UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Translation No. 24

ELECTRICAL TREATMENT OF PLASTIC CLAY

by

Y. Poisson

Translated by Mrs. Séverine Britt

Washington
1951

ELECTRICAL TREATMENT OF PLASTIC CLAY
(A translation)

POISSON, Y. (Engineer of "Arts et Manufactures", Paris) - Traitement d'argile plastique par le courant électrique; Travaux, no. 164, Paris, pp. 386-387, 1948.

Translated by Mrs. Séverine Britt, U. S. Geological Survey, January, 1949.

Introduction

The electrical drainage of clay soils is a well-known procedure particularly since the research of W. Bernatzik and L. Casagrande. This method could be used either to drain the soils or to accelerate settling which results from progressive consolidation of the clay under a load.

These results are generally obtained by means of a direct current passing between two electrodes driven into the ground.

It was interesting to check if the mechanical properties of a clay, dehydrated through that process and therefore temporarily consolidated up to a certain degree, would be permanently improved after the termination of the electric treatment. On the other hand, it was equally desirable to know what would happen if alternating current were used instead of direct current.

The experiments described below include three phases:

1. Investigation of the mechanical properties of clay before treatment (determination of water content and Atterberg's limits, consolidation tests).

Then, investigation of such properties after treatment

2. by means of direct current,

3. by means of alternating current.

Tested clay - Plastic clay from Saint-Brice, near Provins (Seine-et-Marne) was used for these tests. All the tests were made on undisturbed samples which were paraffined as soon as they were taken.

I. Tests on untreated clay

a) Water content

The water content is 27 to 27.8% of the weight of the dry material

b) Atterberg tests

Atterberg tests	Percent
Liquid limit	84.7
Plastic limit	34.7
Plasticity index	47.0

c) Consolidation tests

Two types of consolidation tests were carried out: in the first series (diagram 1), the sample was subjected only to the weight of the piston of the testing apparatus so that it could expand freely before the compression test proper was made. In a second series of tests (diagram 2), any initial expansion was restrained as much as possible by exerting a suitable pressure on the sample.

	Percent
Average water content before the test:	26.8
Average water content after the test:	34.2

Free expansion: under 0.05 kg/cm^2 the void ratio increases from 0.788 to 0.906 in 210 hours. Under 0.026 kg/cm^2 the void ratio increases from 0.758 to 0.94 in 486 hours.

Minimum pressure under which settlement starts: about 2.20 kg/cm^2.

Factor of compression: B = 17 to 25

Factor of swelling: A = 46 to 60

II. Treatment by means of direct current

a) Electrical treatment. Figure 3 shows the schematic lay-out of the electrodes. The clay sample is paraffined over all its faces to avoid evaporation. The anodes and cathodes consist of perforated iron tubes 0.23 m long, enclosed in a thin wire-gauze. Two anodes are set 0.15 m apart and two cathodes with the same distance apart. The horizontal distance between the anodes and the cathodes is 0.35 m. The clay sample included between the electrodes has a volume of 0.15 m x .35 m x 0.23 m = approximately 12 litres. Soda lye at 25 percent, that is containing 1 kg of solid soda for 3 kg of water, was added to the anodes. Water drained by the electric current was collected at the cathodes. The temperature, measured by means of a thermometer set on the longitudinal axis of the sample of 0.10 m from the anodes, was kept below 30° C by suitable regulation of the current.

Total consumption in ampere-hours	122.90
Total consumption in watt-hours	4,548.11
Total consumption of soda	825 gr
Water brought in by the soda lye	2,470 gr
Water collected at the cathodes	3,000 gr

Consumption calculated for $1m^3$ of treated clay:

Kiloampere hours	10.25	kAh
Kilowatt-hours	380	kWh
Solid soda	70	kg

b) Tests on treated clay:

1) Water content:

	Percent
Before treatment: average	26.8
After treatment:	
Between anodes (depth 0.20m)	23.8
0.05 m from the cathodes	27.9
Between cathodes	27.3
0.05 m from the anodes	23.3
Around anode (depth 0.20m)	22.7

Consequently, dehydration took place around the anodes and hydration at the cathodes.

