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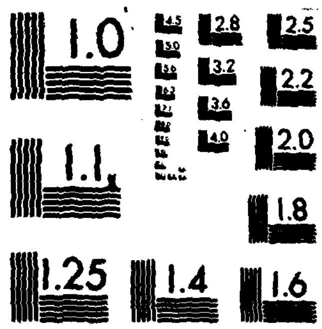

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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Research Project: CREEP AND SLIDING IN CLAY SLOPES: MUTUAL EFFECTS OF INTERLAYER SWELLING AND ICE JACKING

Principal Investigator: KURT A. CZURDA

Contractor: UNIVERSITY OF INNSBRUCK

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3. Interim Report

Report Period: APRIL 24TH, 1983 - AUGUST 24TH, 1983

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Innsbruck, 1983-08-26

Table of Contents

List of Figures

Summary: <u>Results up to Now</u>

Now, eight months after starting the project, material identification in respect to mineralogical composition and physical properties is completed. In addition to the very few data of the first two research periods concerning plasticity and grain size distribution, now, by means of a greater number of test results, the plasticity properties could be filled into the Casagrande plasticity chart and for the grain size a significant distribution area could be found (See fig. 1 and 2).

For the project should consider sliding parameters as well, shear strength test series were performed by means of a vane shear testing device. Characteristic differences in shear- and residual strength of undisturbed and reworked samples, depending on the moisture content, became obvious. (See fig. 3)

The main points of the project, swelling and freezing, have been treated as well. The extent of swell heave of the montmorillonite clay under investigation depends on the amount of moisture uptake and in return this depends on the initial water content. The frost heave results not only from ice lense formation but includes swell heave as well. During the growth of the ice lenses the clay desiccates gradually, if no further water adsorption is allowed. If water penetrates again, through the unfrozen hygroscopic water layers further water adsorption is promoted. This forces the clay phases to expand and the excess water to form ice lenses, finally resulting in a maximum heave, composed presumably of a freeze- and a clay swell part.

1. Further Geotechnical Parameters

1.1. Plasticity Indices

In addition to the former few test results, a great number of Casagrande liquid limit- and plastic limit tests were performed. The test results give now the P_i - area within the plasticity chart of fig. 1 : i_p between 16 and 35% and w_e between 42 and 65%; indicating a plastic clay to plastic silt clay.

The plasticity is determined by the amount of clay size particles: up to 70% and the amount of montmorillonite: up to 35%.

1.2. Grain Size Distribution

Twelve hydrometer tests were performed, resulting in twelve grain size distribution curves. They cover the distribution field shown in fig. 2. The critical content in clay size particles - which are composed solely by clay minerals - reaches from 35 to 70%, which is a comparatively wide range. This is one fact for the up to now scarcely to generalize swell and freeze behaviour.

2. Sliding Parameters

For a first shear strength determination in the laboratory, with measurements near the surface of the samples, a small portable vane tester was used. The unit allows instant accurate determination of clay shear strength to be made. A vane of 19 mm diameter was used for all tests. The pointer was rotated clockwise at a speed equivalent to a complete revolution in a minute. When the sample has sheared, the pointer remains set and enables a reading of shear strength determined from the scale corresponding to the vane used. A further rotation gives the value for the residual strength.

The shear strength, a main parameter in evaluating sliding resistance, depends strongly on the water content - besides other parameter like grain size distribution, mineralogical composition, fabric, slope inclination etc. The diagram of fig. 3 shows the dependence very distinct: between 50 k Pa at 15% water content and 5 k Pa at 47% water content. The maximum shear strength values for almost desiccated samples (w below 10%) are not reliable because of sample disturbance by inserting the vane.

Natural (original) fabric conditions give the clay a much higher shear resistance compared with remolded clays. Freezing and swelling means remolding and therefore considerable weakening of the clay affected. The higher the moisture content, the lower the shear strength differences of original and remolded clay samples.

3. Swell Behaviour

3.1. Test Methods

A swell heave apparatus was constructed where 4 samples at a time can be tested and registered by means if dial gauges. Water penetrates through a filter stone from the bottom by means of a falling head device. In order to induce slight overpressure, the water table in the falling head burette was kept slightly above the filter stone table. The clay specimen of 50 mm diameter and 50 to 60 mm length were mounted in closely fitting glass cylinders which allowed uni-axial swelling only and steady water uptake through a funnel shaped bottom part, connected with the burette mentioned by means of a tube.

