SUBSIDENCE OF THE NORTHERN ABUTMENT OF THE RAILWAY BRIDGE ACROSS THE HOLLANDS DIEP

VI a 3

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When in 1945 the railway bridge across the Hollands Diep in the line Rotterdam - Breda of the Netherlands Railways was repaired, four spans of this bridge have been replaced by an earthen dam and a short connecting bridge, which is sustained at one side by one of the existing piers, and at the other side by a new abutment (vide fig.1).

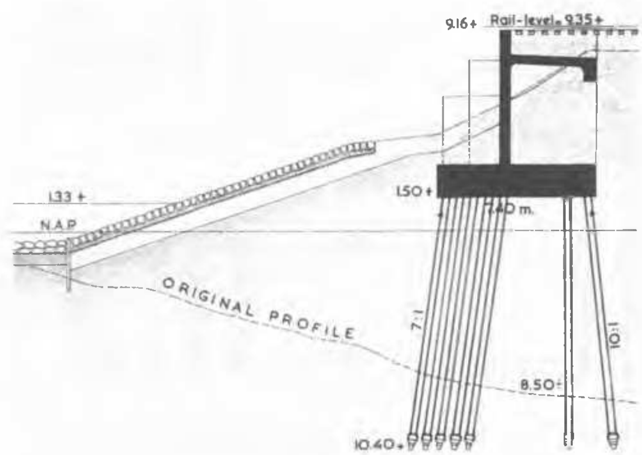


FIG.1

At the place of the new abutment the earthen dam belonging to these works has a thickness of more than 17 metres; it reaches from 9.- metres above N.A.P. (New Amsterdam Level) to 8.50 metres below N.A.P. The subsoil supporting the dam consists of slightly silted, fine grained sand, but from 17.30 to 22.15 m below N.A.P. there are cohesive layers.

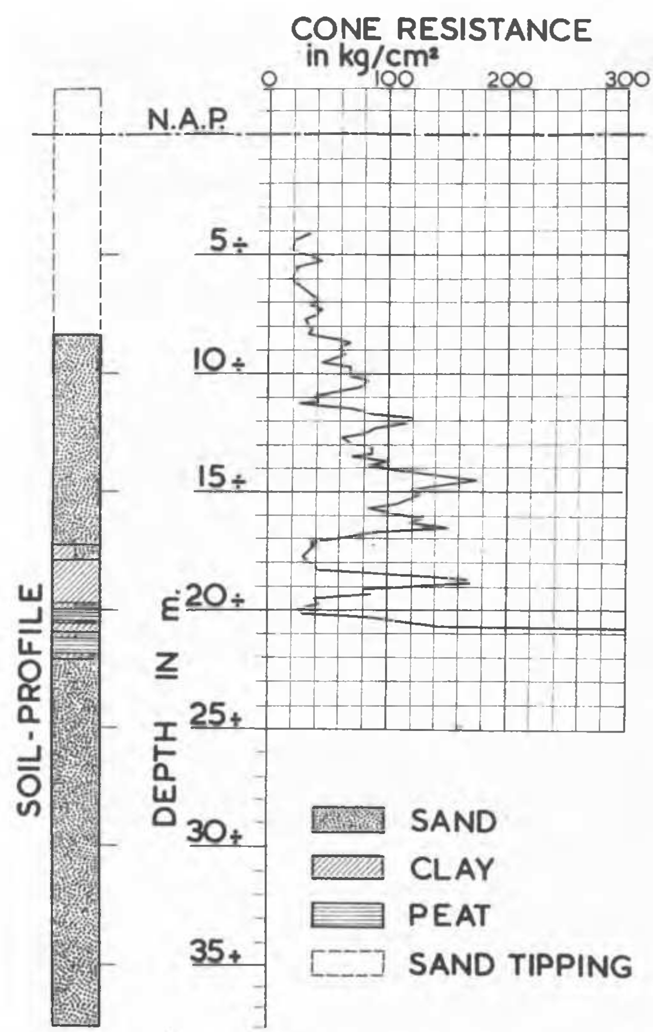
After considering the results of the investigation of the soil, it was decided to build the abutment on concrete piles with square shafts of 43/43 cm and reinforced feet of 55/55 cm at 13. - m - N.A.P.. The area of the feet of these piles amounts to 3025 sq.cm, the weight is 4½ tons.
The bearing capacity in equilibrium of the layers of soil at this depth, as it appears from the depth sounding test, is about 70 kg/sq.cm so that the bearing capacity in equilibrium of the piles is found to be 212 tons.

The dead load on the abutment causes a pressure of a pile on an average of 29 tons a pile. With live load this average becomes about 43 tons. In the most unfavourable position of the load the pressure of a pile may increase to 50 tons in some piles, but these pressures are only of a very short duration and moreover it is only very rarely that they occur.

