used in this test is Shenyang deep foundation pit. It is then laid out in a plastic basin, and water is mixed with clay in a certain proportion and configured into saturated soft clay. Finally, the saturated soft clay was allowed to stand for 24 hours, and the moisture content of the saturated soft clay was determined by the alcohol combustion method. At least 3 different positions were measured, and the difference of moisture content between these three positions was ensured to be less than±1%.

2.2. Test Methods
Three experiments were carried out in this study. The experimental steps are as follows:

1) Consolidation Test. In order to study the consolidation effect of glass sand well on soft soil foundation, four groups of tests were carried out, as shown in Figure 1: model box A is soft clay; model box B is a sand well with 50% glass; model box C is a sand well with 100% glass; Common sand well in model box D. Model boxes B, C and D were used to compare the effect of the content of glass in the sand well material on the degree of soil consolidation. Model box A is a comparison specimen used to compare the effect of sand Wells on the degree of consolidation of soft clay. In this test, sand wells are packed with bags, which are made of geotextiles with good water resistance and permeability to simulate woven bags in engineering practice. The model box is surrounded by coordinate paper, which is used to measure the surface settlement of soft soil. In this test, the stacking device is 20×10×4mm cuboid iron block, and each cuboid iron block is 10kg, the lower part of the iron block is cylindrical iron block. The thickness of the iron block is 1cm and the diameter is 39.8cm, slightly smaller than the model box. This test is divided into two stages of loading, each loading for 6 pieces of iron. During the loading process, the settlement of the soil mass in the model box was measured and read in real time. Two data are measured in the morning and evening of this test.

2) Penetration Test. This experiment mainly studies the permeability of glass sand soil with different glass content. In the test, sand and glass were screened into five groups with particle sizes of 0.15~0.3mm, 0.3~0.6mm, 0.6~1.18mm, 1.18~2.36mm, and 2.36~4.75mm, respectively. The particles of each size group were compacted to different porosity to simulate the compactness of sand and glass under different loads. The diameter of the glass and sand particles used in this test is less than 5 mm. The mass substitution in the test is that the glass particles of the same group replace the sand particles of the same group, and the glass substitution rate is 0%~100%. In this test, tst-70 constant head permeameter was used to measure the permeability of sand and glass.

3) Bearing Capacity Test. In this experiment, ps-mpt-a miniature penetrometer was used to measure the load carrying force of the soil after consolidation test. When collecting soil data, 8 data points were collected from each model box and 3 times were collected from each data point. Data collection is taken from 1/4 and 1/2 of the model box, and the distribution of collection points is shown in Figure 1(c).
3. Analysis of test results

3.1. Penetration test results analysis

According to the variation diagram of the permeability coefficient of glass and sand in each particle size interval drawn in the semi-logarithmic coordinate system as shown in Figure 2(a), it can be found that the variation trend of the permeability coefficient curve of glass and sand in the five particle size intervals is similar with differences. It can be seen from the figure that the permeability coefficient of glass and sand within the same single particle size range increases with the increase of porosity, but the change rate is not significant, no more than an order of magnitude. It can be seen from the figure that the curve representing the permeability coefficient of glass is always higher than that of sand, which means that the permeability coefficient of glass is greater than that of sand under the same porosity. In the interval with small particle size, the permeability coefficient of glass and sand is small, and the permeability coefficient of soil samples with different particle size levels will differ by several orders of magnitude. There is a difference of several orders of magnitude between the smaller size range and the larger size range.
As can be shown in Figure 2(b), the permeability coefficient of sand increases with the increase of porosity. When the porosity is constant, the permeability of sand mixed with glass particles is greater than that of sand without glass particles. Since the shape and surface state of glass particles can improve the permeability coefficient, the permeability coefficient of glass is greater than that of sand when the porosity is the same.

