Tensile strength of compacted and saturated soils using newly developed tensile strength apparatus

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1. Introduction

Recently, many soil-slopes get failed during the excavation or trimming process. In shear failure, sliding surfaces are seen. But in some slope failures, such sliding surfaces are seen at the lower portions only. In such failure, in the upper part, soil layers seem to be detached from each other. This could be thought of due to the development of tensile cracks. Failure of earth dams, embankments, pavements, etc., is also caused by the development of tensile cracks. In addition, development process of ice lens in the freezing soil is also related with tensile strength. Therefore, in order to understand the tensile cracks development, it is necessary to measure the exact value of tensile strength that the particular soil consists of. Due to the limitation in testing method, most of the earlier researches are focused on to brittle elastic materials (stiff, compacted and cement mixed) which have higher tensile strength rather than on to ductile materials (soft, clayey and saturated ones). In this paper, tensile strength of compacted and saturated soils is described which is obtained by using a newly developed tensile strength testing apparatus. Testing method using this apparatus is easy and simple.

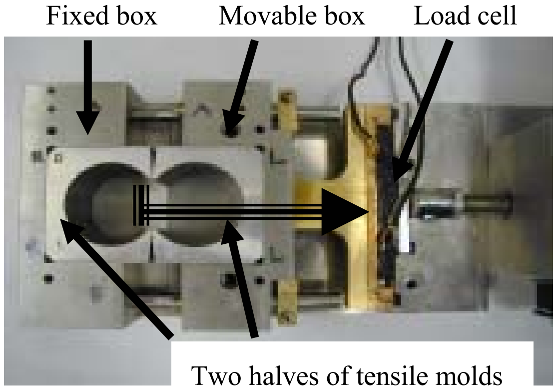

Photo 1. Newly developed tensile apparatus

Photo 2. Consolidometer

2. Testing Apparatus

Tensile test apparatus shown in Photo 1 consists of a horizontal platform upon which a newly developed tensile mold is placed. This tensile mold consists of two separate “C” shaped forms which are almost circular in shape except at the middle portion where these two halves are joined. These two halves of the mold are fixed at first to the boxes which are attached to the horizontal platform. The attachment of one of the box to the horizontal platform is fixed while another box can freely move on to the platform in the horizontal direction. To reduce the friction between the movable body and the platform, linear sliding roller is placed in between. Movable box is pulled out by the motor attached with the horizontal platform. And the load cell placed between the motor shaft and the movable box measures the tensile force that is required to fail the sample in tension. Total inner surface of the tensile mold is 38.506 cm^2 with 5 cm depth. The tensile mold has minimum width of 3 cm where two halves of the mold are joined.

3. Specimen Preparation and Installation Process

For compacted soil specimens, mixtures of kaoline and Toyoura sand and silt (CFP) and Toyoura sand are used. Different proportions are used in the mixture. After thorough mixing, maintaining the water content around 10%, they

Tensile strength, tensile apparatus, kaoline, compacted soil
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are kept in the air tight plastic bags for several days so that homogeneity in water distribution could be obtained. Static compaction is done by putting the predetermined amount of mixed materials (dry density is fixed) into the tensile mold. Dry densities maintained for the mixture of kaoline and sand are 1.2 and 1.5 g/cm^3 and for the mixture of silt and sand are 1.2 and 1.4 g/cm^3. Saturated specimens are prepared by mixing kaoline at three different consolidation pressures; 100, 200 and 300 kPa. Consolidated specimen from the consolidating mold (Photo 2) is then directly pushed into the tensile mold with sufficient attention. Wire saw is used for cutting and trimming of the specimen. Before putting the specimens into the tensile mold in both the compacted and saturated tests, a thin film of grease is applied on the inner surfaces of tensile mold and the inner bottom surface of the body in order to minimize the friction between the inner surfaces of mold and the specimen. After that the two halves of the tensile mold are screwed to the body. The movable body is fixed by screwing it to the horizontal platform before the sample preparation. Once the specimen preparation is finished, then load cell is attached at the movable body towards the pulling direction. Finally, movable body is freed and pulling is done by rotating the motor at the constant speed of 0.0083mm/sec.

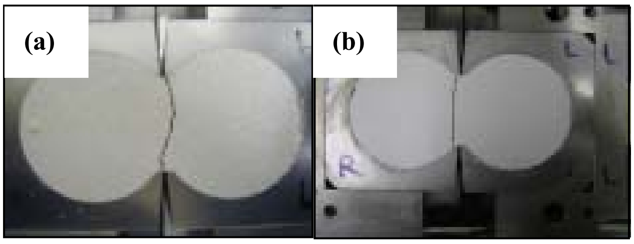

Photo 3. Tensile crack (a) compacted, (b) saturated

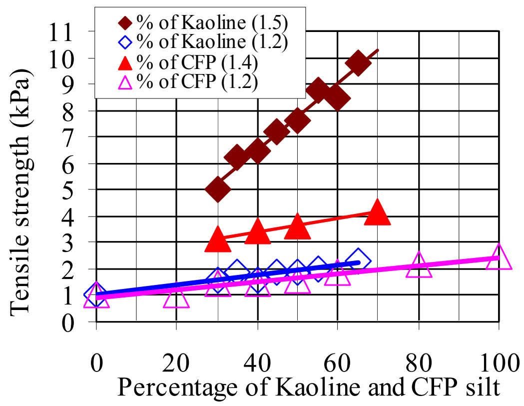

Figure 1. Tensile strength of mixtures

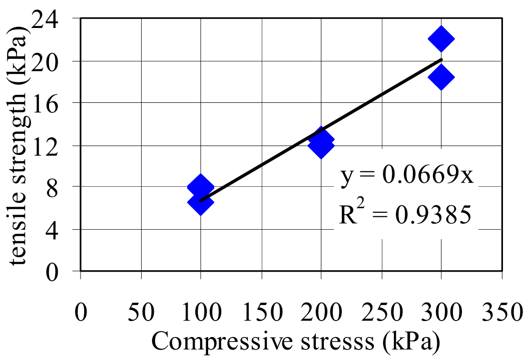

Figure 2. Tensile strength of saturated kaoline

4. Test Results and Discussion

Tensile cracks developed during the tests of compacted and saturated specimens are shown in Photo 3. Figure 1 shows the tensile strength measured for the mixtures of compacted soils. In the figure, tensile strength increases with the increase in the kaolin and silt percentage. But comparing the results of similar density, the tensile strength with kaoline mixture is higher than that with silt mixture. Increase in the finer particles changes the modes of particle arrangement within the soils matrix and size of particle affects the contact surface which finally affects the tensile strength. So, it could be said that the tensile strength of soil increases with the increase in finer particles. But with the increase in size of finer particles (here silt), contact surfaces are decreased which in turn decreases the tensile strength. Figure 2 shows the tensile strength results measured for saturated Kaoline consolidated at 100, 200 and 300 kPa. A good correlation of test results could be seen although there are slight variations in the results.

5. Conclusions

1. This newly developed apparatus could be used for measuring tensile strength of both compacted and saturated soils. Sample preparation is easy and testing method is also simple with reproducibility.
2. From the test results of kaoline-sand mixture and sand-silt (CFP) mixture, it could be said that with the increase in the amount of finer particles, tensile strength increases. But with the increase in the size of finer particles there is decrease in the tensile strength.
3. A good correlation between the tensile strength and compressive strength for saturated kaoline is obtained.