A second type of swell tests was performed by means of an Heraeus dilatometer. In the dilatometer, the change in length or volume of a sample (size: 8 mm diameter, 10 to 50 mm length) causes a shift of the probe. This shift is converted into a D.C. voltage by a linearly variable differential transformer. This transformer permits a resolution of 0,1 μm of probe shift per centimeter of recorder deflection. In order to make use of the high accuracy of the dilatometer, it is necessary to thermostate the dilatometer head, because a change in temperature of 1°C would simulate a change in length of 2 μm.

3.2. Swell Behaviour

The tests discussed in this chapter were performed by the self designed swell heave apparatus and the Heraeus dilatometer. Despite the different sample sizes, the results are comparable and are plotted in the same diagrams. This because of the same test principle: undisturbed samples with bedding planes vertical to swell heave direction, confined by sample tubes and moisture uptake by bottom adhesion from falling head device.

As can be seen clearly from the diagrams in fig. 4, the extent of swell heave depends on the amount of moisture uptake and in return this depends on the initial water content.

Very dry clays with almost zero moisture content indicate danger for constructions for they show a swell heave up to 15%. On the other hand, a water content of about 30% - as it is the case with the original samples - indicates, that most of the expansion has already taken place and further expansion will not occur. Time dependent it can be stated, that the swell heave goes steadily but increases tremendously if water pressure is rised. Shifted towards field conditions, this means considerable swell heave of the ground surface parallel to possible rises of the groundwater table. However, moist clays may desiccate due to lowering of water table or other changes in physical conditions and exhibit swelling again upon subsequent wetting.

Another important swelling parameter is the montmorillonite content, that amounts to only 22% for the sample shown in fig.4. Swell heave increases parallel with the amount of expanding clay minerals.

4. Freeze - Thaw - Behaviour

4.1. Freeze Box

A new freezing apparatus has been constructed. It works in the same manner as the freezer described in the 2nd Interim Report; the new one has been enlarged, so that 6 (resp. 10) samples may be tested at the same time.

The new freezer is subdivided into 6 compartments, alternating one cold and one warm compartment. Freezing temperature may be lowered to - 28°C. Every warm compartment contains 2 (resp. 4) samples. The clay samples are mounted in glass cylinders of the same sample dimensions as for the swell tests (chap. 3.1.), so that the samples may be installed after freezing in the swell heave apparatus, where the thaw-behaviour can be observed and a new swell test, only by water uptake, may be performed.

In the warm compartment every sample is surrounded by an insulation material, so that only the surface is cooled. The water is moderately tempered immediately before absorption through the porous stone, so that groundwater temperature is nearly simulated.

4.2. Freeze - Thaw - Behaviour

As freezing tests have just started in the new freeze box, we got no new ice heave results.

Several samples had been frozen without water uptake. They showed no or only a very small amount of heave. The extent of shrinkage with subsequent thawing is the same as for a water saturated sample which previously has been air dried. The swell heave subsequent water uptake ranges within the same dimension.

5. Field Investigation

At the site selected within the Molasse region of the province of Upper Austria and described in the previous reports, up to now field thermometers have been installed and recently a piezometer borehole was drilled. At present, temperature and ground water fluctuation is measured only from time to time.

A Bison soil strain gauge is now calibrated and tested in our laboratory and will be installed at the test site in a few weeks.

6. Research Plans for the Coming Research Period

The efforts of the coming four months will be focused on freezing - thawing - tests in our new cold box, thawing - swelling tests in the swell heave apparatus and the installation and testing of the soil strain gauges at the test site in the field.

We consider the material identification now as sufficiently treated with the exception of the cation balance and the micro-fabric condition and alteration during freezing and thawing. The scanning microscope studies in this respect need some more preparation- and performance know how and will be treated in one of the coming research periods.