3.2. Consolidation test results analysis

Figure 3 shows that the maximum settlement in the consolidation settlement curve of soils with 50% glass mass incorporation and 100% glass mass incorporation was 13.63mm and 14.62mm respectively, indicating that the increase of glass incorporation can promote the consolidation of soft clay. This is mainly because the increase of the glass content in the sand well leads to the increase of the porosity ratio of the glass-sand mixture. Under the condition of the same stowage and the circulation path of pore water, the increase of the glass content is more conducive to the discharge of pore water. Set common sand wells of soil settlement at the same time a small glass quality soil mixed with the percentage of 100%, that of compressibility of soil set glass sand wells is greater than common sand drain consolidation test, this is mainly because of permeability coefficient of soil set glass sand wells in doped glass quality percentage was 100%, higher than the set of ordinary sand soil, so the model box D degree of consolidation of the soft clay in no model box C in the soil is high. The permeability coefficient of the soil with 50% glass content is not different from that of the soil with common sand wells, so the soil in model box B is similar to the settlement of soft clay in model box D.
3.3. Test results analysis of bearing capacity of consolidated soil

Table 1 shows that in four plane model in various soil bearing capacity of the trend of: a model of sand drain box of soil bearing capacity greater than the model of sand drain tank, glass quality of bearing capacity of soil mixed with the percentage of 50% is below the set of ordinary soil, sand drain soil bearing capacity of doped glass quality percentage is 100% greater than the set of ordinary sand soil of wells. Considering the bearing capacity of the same layer, the bearing capacity of the soil body with ordinary sand wells is \(5 \times 10^2\) kPa larger than that with common sand wells, indicating that the bearing capacity increases obviously. Since the glass sand well is composed of a mixture of glass and sand soil in the model box of the glass sand well, the pores between the particles are more conducive to the flow of pore water when the percentage of glass content is 50% and 100%.

As shown in Table 2, it can be seen from the data of soil bearing capacity test that the soil bearing capacity in the model box increases gradually with the increase of glass content. Glass doped volume percentage of 100% after the consolidation of soft clay, the average soil bearing capacity set higher than that of ordinary sand wells of the bearing capacity of soft clay around 10 kPa, but adding amount of 50% of the bearing capacity of soft clay is lower than set the soft clay of ordinary sand wells, mainly because in the process of the consolidation of soft clay, soil in the heap load under the action of pressure difference, high degree of consolidation of soft clay its bearing capacity is superior to the low degree of consolidation of soft clay.

| Box | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----|---|---|---|---|---|---|---|---|
| A   | 1.06 | 0.96 | 1.03 | 1.05 | 1 | 0.98 | 1.05 | 1 |
| B   | 1.4 | 1.5 | 1.63 | 1.59 | 1.52 | 1.41 | 1.48 | 1.57 |
| C   | 1.79 | 1.75 | 1.67 | 1.77 | 1.72 | 1.74 | 1.73 | 1.77 |
| D   | 1.59 | 1.575 | 1.60 | 1.72 | 1.56 | 1.61 | 1.62 | 1.68 |

Table 2. Bearing capacity of four model box.

| Model Box | Soil Layer | Glass 50% | Glass 100% | Common sand well | Soft clay |
|-----------|------------|------------|-------------|------------------|-----------|
| 1         | 1.52917    | 1.74667    | 1.6325      | 1.00667          |
| 2         | 1.49583    | 1.7325     | 1.63417     | 0.985            |
4. Conclusion

Through experiments, this paper comes to the following conclusions:

(1) The permeability coefficient of glass and sand in the same single particle size range increases with the increase of porosity, but the change rate is not significant, which does not exceed an order of magnitude; the permeability coefficient of glass is always higher than that of sand.

(2) Under the same external load, the settlement of the model box with sand wells is larger than that of common clay. In addition, the settlement of soil with 100% glass content is the fastest.

(3) For the same plane bearing capacity, the average bearing capacity of the soil with ordinary sand wells is less than that of the soil with 100% glass content, and the bearing capacity of the upper part of the model box is greater than that of the lower part.

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