2) Atterberg limits

Liquid limit	83.2
Plastic limit	35.7
Plasticity index	47.5

3) Consolidation tests

In a first series of tests (diagram 4) the sample is left free to expand at the beginning of the compression test under the sole weight of the piston of the apparatus. In a second series (diagram 5) the initial expansion is partly restrained.

	Percent
Average water content before test;	24.6
Average water content after test;	33.2 to 45.4

Free expansion: under 0.05 kg/cm^2, the void ratio increases from 0.792 to 2.07 in 675 hours. Under 0.026 kg/cm^2 the void ratio increases from 0.522 to 0.95 in 172 hours.

Minimum pressure under which settlement starts: 2.2 to 4.3 kg/cm^2

Factor of compression B= 12.1 to 13.6

Factor of swelling A= 14 to 29.6

Conclusion - After treatment, the clay appears to be more compressible and is also susceptible to more rapid, as well as greater, expansion than non-treated clay. Consequently, the slight initial consolidation seems to be only temporary, and the treated clay seems to become more responsive to the load variations.

III. Treatment by means of alternating current

Apparatus, similar to that designed for treating clay by direct current, was used in these tests.

The treated clay sample measures 0.23 m x 0.18 m x 0.35 m = approximately 14.5 litres.

Total consumption in ampere-hours	416.5
Total consumption in watt-hours	7,364
Total consumption of solid soda	2,124 gr
Water brought in by soda	6,370 gr

Consumptions calculated for 1 m^3 of treated clay

Kiloampere-hours	28.8 kAh
Kilowatt-hours	510 kWh
Solid soda	147 kg

a) Average water content

	Percent
Before treatment	26.8
After treatment	
Against electrodes	31.4
0.05 m from the electrodes	33.3
0.10 m from the electrodes	31.1
0.15 m from the electrode	30.6
0.20 m from the electrode	29.6

b) Atterberg limits

Liquid limit	84.8
Plastic limit	38.9
Plasticity index	45.9

c) Consolidation tests

Free initial expansion: diagram 6

Initial expansion partly restrained: diagram 7

Water content before test:	30.6 to 33.3
Water content after test:	39.3 to 58.6

Free expansion: under 0.05 kg/cm^2 the void ratio increases from 0.886 to 1.2 in 150 hours; under 0.026 kg/cm^2 the void ratio increases from 0.93 to 1.14 in 150 hours.

Conclusions

From the preceding results, it can be concluded that:

1. The treatment by means of direct current, with addition of soda lye, does not permanently improve the mechanical properties of clay, because the product obtained is more compressible than untreated clay (in spite of a reduction in water content) and, at the same time, is subject to greater and more rapid swelling under a reduced load.

2. The treatment by means of alternating current results in hydration. Consequently, the material is more compressible (B changes to 11-13.7) and is susceptible to greater swelling (A changes to 32-33). The effect of the treatment is, therefore, opposite to the desired result.

3. Only direct current produces temporary drainage. It will be necessary, however, to see if the clay, after treatment, is still able to bear the loads to which it will subsequently be subjected, and to check the extent to which its mechanical properties have been modified.

It may be said, therefore, that the dehydration produced by the current is reversible and, moreover, that the mechanical properties of the treated and dehydrated clay run the risk of being inferior to those of the natural clay.