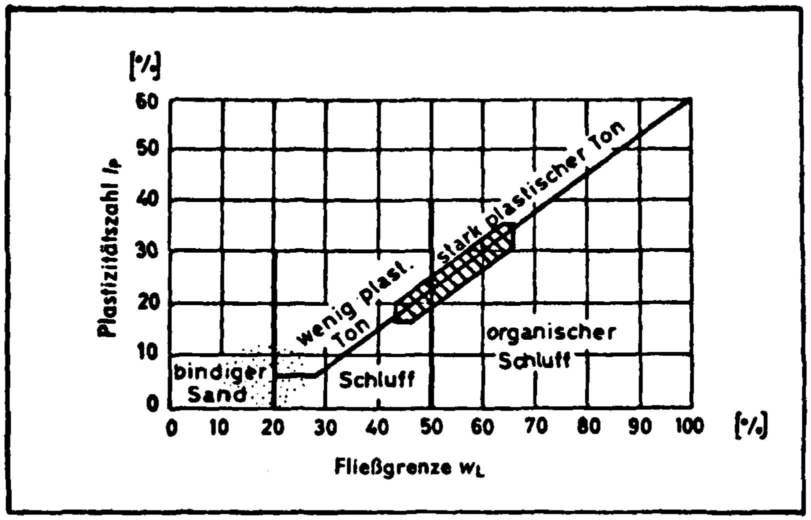

Fig. 1: Field of plasticity indices (PI) of investigated fresh-water clay (high montmorillonite content) within the plasticity chart. A-line PI = 0,73 (LL-20)

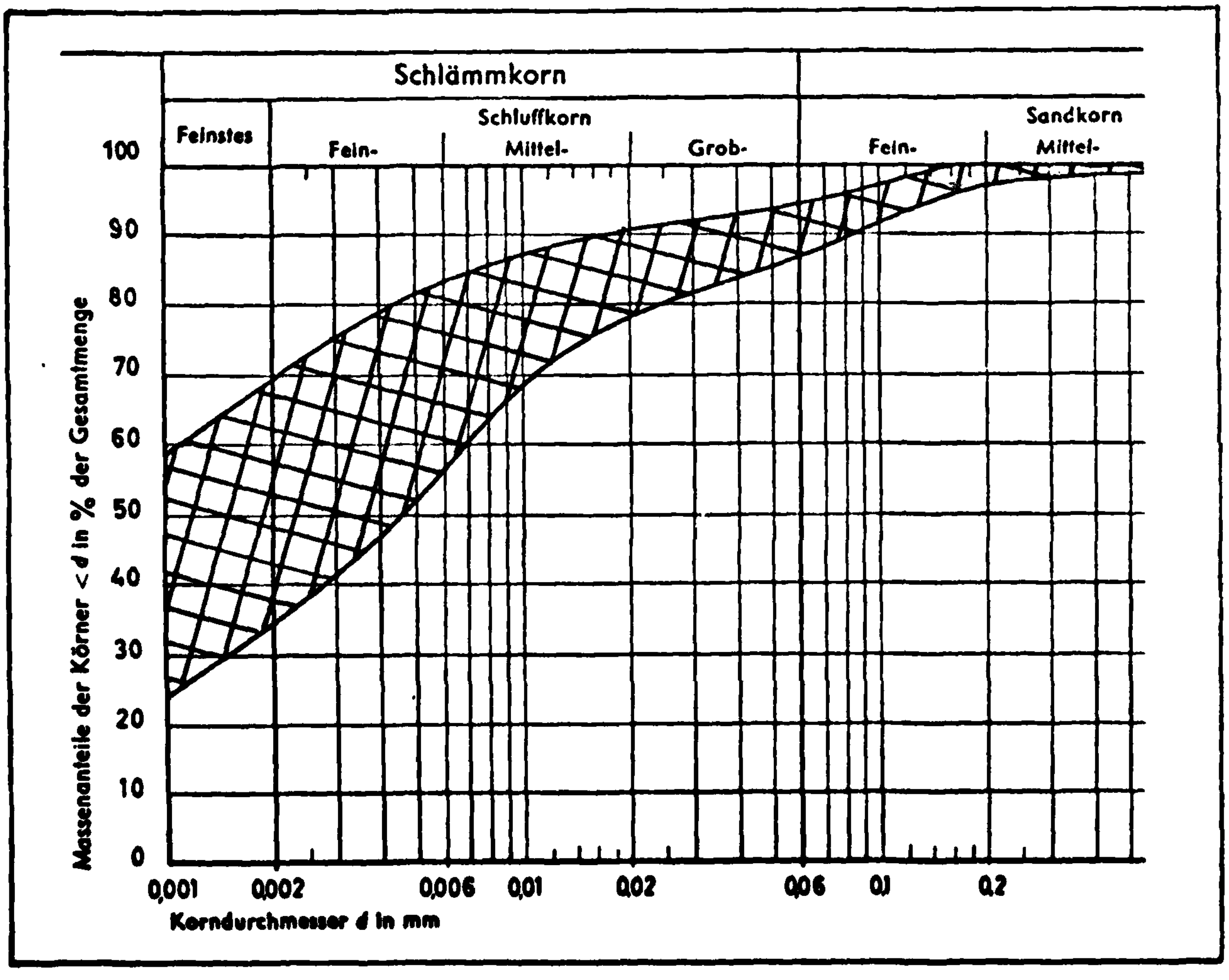

Fig. 2: Field of grain size distribution of investigated fresh-water clay. Content of clay size particles up to 70%.