The piles are loaded not only by the dead and live loads, but also by the negative friction along the aggregate of spaced piling as a consequence of the subsidence of the newly dumped road-bed. This was figured out at 34 tons a pile. The total load on the foot of the pile therefore is more than 68 tons.

It appeared, however, that the piles could not be driven in to a deeper level than, on an average of 10.40 m below N.A.P., with the rammer of the pile-driver which was available during the construction and which weighed 3 tons; during the last blows the average penetration of the piles was 0.28 cm at each blow. If the bearing capacity in equilibrium of the piles at this depth is calculated from the data of the depth sounding test, then 76 tons are found which load is quite near to the real load.

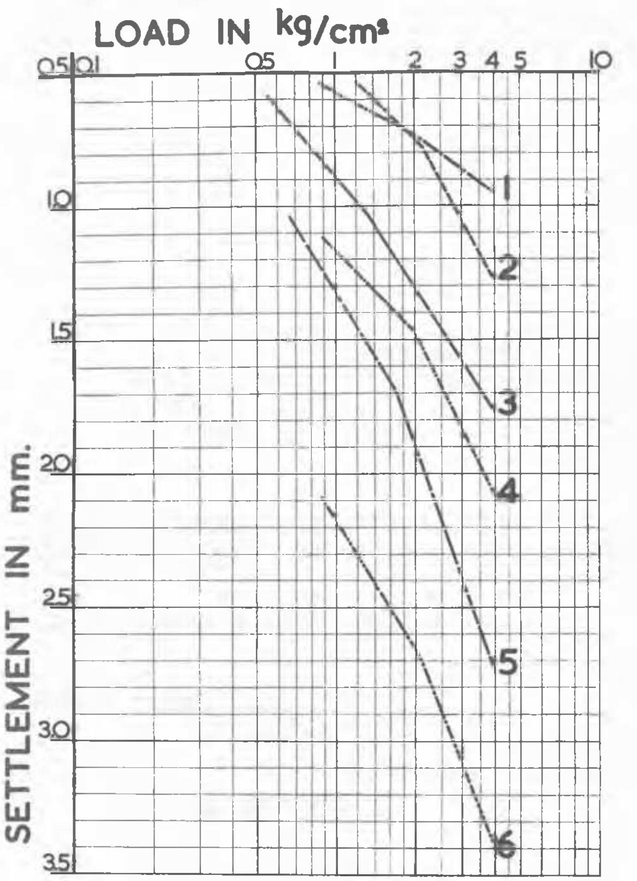
Experience, however, shows that the soil, if consisting of sand, usually is strongly compressed under an aggregate of concrete piles, so that there need be no fear for loss of equilibrium of the soil under the feet of the piles, also because, when calculating the bearing capacity in equilibrium, the minimum value of 25 kg/sq.cm which was shown by the depth sounding test, was applied. Certainty concerning this might be obtained by executing a depth sounding test between the aggregate of piles, for instance at the front of the abutment.



Deep sounding test.
FIG.2

The possibility, however, that the abutment will settle a little as a result of the presence of the cohesive layers from about 17 to 22 m below N.A.P. is by no means out of the question.

In order to obtain data concerning the properties of compressibility of these layers, undisturbed samples were taken from the boring depicted in fig. 2, which have been examined in the Laboratory for Soil-mechanics at Delft. The results of the experiments have been depicted in fig. 3.



SAMPLE 1 : SANDY PEAT 19.40+NAP c= 76.0/59.0
SAMPLE 2 : GREY CLAY 18.50+NAP c= 43.6/24.0
SAMPLE 3 : CLAY WITH PEAT 17.00+NAP c= 38.2/29.1
SAMPLE 4 : GREY FIRM CLAY 20.50+NAP c= 40.6/21.0
SAMPLE 5 : GREY CLAY 17.00+NAP c= 26.6/15.5
SAMPLE 6 : GREY CLAY 20.50+NAP c= 25.6/16.4

FIG.3

By means of these data the subsidences were calculated for the sub-soil as a result of the construction of the road-bed, as well as the additional subsidence caused by the load of the abutment.

This calculation started from the formula of von Terzaghi which runs as follows:

$$z = 2.3 \frac{h}{C} \log \frac{P_2}{P_1}$$

in which z is the subsidence,
h the thickness of the layer of soil,
C the constant of compression,
P_1 the original tension in the layer of soil in view, and
P_2 the new tension.

