The currently used methods of determining the tensile strength of soils [1-3] have substantial deficiencies. For this reason the writers developed and tested in the field [4], using volcanic ash soils, two relatively simple field methods of determining the tensile strength of soils, based on the first classical theory of strength, which make it possible to evaluate the strength of soils in the vertical and horizontal directions.

Let us consider a sample of constant cross section singled out from a soil wall and loaded by its dead weight (Fig. 1). At a certain section \( y = \text{const} \) tensile stresses \( \sigma \) act which are determined from the relation

\[
\sigma = \frac{P}{F},
\]

in which \( P \) is the weight of the sample bounded by section \( y = \text{const} \); and \( F \) is the cross-sectional area of the sample.

If it is taken into account that

\[
P(y) = \gamma F y,
\]

in which \( \gamma \) is the unit mass of the soil, then relation (1) can be written in the form

\[
\sigma(y) = \frac{P(y)}{F} = \gamma y.
\]

When the sample is elongated, the tensile stresses increase in it. Upon reaching the critical length, rupture of the sample occurs through section \( F \) at a certain ordinate \( y = y_{\text{crit}} \), where the stresses reach the limit values \( \sigma_{\text{crit}} \). The given limit state is described by the equation

\[
[\sigma] = \gamma y_{\text{crit}}.
\]

The tests are performed in the following manner. At the face of the excavation (shaft, gallery, test pit), by precise cutting of the soil from the sides a soil wall is formed (see Fig. 1). In its lower part a through opening is made with an upper surface outline corresponding to a stable arch. By means of a prospecting saw or a stretched steel wire operating simultaneously or alternately from the bottom, cuts are made which separate, at the sides, the tested sample from the mass. The cuts advance upward until the sample comes off from the overlying soil under the action of the increasing force of gravity. The ultimate tensile strength of the soil is determined from the equation

\[
R_t = \frac{P}{F},
\]

Fig. 1. Schematic of test of soil under tension in the vertical direction.
The procedure here described was tested using volcanic ashes, which constitute soils of a very loose morphology possessing weak structural links [5]. Their unit mass at the natural water content varies from 0.95 to 1.52 g/cm³ with mean values at different parts being in the range 1.16-1.20 g/cm³. Correspondingly, the dry density varies from 0.53 to 1.0 g/cm³, the mean values being in the range 0.76-0.86 g/cm³. The porosity was in the range 60-80%, and the void ratio lay in the range 1.55-4.1 with its predominant values varying from 1.65 to 3.1. For the ashes a high variability of the density in the section and in pan was characteristic both at different places and within the limits of an excavation, and even of a single earth block.

The ashes possess weak structural links. The ultimate structural strength according to plate test data is 0.09-0.12 MPa. The cohesion, determined by different procedures with a variable area of the shear surface, lies in the range 0.01-0.05 MPa, but it is mostly in the range 0.017-0.020 MPa.

The test results are presented in Table 1.

From Table 1 it is seen that despite the relatively gross measurements, the test results do not differ substantially. In fact, from statistical processing the following values were obtained: arithmetic mean value of the strength $R_t = 1.19 \times 10^{-3}$ MPa, variance $\sigma^2 = 6.3 \times 10^{-3}$ MPa, standard deviation $\sigma = 0.8 \times 10^{-4}$ MPa, and relative error $\Delta n(R_t) = \pm 2 \times 10^{-1}$.

In the engineering practice it is not less important to obtain the tensile strength of soils in the horizontal direction. Under field conditions the tests can be performed also, applying the theory of bending of a cantilever beam, by subjecting the sample to tension under the action of its dead weight.

The bending moment in a cantilever beam at any cross section under the dead weight action (Fig. 2) is equal to

$$M = \gamma bh^2/2 \cdot x^2,$$

in which $\gamma$ is the unit mass of the material; $b$, $h$, width and height of the sample; and $x$, current ordinate.

### Table 1

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Mass of detached portion, kg</th>
<th>Tearing-off area, cm²</th>
<th>Ultimate tensile strength, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.75</td>
<td>416</td>
<td>$1.09 \times 10^{-3}$</td>
</tr>
<tr>
<td>2</td>
<td>4.35</td>
<td>346</td>
<td>$1.23 \times 10^{-3}$</td>
</tr>
<tr>
<td>3</td>
<td>5.87</td>
<td>611</td>
<td>$1.05 \times 10^{-3}$</td>
</tr>
<tr>
<td>4</td>
<td>5.85</td>
<td>482</td>
<td>$1.10 \times 10^{-3}$</td>
</tr>
<tr>
<td>5</td>
<td>3.34</td>
<td>333</td>
<td>$1.09 \times 10^{-3}$</td>
</tr>
<tr>
<td>6</td>
<td>7.14</td>
<td>518</td>
<td>$1.23 \times 10^{-3}$</td>
</tr>
<tr>
<td>7</td>
<td>6.04</td>
<td>479</td>
<td>$1.35 \times 10^{-3}$</td>
</tr>
<tr>
<td>8</td>
<td>2.96</td>
<td>221</td>
<td>$1.32 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

Fig. 2. Schematic of soil test for strength under tension in the horizontal direction.