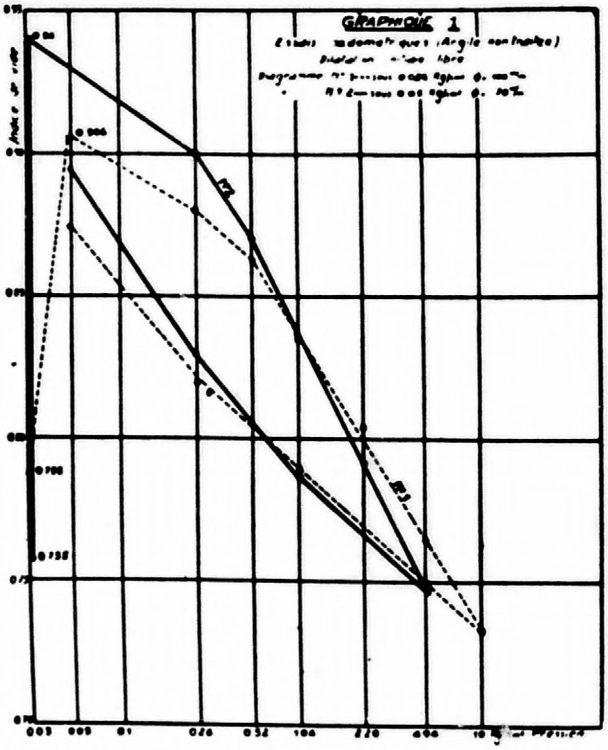

Fig. 1
Consolidation tests (untreated clay)
Initial expansion free
Diagr. no. 1 ---- under
0.026 kg/cm² ∅ 0.100 m
Diagr. no. 2 ——— under
0.05 kg/cm² ∅ 0.070 m
(Indice de vide) Void ratio

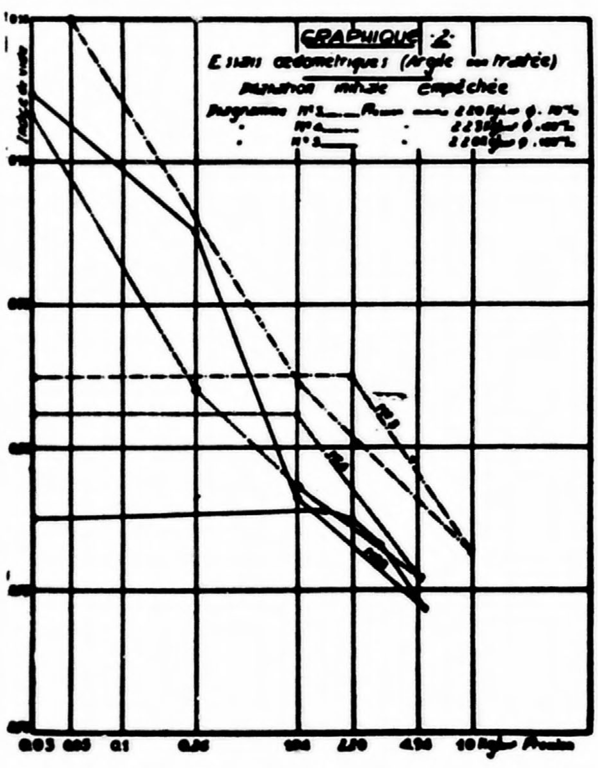

Fig. 2
Consolidation tests (untreated clay)
Initial dilatation restrained
Diagr. no. 3 -·-·- Minimum pressure
220 kg/m² ∅ 0.070 m
Diagr. no. 4 .... Minimum pressure
223 kg/m² ∅ 0.100 m
Diagr. no. 5 ——— Minimum pressure
220 kg/m² ∅ 0.100 m

