# The Study of the Yellow River Alluvial Silt Engineering Properties

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## Abstract

**The silt belongs to the engineering properties of bad soil, roadbed with difficult compaction, there are a lot of diseases. Besides, the Yellow River alluvial plain silt is special, its particle size distribution and structure with unique characteristics. Therefore, It is very necessary to study some engineering characteristics of silt by using indoor soil test. For the Yellow River alluvial plain area of subgrade construction and the pile foundation engineering construction to provide theoretical support.**

## Keywords

**Yellow-River alluvial silt; Engineering properties; Soil test.**

## 1. Introduction

Silt as being between sand and clay soil, the particle size distribution of fine sand（0.1-0.075mm）and the silt sand（0.075-0.005mm）occupies the overwhelming majority. Interaction of soil particles and soil moisture's nature is easily to be liquefied which is close to the nature of sand; and the nature is easily collapsible and frost which is close to the nature of clay [1]. Silt soil is loose, the shearing strength is low, soil bearing capacity is small, water permeability is strong,the water retention property is poor, and compaction is difficult.

Soil in our country is widely distributed, including Henan, Shandong, Shanxi, Zhejiang, Beijing and other provinces have a large area of silt [2]. Such as Shandong province, the Yellow River alluvial silt all over Heze, Jining, Dezhou, Binzhou, Jinan, Zibo, Weifang and other regions, the cover area amounts to 52100 square kilometers, accounts for about 34% of the area of Shandong province [3]. The Yellow River alluvial silt is a kind of special soil in our country. This kind of soil is layered on the structure of soil layer, and there are some clay layers in some area; On the particle size distribution, the distribution of soil particles is even, poor gradation, powder generally over 80%, mostly concentrated in 0.074mm-0.002mm, clay content is extremely low, which content is less than 10%; At the same time the silt has high porosity and compressibility; And when the underground water level is higher, the foundation settlement is bigger; On the particle structure, particle size is uniform as well as grain roundness is higher; Capillary is developed, capillary effect is violent. The above properties of alluvial silt in the Yellow River have determined the following engineering characteristics: Firstly, it is difficult to compaction； Secondly, the combination of material stability is difficult; Thirdly , the consolidation settlement of foundation is larger; Fourth, the pavement structure stress is disadvantageous;Fifth,it is easy to liquefied. This paper will be based on the basic physical properties of silt such as particle size distribution, liquid plastic limit,the compaction function, etc .With these as a starting point to learn more about characteristics of silt, So as to lay a foundation for solving the problem of subgrade and pile foundation.

## 2. Laboratory soil test

Test silt to take the Heze County in Dongming City, Shandong Province in the construction of the the Yellow River highway bridge mileage pile number for the k55+524.93, soil samples for the disturbance of soil samples. Soil particle size analysis test, boundary water content test and compaction test are carried out using the test equipment of the geotechnical Laboratory of Southwest University of Science and Technology.

### 2.1 Particle analysis test

First of all, carried on the pellet size analytical investigation to the soil sample. The main methods are sieve analysis, gravity method, suction tube method and combined determination method. Because of the silt particle size is less than 0.1mm, so the choice of the method is gravity method. The testing process is carried out in accordance with the provisions of the geotechnical test method standard (GB/T50123-1999), test results are shown in table 1.

Table 1 Characteristics of particles of alluvial soil of the Yellow River

| Soil sample number | 0.25-0.074 | 0.074-0.05 | 0.05-0.005 | 0.005-0.002 | <0.002 |
|---|---|---|---|---|---|
| 1 | 0 | 11 | 80 | 6 | 3 |

Table 2 Particle size analysis table

| Limiting particle size $d_{60}$ | Effective particle size $d_{10}$ | $d_{30}$ | Uneven coefficient $C_u$ | Curvature coefficient Cc |
|---|---|---|---|---|
| 0.022 | 0.0047 | 0.012 | 4.68 | 1.39 |

From the table 1, we can see that the Yellow River alluvial plain soil particle size is mainly concentrated in the 0.002mm -- 0.074mm, the silt content is as high as 90% or more, the clay content is less than 10% .From the table 2, we kan see that uniformity coefficient Cu (d60/d30) <5, for the homogeneous soil, poor gradation. Thus it can be seen, The Yellow River alluvial plain soil is mainly in silt, the silt content reaches as high as 80% (general 90%) above, the gradation is poor.The grading curve of silt is shown in Figure 1.

