VI a 19 PRESSURE SETTLINGS - MEASUREMENTS WITH TRIAL PLATES AND PILES OF VARIOUS SIZES.

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A) TRIAL ARRANGEMENTS.

The fundamental Trial Arrangements are shown on Illustration 157, Diagramm II in Bendel, L : Engineering-Geology; Vol. II, 1948.

B) SIZES OF TRIAL PLATES

The trials were carried out with Pressure-Plates of different sizes, namely:
Pressure Plates with surface F_1 : F_1 = 700 cm^2
" " " " F_2:F_2 = 2'000 cm^2
" " " " F_3:F_3 = 10'000 cm^2

C) RESULTS OF TRIALS

1) Pressure of the ground occuring for the time. The results of the pressure-settling measurements of the first pressure of the ground are shown on the enclosure 1.
The results may be summarized as follows:
S = total settling in mm; σ = specific pressure of ground in kg/cm^2
s = increase of settling
σ_a = previous loading of ground in kg/cm^2
X = Performed settling work in kg/mm

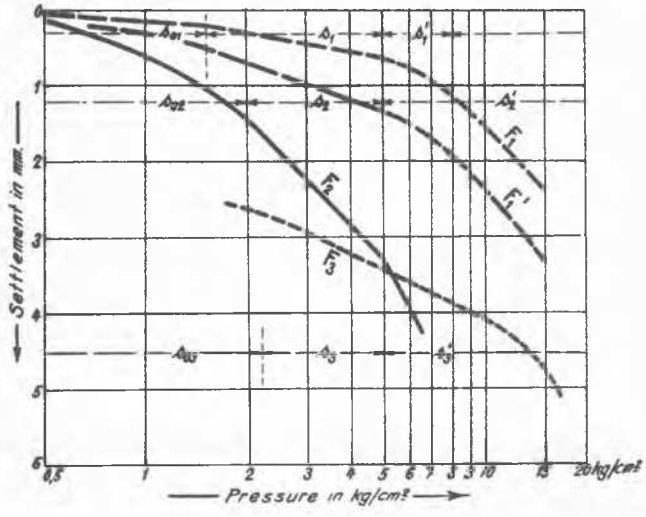
a) Summary of Trial values, obtained by weighting surfaces of various sizes. (Plates - Settling Formula)

TABLE

Scope	Size of Weighted Surface F_1 = 700 cm^2	Size of Weighted Surface F_2 = 2000 cm^2	Size of Weighted Surface F_3 = 10000 cm^2	Mode of Working	Validity of Law of Deformation	Nature of Ground
a) Elastic Reach	$s = \frac{\sigma}{M_E} \cdot \ell$ $M_E = \frac{\Delta\sigma}{\Delta s} = 70\ kg/cm^2$	$s = \frac{\sigma}{M_E} \cdot \ell$	$s = \frac{\sigma}{M_E} \cdot \ell$ $M_E = 60 \div 75\ kg/cm^2$	Plate Working	Hooke's Laws of Elasticity 1) $M_E = E$ Const.value	gravel sand 0/200 mm
b) Scope influenced by effects of elasticity or plasticity	$s = K \log\left(\frac{\sigma_a + \sigma_z}{\sigma_a}\right)$ or $s = K \log\left(\frac{\sigma}{\sigma_a}\right)$ Numerical values σ_a = 1,5 σ_e = 0,9 K = 0,75 % $\sigma = (\sigma_a + \sigma_z)$ σ_z = additional pressure for previous weighting σ_e = previous pressure at flowing limit of material	Numerical values σ_a = 2,0 σ_e = 0,96 K = 4,5 %	Numerical values σ_a = 2,2 σ_e = 0,6 K = 4,3 %	Plate Working	Commonly valid Law of deformation after Bendel 2) $s = K \log\left(\frac{\sigma_e + \sigma_z}{\sigma_e}\right)$ for σ_a = Previous weighting $\Delta s = K \log\left(\frac{\sigma_a + \sigma_z}{\sigma_a}\right)$ holds good respectively $E = M_E$ Variable dependent from pressure $\sigma = \sigma_a + \sigma_z$	
c) Plastic Scope (only slightly elastic) Pile working	$s = a \cdot \sigma^b$ a = 0,107 b = 0,24 or $s = a\ x^b$ a = 0,32 b = 0,55	$S = a \cdot \sigma^b$ a = 5 b = 0,7 or $s = a\ x^b$ a = 0,29 b = 0,55	Pile Working	Relation between pressure and settlement according to Bendel for Pile working $S = a \cdot \sigma^b$ $S = a\ x^b$	X = Performed Work of settling	Gravel sand 0/200 mm

Plate Mark	Plate size	Elastic range $s_o = \frac{\sigma}{E}\,\ell$	elastic - plastic range $s = K \log\left(\frac{(\sigma_o + \sigma')}{\sigma_o}\right)$	plastic range (Pile working) $s_1 = a \cdot x^b$ x = bulk work
F_1 F_1	700 cm² 700 cm²	$\sigma_{s_1} = 1{,}5$	$(\sigma_o + \sigma') = \sigma \cdot$ (1,5 to 5')$_2$ $s_1 = 0{,}75 \log\left(\frac{\sigma}{0{,}9}\right)$ kg/cm²	$s'_1 = 0{,}32.x^{0.55}$
F_2	2000 cm²	$\sigma_{s_2} = 2{,}0$	$(\sigma_o + \sigma') = \sigma \cdot$ (2 to 5)$_2$ $s_2 = 4{,}5 \log\left(\frac{\sigma}{0{,}96}\right)$ kg/cm²	
F_3	10000 cm²	$\sigma_{s_3} = 2{,}25$	$(\sigma_o + \sigma') = \sigma \cdot$ (2,25 to 5,5)$_2$ $s_3 = 4{,}3 \log\left(\frac{\sigma}{0{,}6}\right)$ kg/cm²	$s'_3 = 0{,}29.x^{0.58}$

s_o = Range of law of elastic deformation according to Hooke
s = Range of law of elastic - plastic deformation according to Bendel (Plate effect)
s' = Range of law of plastic deformation (Pile - effect) according to Bendel.