GPO 82-8000896

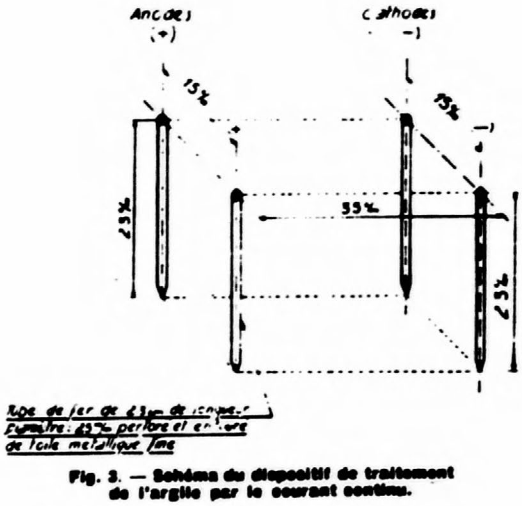

Fig. 3

Apparatus for the treatment of clay by means of direct current
Iron tube 0.23 m long
Diameter: 0.025 m, perforated and enclosed in a thin wire-gauze

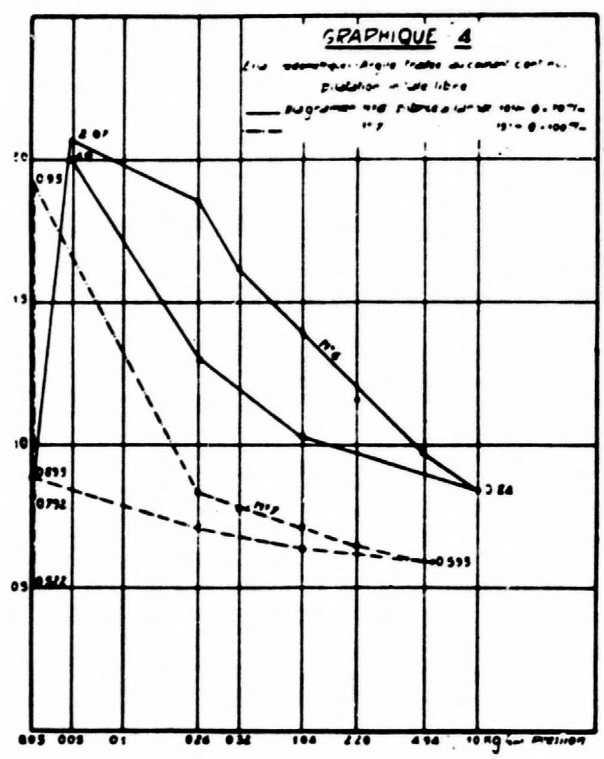

Fig. 4

Consolidation tests (clay treated by means of direct current)
Initial expansion free
____ Diagr. no. 6 distance from anode 0.10 m ∅ 0.070 m
·-·-· " " 7 " " " 0.15 m ∅ 0.100 m

GPO 82-8000896

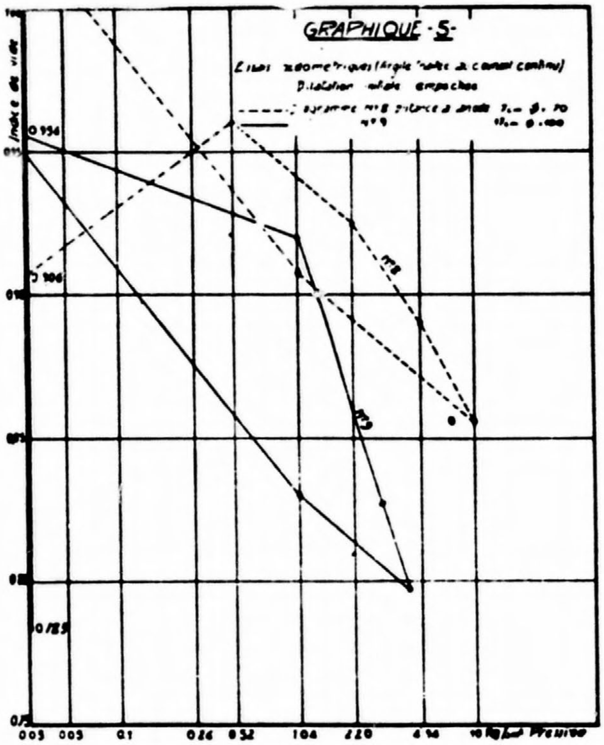

Fig. 5
Consolidation tests (clay treated by means of direct current)
Initial expansion restrained
---- Diagr. no. 8 distance from anode 0.07 m ∅ 0.070 m
____ " " 9 " " " 0.17 m ∅ 0.100 m