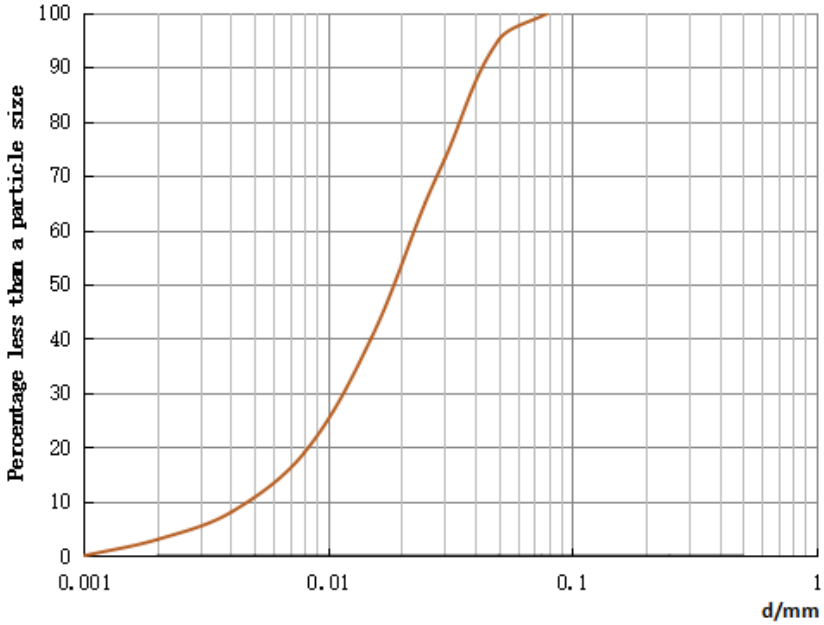


Fig. 1 Test chart of particle size distribution of silt in the Yellow River

### 2.2 Limit moisture content test

Secondly, the boundary water content test of silt was carried out. At present, the liquid limit of the cohesive soil is determined by the cone liquid limit apparatus. In this experiment, the liquid limit and plastic limit of silty soil were determined by the extensive application of the liquid and plastic limit in China [4-6]. The theoretical basis is the linear relationship between the h and the corresponding soil water content w in the double logarithmic coordinates based on the depth of the cone[7-8]:

$$\lg h = \frac{m}{2}\lg w + (c_1 - c_2) \tag{1}$$

Type: m for the cone quality; $c_1$, $c_2$ for constant.


Fig. 2 Liquid-plastic limit determination test of silt

Liquid plastic limit combined test is made with 76g cone.when the time is 5s, the depth of the cone in the soil under different water content is 17mm, and the corresponding water content is the liquid limit.; The corresponding water content in the depth of 2mm is plastic limit. The laboratory soil test using Nanjing zhi long Technology Co, the model for the production of SYS digital display liquid plastic limit tester, the soil sample is the air seasoning soil sample. The soil is taken by 0.5mm sieve of representative soils 400g, divided into 3 parts, puted in three soil in the dish, added different amounts of water make the cone sinking depth of 3-4mm, 7-9mm and 15-17mm for the preparation of different consistency [7] .And the soil sample is modulated evenly, then puted in a sealed moisturizing cylinder, a day and a night. Test diagram as shown in Figure 2, the test result is shown in Figure 3.

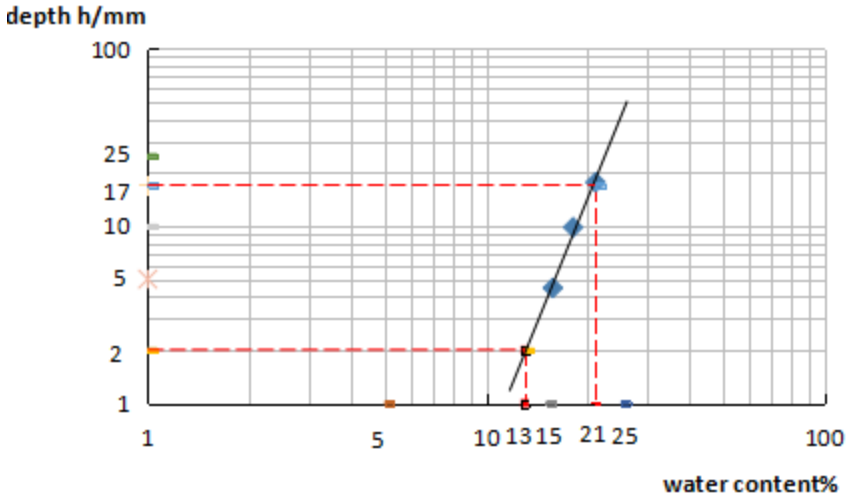


Fig. 3 Experimental results of liquid plastic limit test

The figure 3 shows that the relationship between the depth of sinking and the corresponding water content has good linearity in the double logarithmic coordinates. Therefore, the liquid limit of the test soil is 21%, the plastic limit is 13%, the plastic limit index is 8<10,which shows that the soil sample is difficult to be compacted, and the soil sample is not suitable to be pressed into the pile.

### 2.3 Compaction test

Compaction test of silt based on the determination of plastic limit. Soil samples were prepared by dry method, and the representative soil sample 20kg was dried in an oven at a temperature of less than 60 temperature. And the soil samples were placed on the rubber board with a wooden roller mill as well as over 5mm sieve mix well. According to the plastic limit estimated its most superior water content, and differs 2% water content to prepare a group approximately in turn (Five samples) the test specimen.Two larger and two smaller than the optimum moisture content is 9%, 11%, 13%,15%,17% and so on. Preparation method: Each specimen taking soil 2.5kg, flat out on the tablet not bibulous.The water spraying device is used for evenly spraying the predetermined amount of water, later settled period of time, which is arranged in a plastic bag and is put into a sealed container for a day and a night. Soil samples were taken rest for a day and a night in the standard compaction instrument. The parameters of the compaction instrument are shown in table 1.

