SUB-SECTION VI c

INFLUENCE OF GROUNDWATER

VI c 2

WATER-DAMS (OBSERVATION IN NATURE)

RISING AND FALLING AT THE BANKS, ON ACCOUNT OF THE VARIATION IN THE SURFACE OF THE LAKE

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A. SETTLING OUT OF PROBLEMS.

Among the most important problems which arise in the construction of artificial dams or in the regulating of existing lakes are the following:

1. Determining the connection between the variations in the surface of the lake and the movements of the buildings and of the ground.
2. Ascertaining the connections between the variations in the surface of the lake and the variations in the level of the underground water.
3. Determining the critical erosive slope of the level of the underground water i.e. Determining the drop at which an inside washing - out of the ground takes place (Mechanical Erosion).
4. Determining the possibilties of chemical erosion.

B. OBSERVATION OF NATURE.

1. Observation of the movements of buildings and the ground as a result of the variations in the surface of the lake.

The lake of Lugano shows variation - amplitudes of the lake surface of about 2,5 metres in height. In the years 1943 till 1946 numerous fixed - point observations were carried out, in order to find out the appearances of movements of the buildings and of the ground, depending on the variations in the surface of the lake.

a) Fixed - point observations.

aa) Number.

Repeated measurements for observing their movements were taken at 23 fixed points.

bb) Accuracy of Measurements.

The most conseivably exact fixed - point measurements were carried out. The mean error per kilometer of the double leveling amounted to : M = ± 0,26 mm. The measured displacements were greater than the accuracy of measurement.

b) Results of Measurements.

aa) Compilation of Results of measurements Rise and Fall at Lugano.

TABLE I.

Nr. of measurement	Rise or Fall, mean-value in mm.	Height of Water surface of Lake	Characteristic of Water - level	Date of Measurements	Nr. of observed Fixed-points
1	± 0	270,01	Low Water	30.8. - 1.9. 43	23
2	± 0,13	270,28	Rising surface	24.9. -25.9. 43	23
3	- 1,65	270,02	Low Water	2.5. - 4.5. 44	23
4	- 1,65	270,02	Rising surface	5.10. - 8.10.44	23
5	+ 0,12	271,25	High water	14.10. -16.10.44	23
6	- 0,42	270,56	Sinking surface	23.11. -24.11.44	23
7	- 2,41	270,07	Low water	14.2. -15.2. 45	23
8	- 1,25	271,40	High water	27.5. -29.5. 46	23

In Illustration 1 the Falls and the Rises obtained are shown graphically with reference to the height of the level of the lake.

bb) Inferences.

From the above compilation Table 1 and from the graphic illustration it is shown quite clearly

1) As shown by all observations the fixed points rise by a rising lake level and they fall by a falling lake-level.
2) The tendency exists that after every sinking of the surface of the lake i.e. at every new Low-water the fixed-point lies deeper than at the preceding Low-water.

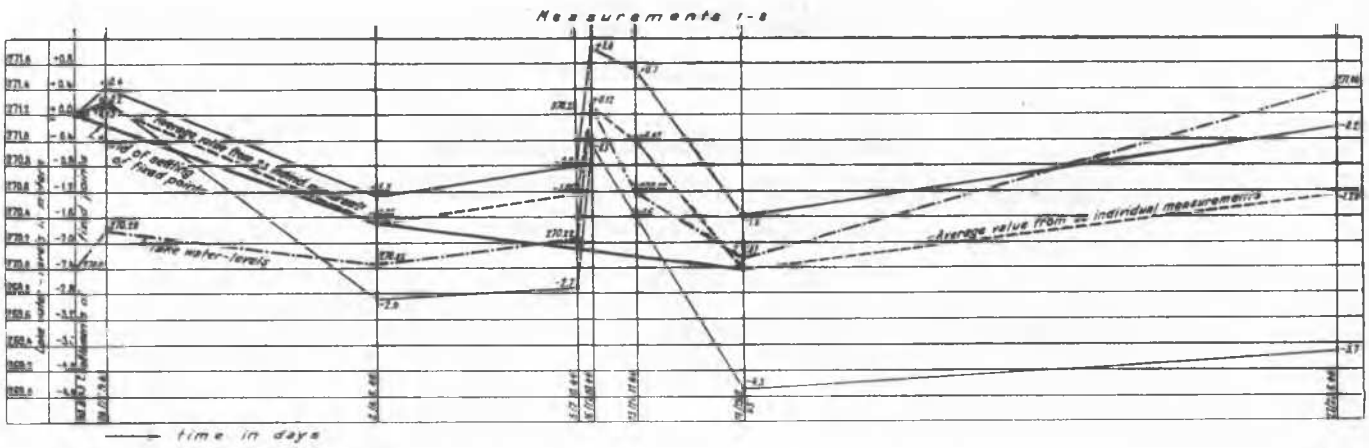
c) Dispersion, extreme Outsider and Frequency in the Range of Dispersion.