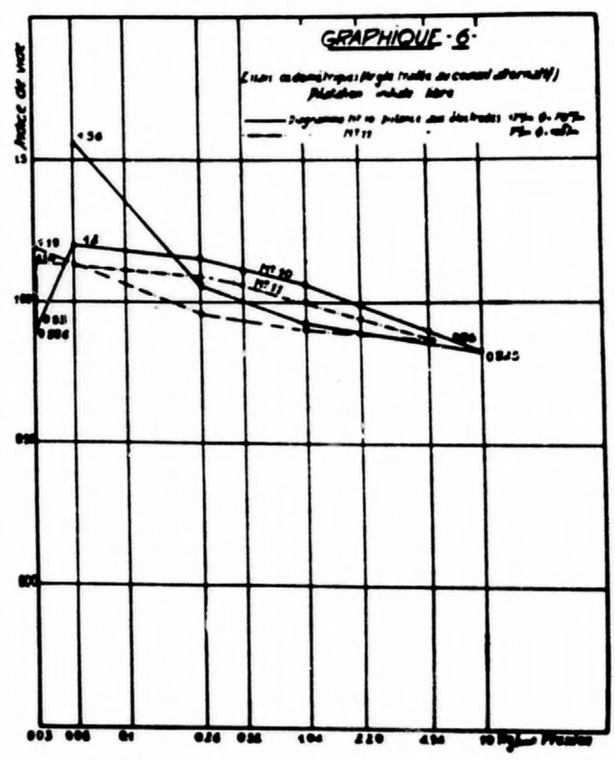

Fig. 6
Consolidation tests (clay treated by means of alternating current)
Initial expansion free
____ Diagr. no. 10 distance from electrodes 0.17 m ∅ 0.070 m
-.-.- " " 11 " " " 0.07 m ∅ 0.100 m

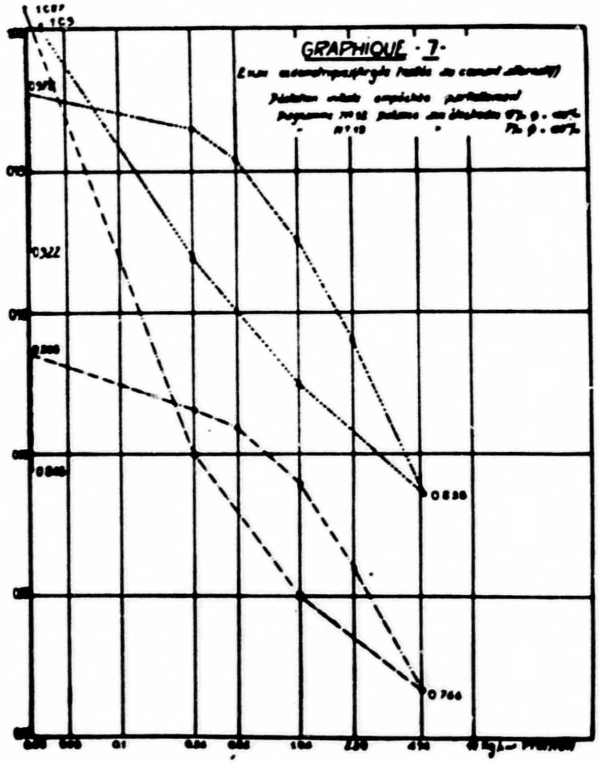

Fig. 7
Consolidation tests (clay treated by means of alternating current)
Initial expansion restrained

?	Diagr. no. 12	distance from electrodes	0.17 m	∅ 0.100 m
?	" " 13	" " "	0.07 m	∅ 0.100 m

GPO 82-8000896