Experimental Study on the Influence of Gravel Content on the Tensile Strength of Gravelly Soil

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Abstract. Tensile strength is one of the most important properties affecting anti cracking performance of earth core rockfill dam. However, the influence of gravel content on the tensile strength of gravelly soil is still unclear. In the paper, based on the self-developed uniaxial tensile test device, a series of tensile tests were performed on gravelly soils with different gravel content. For gravelly soils with different gravel content, the tensile strength decreases linearly with the increase of gravel content at the optimal water content and maximum dry density. In addition, Empirical formula to calculate tensile strength of gravelly soil based on the gravel content is put forward. The relevant conclusions are helpful to improve the anti-cracking design level of actual earth core rockfill dam.

Keywords: Gravelly soil · Tensile strength · Uniaxial tensile test
Gravel content

1 Introduction

High earth-rock dams are widely distributed in China, among which, earth core rockfill dams are frequently used in poor geological conditions due to its excellent ability of coordinating deformation. Usually, in order to increase the modulus of the core, a certain proportion of gravel is incorporated into the clay as the core wall. With the increase of gravel content, the ability of the core to resist shear deformation increases significantly. However, whether the crack resistance of the gravelly soil can still reach the anti-crack design requirements of the dam is worth further study.

At present, many researchers [1, 2] have conducted a large number of uniaxial and triaxial tensile tests on clay and obtained quantitative relations between tensile strength and properties (e.g. dry density, and matrix suction). Besides, some researchers [3, 4] have conducted a series of tensile tests toward some special soils. Zhu [5] studied the variation of tensile strength on gravelly soil with different compaction energy, saturation

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and water content. In general, there are few studies on the tensile properties of gravelly soil, and the variation of tensile strength with different gravel content on gravelly soil needs to be further investigated.

In this paper, the uniaxial tensile tests of gravelly soil with different gravel content were carried out by using a self-developed tensile device. The variation of tensile strength on gravelly soil with different gravel content was investigated.

2 Device, Soils and Schemes of the Test

2.1 Tensile Test Device

In view of the disadvantages of tensile devices used by the former researchers, a new type of uniaxial tensile device was applied in the test as can be seen in Fig. 1.

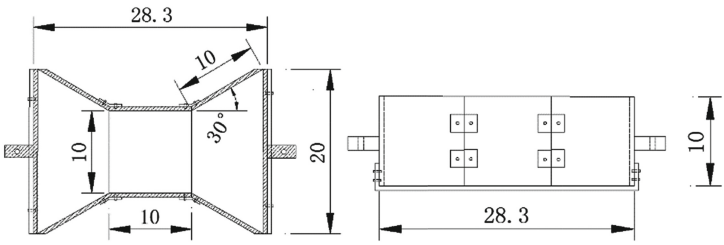

Fig. 1. Schematic diagram of tensile device (unit cm).

2.2 Soils Used in the Test

The clay used in the test was from the core of an earth core rockfill dam. The maximum particle size is 2 mm. The basic parameters of the clay are shown in Table 1.

Table 1. Basic parameters of the core material.

Gs	ω_L/%	ω_P/%	I_p	ω/%	k/cm•sec^{-1}
2.74	30.4	20.5	10	22.2	2.0×10^{-6}

The gravel in the gravelly soil used in the test was from an earth core rockfill dam and the parent rock was granite. The particle size of the gravel is controlled to be 20 mm (1/5 of the longest side of the sample) and the minimum size is controlled to 2 mm.

2.3 Schemes of the Test

First, compaction tests were conducted on gravelly soils with different gravel content to obtain the maximum dry density and the optimum water content. The compaction test results can be seen in Table 2.

Table 2. Optimum water content and maximum dry densities of gravelly soil with gravel content from 0–50%.

Gravel content/%	0%	10%	20%	30%	40%	50%
ω_{op}/%	17.5	16.4	14.8	13.3	11.5	10.1
ρ_{max}/g•cm^{-3}	1.73	1.82	1.88	1.98	2.01	2.05

The control variable method was used to formulate the test schemes as can be seen in Table 3.

Table 3. Tensile test schemes of gravelly soil.

Classifications	Gravel content/%	ρ/g•cm^{-3}	ω/%
Clay	0	1.73	17.5,15.5,19.5
		1.73,1.63,1.53	17.5
Gravelly soils	10	1.82	16.4,14.4,18.4
		1.82,1.72,1.62	16.4
	20	1.88	14.8,12.8,16.8
		1.88,1.78,1.68	14.8
	30	1.98	13.3,11.3,15.3
		1.88,1.78,1.68	13.3
	40	2.01	11.5,9.5,13.5
		2.01,1.91,1.81	11.5
	50	2.05	10.1
		2.05,1.95,1.85	10.1,8.1,12.1

3 Test Results

The tensile strength is mainly dominated by the clay content in the gravelly soil. When the gravel content increases, the clay content of the sample will decrease. Theatrically, if the gravel content increases to 100%, the tensile strength of the sample is almost equal to 0 except the partial bite force between the gravels. Figure 2 shows the relation curve of tensile strength versus gravel content.

It can be seen that when the gravel volume increases from 0% to 50%, the tensile strength decreases from 122.6 kPa to 49.8 kPa. The linear relationship can be expressed as:

$$\sigma_t = -1.5741\lambda + 120.96 \tag{3}$$

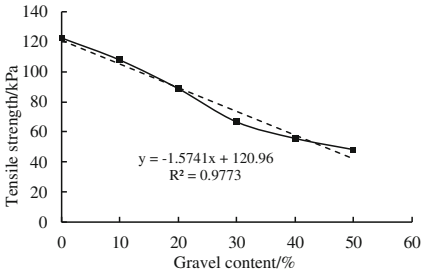

Fig. 2. Relation curve of tensile strength and gravel content.

4 Conclusions

In the paper, based on the self-developed uniaxial tensile test device, a series of tensile tests were performed on gravelly soils with different gravel content. The main conclusions are as follows:

(1) For gravelly soils with different gravel content, tensile strength decreases linearly with the increase of gravel content.
(2) Based on the test results, empirical formula to calculate tensile strength of gravelly soil based on the gravel content was put forward in the paper.

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