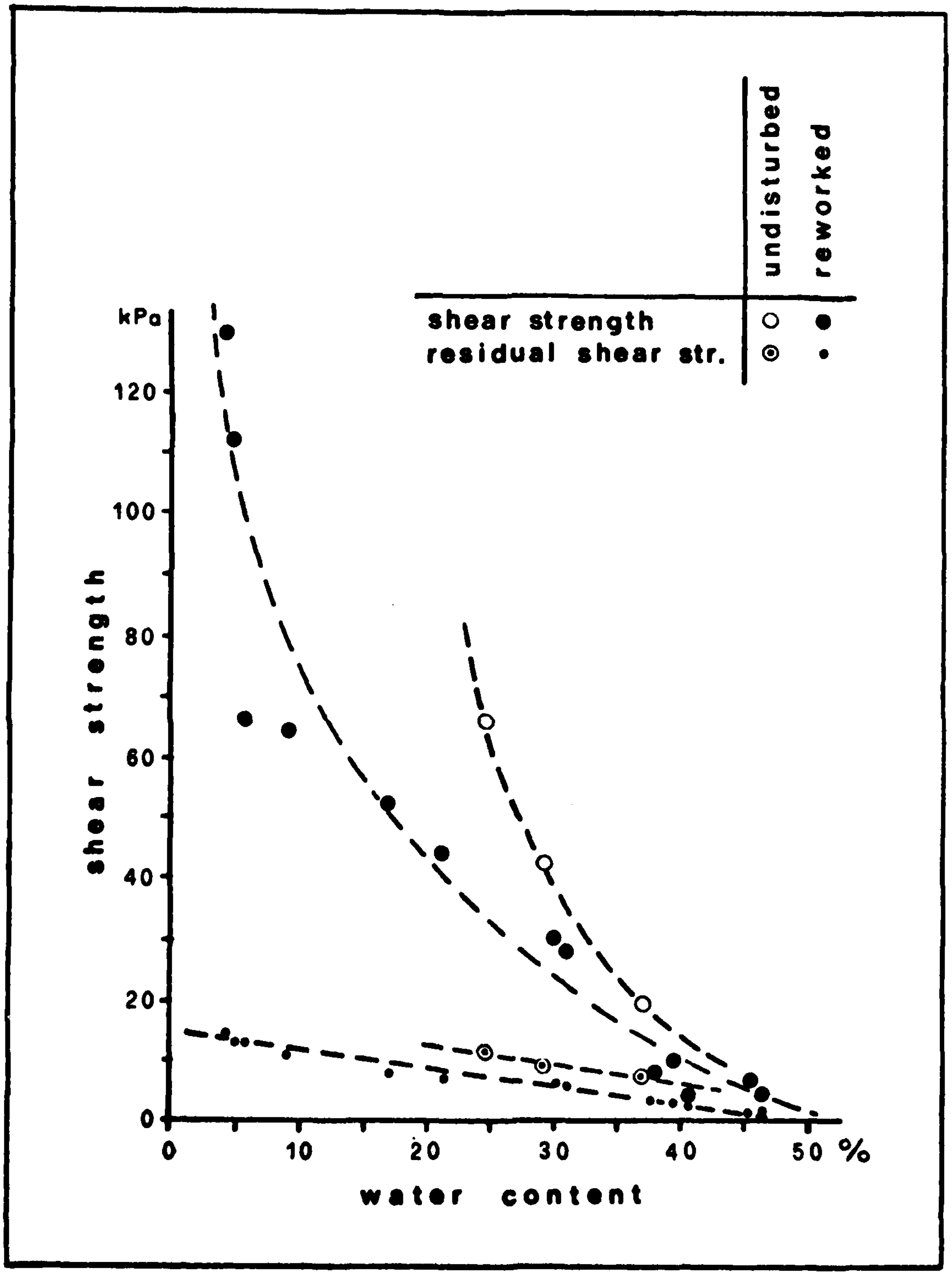

Fig. 3: vane shear diagram. Shear strength and residual strength. Dependence of shear strength from moisture content and original fabric (undisturbed samples with higher shear resistance).