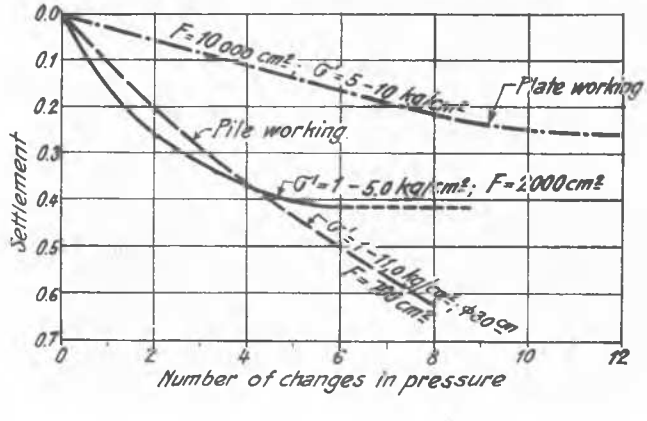


Trials showing effect of pressure and settlement with plates of different sizes.

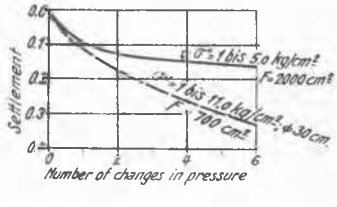
FIG.1

σ = Alternating pressure from 1 to 5,0 kg/cm²
" " " 1 to 11,0 "
" " " 5 to 10,5 "

Gravel - sand 0/200 mm.
(Sounding - hole SK 2)



Gravel - sand 0/200 mm
(Sounding - hole SL 3)



Measurements of pressures and settlements (Plastic deformation of soils) with repeated pressure and relieve.

FIG.2

b) Compilation of the experimental values of Pile-settling. Formula (see table 1)

TABLE.I

Kind of Soil	Constant value for formula $s = a \cdot X^b$		Pressure surface	Remarks
	a - Value	b - Value		
Gravel sand 0/100 m	0,32	0,55	F_2 = 2000 cm^2	Unpublished Trials for a chemical factory. Further see : Vol. II, Bendel :
Gravel sand 0/250	0,29	0,58	F_3 = 10'000 cm^2	Engineering - Geology page 114
Cleansed Sand mixed with loam	0,23	0,40	Concrete pile with 32/32 cm lateral lengths	See Vol. II Bendel, Engineering - Geology page 130 and Ill. 166
Pure cleansed sand	$155\lambda^{-1}$	0,71	wooden pile Ø 41 cm Trial by Model	See Vol. II, Ill. 270 for model scale a = I,55 λ = Model scale $\lambda = \frac{r}{rm}$ b = ground-physical coefficient a = Pile data for Lengths Diameter and form of Model - scale λ $\lambda = \frac{r}{rm}$ $\lambda = \frac{\text{Diameter in nature}}{\text{Diameter in Model}}$

2) Repeated pressure and easing-up of the ground

a) Arrangement for Trial

The fundamental arrangement for trial is shown by Illustration 157. Vol. II Bendel: Engineering-Geology 1948.

b) Results of Trials

By Illustration 2 it is shown how the settlings are becoming greater with repeated pressure and easing-up in gravel-sandy ground.

D) INFERENCES FROM THE RESULTS OF TRIALS

1) In the elastic range Hooke's Law of Elasticity is considered as a special case of the generally valid Law of Deformation according to Bendel. It is

$$S = k \log \left(\frac{\sigma_1 + \sigma}{\sigma_1} \right)$$

of, when a previous pressure already pressed the ground together:

$$s = K \log \left(\frac{\sigma_2 + \sigma}{\sigma_2} \right)$$

holds good as increase of settling.

2) In the plastic range large plates also show a working of piles. The law of settlement according to Bendel is as follows

$$S = a \cdot \sigma^b = s_0 \cdot \sigma^{K_0}$$

By the aid of the performance of work $\varkappa$ the settlement S is calculated

$$S = a \, \varkappa^b$$

3) With repeated weighting-down and easing-up it is shown that:

a) The smaller the cross-section of the weighted-down surface is, the deeper does the pressure object sink into the ground. Pile-working occurs.

b) The larger the cross-section of the weighted-down surface is, the quicker will a final value in the compression of the ground, or, in the settling of the pressures object be reached.

The reason for this phenomenon is to be sought for in the specific change occuring in the arrangement of the grains as well as in the tecture of the soil underneath a weighting object of larger or smaller cross-section. Cinematographic investigations aiming at an explanation of this phenomenon are in progress but not yet finished.

REFERENCES.

1) Cf. Vol. I, Bendel L : Engineering Geology 1944, page 413 where it is proved that Hooke's Law of Elasticity is a special case of the commonly valid Law of Deformation according to Bendel.

2) Derivation of the Law: See Bendel, Engineering Geologiy Vol. I, page 399.

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