aa) Theoretical Basis.

In order to ascertain whether the measurements obtained are suited to further statical elaboration the dispersions (e) are calculated

$$e = \pm \sqrt{\frac{[VV]}{n}}$$

It means: V = mean-value minus value of observation
n = number of observations



Settlement and heavings of fixed points in dependance of lake water level. Measurements in field.

FIG.1

TABLE 2.

Nr. of measurement	Difference in Days	Height of Level of Lake	Rate worth of Dispersion (Quantity)	Mean value (m) in mm	Extreme Outsider positive	Extreme Outsider negative	Frequency in range of spread (e)		
1	—	270,01	± 0	± 0	± 0	- 0	%	%	%
2	25	270,28	± 0,176	+ 0,13	± 0,6	- 0,2	70	4	26
3	221	270,02	± 0,95	- 1,60	- 0,11	- 3,7	70	9	21
4	156	270,22	± 0,99	- 1,26	0	- 3,5	65	17	18
5	10	271,25	± 0,76	+ 0,12	+ 1,0	- 2,4	68	23	9
6	38	270,56	± 1,07	- 0,42	- 0,3	- 3,3	74	13	13
7	83	270,07	± 1,48	- 2,41	- 0,3	- 0,57	70	17	13
8	476	271,40	± 1,68	- 1,25	+ 0,3	- 6,6	86	—	14
Mean of all observations							72	12	16

(X) The mean - value (m) refers to the starting position ± 0 mm.

(7 - 3) means settlement of F. P. between leveling Nr. 3 with low water and leveling Nr. 7 with low water level.

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(7 - 1) means settlement of F. P. between leveling Nr. 1 with low water and leveling Nr. 7 with low water

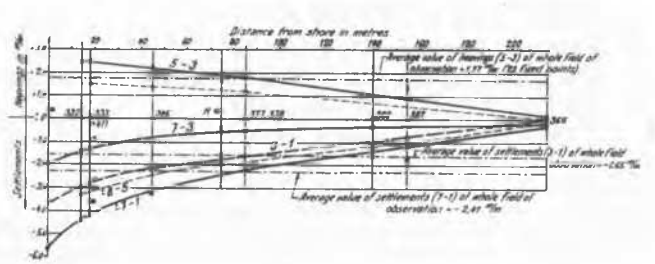
(3 - 1) means settlement of F. P. between leveling Nr. 1 with low water and leveling Nr. 3 with low water.

(5 - 3) means rising of F. P. between leveling Nr. 3 with low water and leveling Nr. 5 with high water.

(8 - 5) means settlement of F. P. between leveling Nr. 5 with high water and leveling Nr. 8 with high water.

(8 - 7) means rising of F.P. between leveling Nr. 7 with high water and leveling Nr. 8 with high water.

Measurement Nr.	Lake - Water-Level	Height of Water Surface of Lake
1	Low Water 1	270,01 m
3	" " 2	270,02 "
5	High Water 1	271,25 "
7	Low Water 3	270,07 "
8	High Water 2	271,40 "



Settlement and heavings of fixed points in dependance of difference between high and low levels of lake.