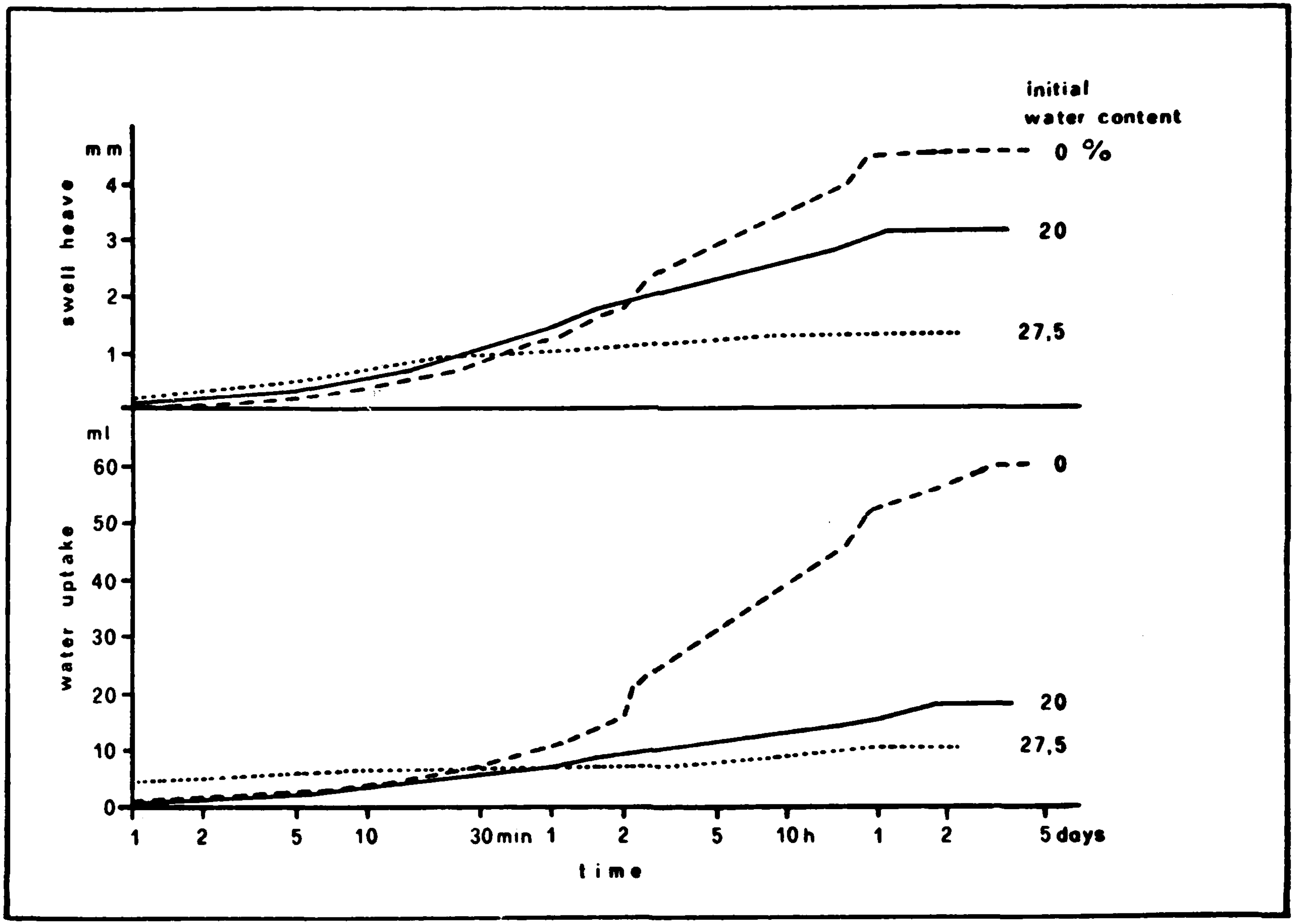

Fig. 4: Swell heave and water uptake time dependent. Dependency of swell extent from amount of water