Table 3 Parameters of the compaction instrument

| Tube diameter (mm) | Tube height(mm) | Tube volume ($mm^3$) | Hammer quality(kg) |
|---|---|---|---|
| 100 | 127.3 | 1000 | 2.5 |

| Hammer height（mm） | Hammer diameter（mm） | Hitting work per unit（$KJ/m^3$） | Alluvial quantity per unit area kpa s |
|---|---|---|---|
| 300 | 50 | 607.5 | 3 |

In accordance with the geotechnical test method standard (GB/T50123-1999) for compaction test. Compaction test data and the compaction curves are shown in table 4 and figure 4 respectively.

Table 4 Compaction test data

| Serial number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Moisture content (%) | 8.847 | 10.966 | 13.089 | 15.038 | 16.652 |
| Dry density ($g/cm^3$) | 1.381 | 1.416 | 1.453 | 1.141 | 1.396 |

From Figure 4, we can know that the optimum water content is 13.6%, the maximum dry density is $1.453g/cm^3$. The compaction test has single peak. From the graph 4, it can be concluded that the dry density increases with the increase of the water content when the moisture content is less than the optimum water content; When the moisture content is bigger than the best moisture content, the dry weight density increases along with the moisture content reduces;Near the optimum moisture content curve is steep, the silt near the optimum moisture content is more sensitive to water.

The reason for this phenomenon is that when the moisture content is low, the surface water is absorbed as soil particles adsorbed water in soil particles, soil particles due to the capillary action is not easy

to combine.In this stage, the soil particles impact compacted easily scattered and difficult to dense. With the increase of water content, the relationship between soil particles and water was enhanced, and the ability to maintain the tight arrangement state is formed along with the compaction increased. The pore water capillary force that it is prevent soil particles from getting close will become dense. On the contrary, the lubrication effect of soil particles is enhanced, and the soil is in a close state.When the water content is increased to more than the optimum moisture content, the increase of water is only a part of the soil particles, and the density of the soil will be reduced.

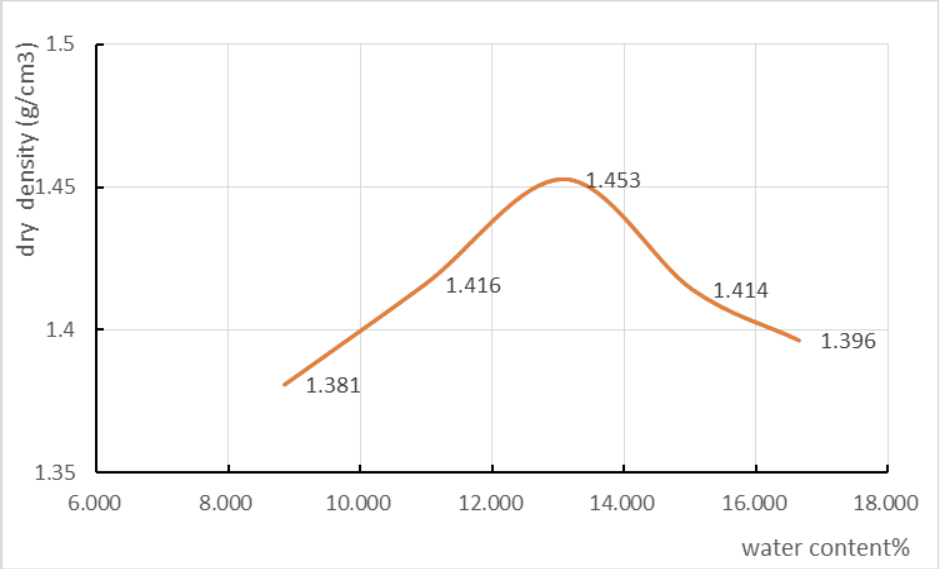


Fig. 4 Compaction test of silty soil

## 3. Conclusion

Silty soil in the Yellow River alluvial plain is a special kind of special soil in our country. It is found that the engineering properties of the soil are characterized by the laboratory tests:

(1). The particles of the alluvial plain in the Yellow River are mainly concentrated on the 0.002-0.074mm powder, and the content of the silt is as high as 90% or more, and the clay content is less than 10%.

(2). Through routing soil mechanics test, we know that the liquid limit of the silt is 21%, the plastic limit is 13% as well as the plastic limit index is 8<10. It shows that the soil sample is difficult to be compacted, and the soil sample is not suitable to be pressed into the pile.

(3). The optimum moisture content of the silt is 13.6%, the maximum dry density of the silt is 1.453g/cm$^3$, and the silt is sensitive to water in the vicinity of the best water content, and it is difficult to compaction.

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