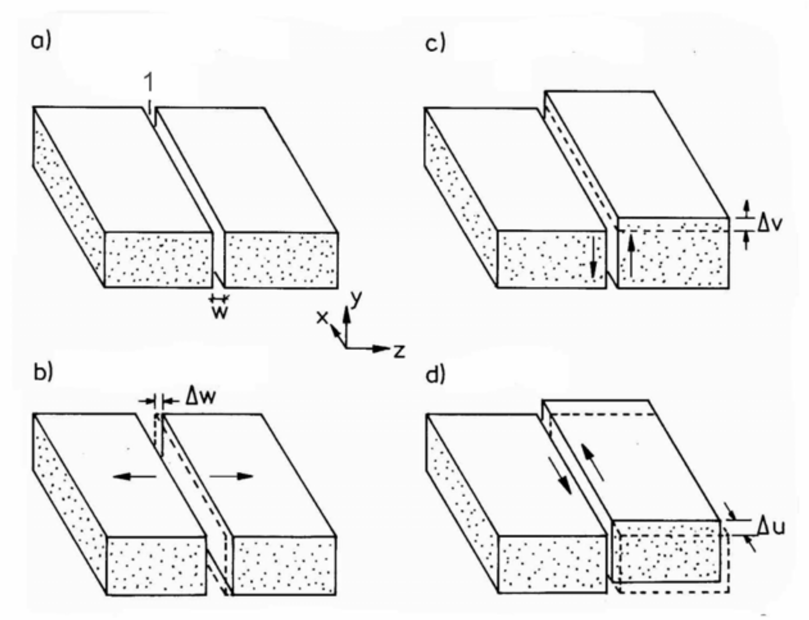
Measurements of substructure displacements at fissures or cracks on structures reveal nothing about the deformation of the rock structure or of a larger structure, but they can provide an insight into the time-related development and current stage of a displacement cycle. The measurement of sub-displacements throws light in particular on disturbances and accelerations of the displacement cycle such as may be triggered, for example, by construction work or the weather.

Sub-displacements at fissures can be measured in terms of crack size (b), vertical height (c) and shift (tangential displacement), as shown in Fig. 1. Ideally measurements should be based on all three components of displacement.

As a rule, the flanks of a fissure change most in their crack width. This explains why the majority of instruments are set to monitor crack width.



a) Initial state
b) Changes of width
c) Vertical offset
d) Shear
1) Crack

Fig. 1 Possible displacements of crack flanks and their coordinates

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The simplest and most frequently used method is to apply plaster markers about 10 mm thick over the crack. To ensure that the hardened plaster marker actually tears above the fissure when the crack opens (rather than shearing off at the point of adhesion to the rock, as is often observed), it is advisable to place a strip of cardboard or polystyrene over the crack. This will weaken the plaster marker at this point and the observation tear will be produced at the weak point when the crack opens.

This more or less reliable method can be replaced by either a mechanical fissurometer type FM 100 or FM 250 (also known as micrometer, deformeter and jointmeter) or an electric fissurometer type FE, where measurement accuracies of up to 0.002 mm are easily possible. The following set ups find application:

1. Displacement measurements across a crack or joint. With a setting gauge, two measuring rods type FB 70 are positioned on either side of the joint at a distance of 100 or 250 mm apart. At fixed intervals the distance is measured by hand with the fissurometer type FM 100 or type FM 250, or electric measurements are taken continuously by a fissurometer type FE that is permanently installed between the measuring rods.

2. Displacement measurements across and parallel to a crack or joint. With a setting gauge, three measuring rods type FB 70 are positioned at the corners of an equilateral triangle so that one side of the triangle is parallel to the joint (see Fig. 2).

3. Displacement measurements in three mutually orthogonal directions in order to determine Δw, Δv and Δu. The displacements can be measured with a jointmeter type F3E parallel to the surface (see Fig. 3).

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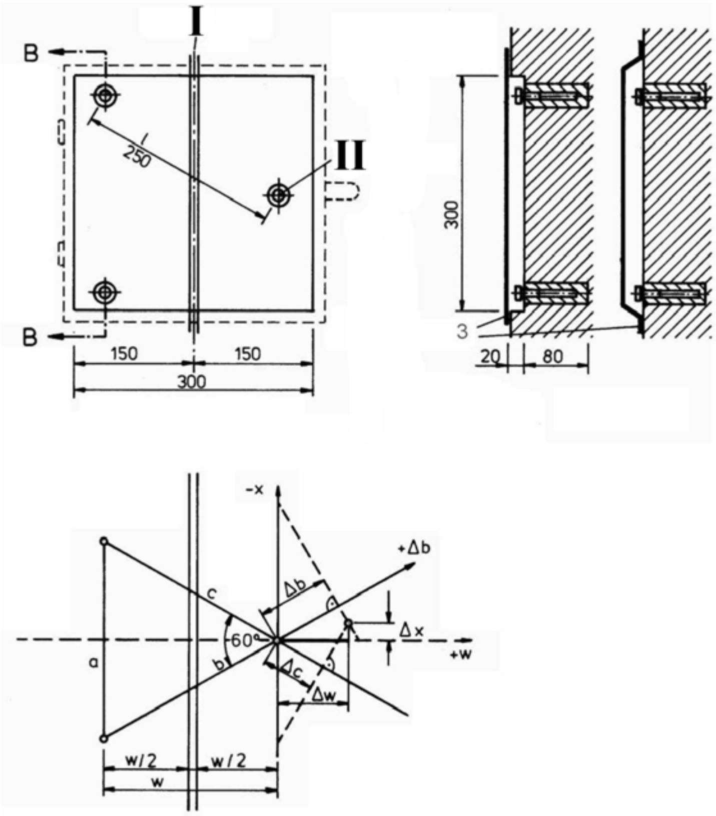


I Joint
II Bolt

Section B-B

1) 3 sides of the triangle are measured (each one twice):

$$\Delta x = \frac{1}{2\Delta a}(\Delta a^2 + \Delta b^2 - \Delta c^2)$$

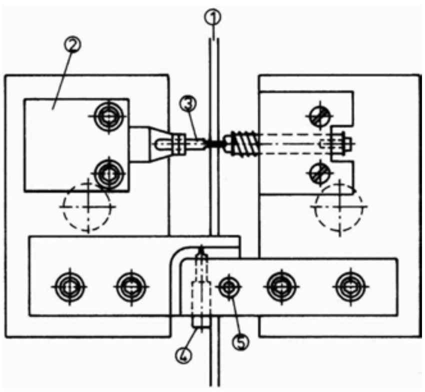
$$\Delta w = \sqrt{\Delta b^2 - \Delta x^2}$$

2) The 2 sides of the triangle which cross the joint are measured:

$$\Delta x = \Delta b - \Delta c$$

$$\Delta w = \frac{1}{\sqrt{3}}(\Delta b + \Delta c)$$

Fig. 2 Displacement measurements with three measurement rods
a) Installation drawing; b) Calculation of relative displacement



1 Joint
2 Limit switch
3 Displacement transducer Δw
4 Displacement transducer Δu
5 Displacement transducer Δv

Fig. 3 Three-dimensional displacement measurement at a joint using a jointmeter type F3E

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