FIG.2

as n = 23 i.e. greater than 20, (n - 1) = n can be put (Cf. illustration Vol I, p. 788/790 in Bendel: Engineering Geology 1944)

bb) Dispersion and Extreme Values (cf. Table 2)

cc) Inferences from the value of the numbers of the research.

The frequency of 72% of the values of observation which lie in the Range of Spread (e) and the more or less dymmetrical division of positive and negative Outsiders correspond to the expectations of the Gauss-law.

For this reason it is possible to carry out further statistical researches in the rising and falling of the Fixed-points, depending from the level of the lake and to draw inferences from them.

2. Observations of the variations of the lake surface and the variations of the level of underground water.

a) Places of observation.

Numerous Piezometer pipes were put into the ground at Lugano to find out the variations of the level of surface water in relation to the variations of the level of the lake. The observations were carried out at a distance of 300 metres from the shore of the lake.

b) Fall and Rise of the Fixed-points depending on the differences between high and low water - level of Lake.

In order to be able to determine whether the falls and the rises of the Fixed-points between the various low levels or between low and high levels occur in accordance with certain laws the differences between falls and rised between the various lake levels were calculated and graphically evaluated in diagramm 2.

c) Inferences.

aa) From the enclosure 2 it is clear that the falls between the different low and high lake levels diminish with the distance from shore of the lake.

bb) With the help of fixed-point observations isohypses of falls and rises of the buildings and the ground could be determined. They run parallel with the shore of the lake.

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WATER-DAMS

VI c 3

MODEL - TRIALS FOR DETERMINING THE SETTLEMENT AND RISING OF SURFACE OF SOIL

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1) Purpose of Model-trials

Model-trials should determine whether the settling and rise of buildings, works, technical constructions and polygon-points mean a casual incident, or whether they represent a regular result of nature.

2) Description of Test-apparatus. (C.f. illustration 4)

The essential component parts of the apparatus are:

a) An iron receptacle of 400 x 400 cross-section surface, whose surrounding sides are 15 mm thick. The sample of soil which is formed in the vessel by the infiltration of mud rests on a finely perforated sieve. The latter is covered with filter paper, so that no fine sand can come out through the sieve.

b) The sample of soil can be loaded down with different weights by a trial bucket of 100 x 100 mm cross-section.

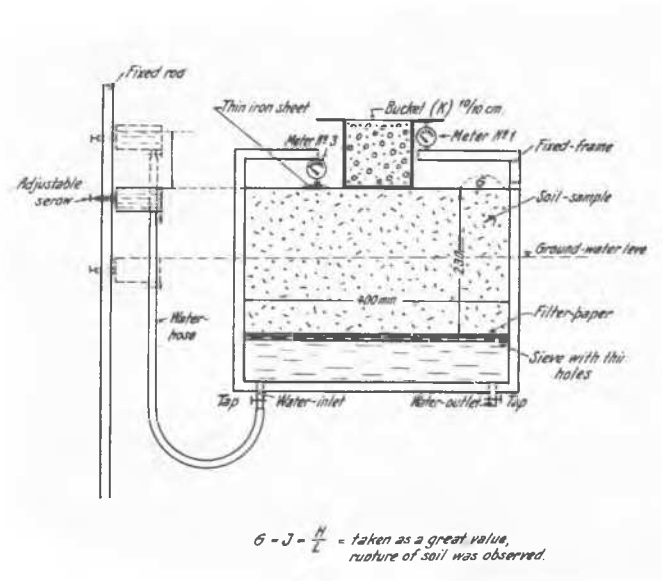
c) Next to the iron vessel there is a water vessel fastened to a rod, and adjustable as to its height. From the height H of the water-vessel over the upper edge of the sample of soil and the depth L of the sample of soil the slope J can be calculated.

$$J = \frac{H}{L} = p \text{ (pressure of current)}$$

see illustration 3 and 5.

3) Instruction for Test

For the carrying out of the tests were



J = fall
4 metres
Trial bucket (K)
Thin iron plate

Apparatus for determination of settlements and heavings of surface of soil.

FIG.3