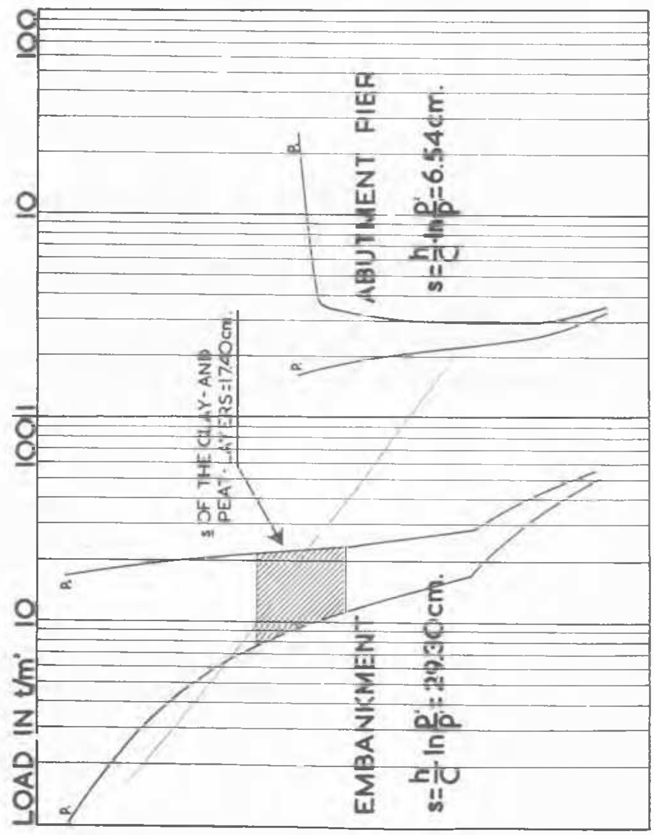


FIG.4 , 5

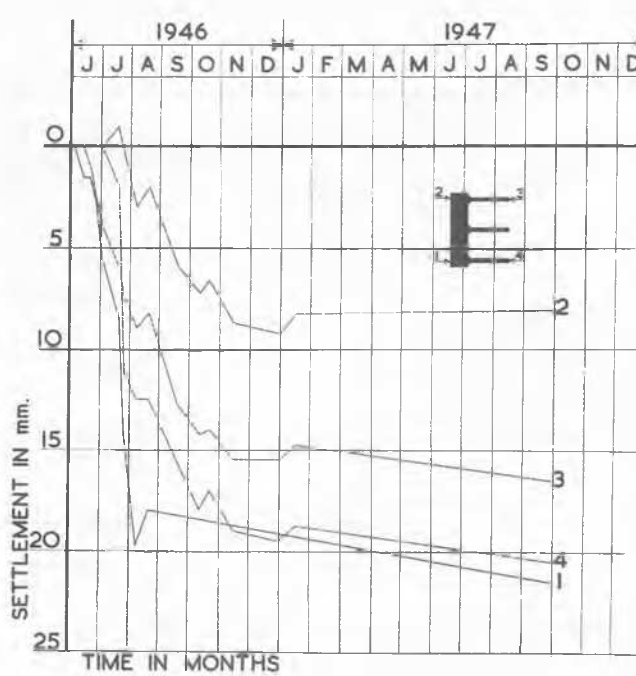


FIG.6

The subsidence of the sub-soil as a result of the construction of the road-bed was figured out at more than 29 cm (vide fig.4). It may be assumed that the part of this that corresponds with the settling of the layers of sand will practically have come about, before the beginning of the building of the abutment.

The subsidence caused by the compression of the cohesive layers to the amount of more than 17.4 cm would therefore - in so far as this has not been completed when the piles are being driven in - still have to be expected as a subsidence of the abutment.

According to calculations a subsidence of 6¼ cm must be expected to be caused by the new load on the sub-soil as a result of the building of the abutment.

The ultimate subsidence of the abutment since the beginning of building would therefore have to be between 6½ and 24 cm.

The measured subsidences have been represented in fig.6. The subsidence of the different points varies from 1 to 2 cm.

As appears from the form of the lines of subsidence, it is improbable, that there will be a subsidence of 24 cm, whilst to all appearance the minimum of 6½ cm will not be reached.

Hence we must suppose that the cohesive layers possess a higher coefficient of compressibility than was determined from the experiments and that the influence of the initial tension these layers will have had, has been lost during the sampling and the transportation of the samples.

The result of an experimental load executed on one of the piers of the same bridge points in the same direction.

During the period of repairs one of these piers, still sustaining the 2 bridges which caused a load on the foundation of 3300 tons, was loaded with rails having an additional weight of 1500 tons. The subsidences were observed for some months and amounted to no more than about 2 mm.

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VI a 4

SETTLEMENT OF AUXILIARY PIER NO. 5 OF THE RAILWAY BRIDGE ACROSS THE MAAS (MEUSE) NEAR VENLO.

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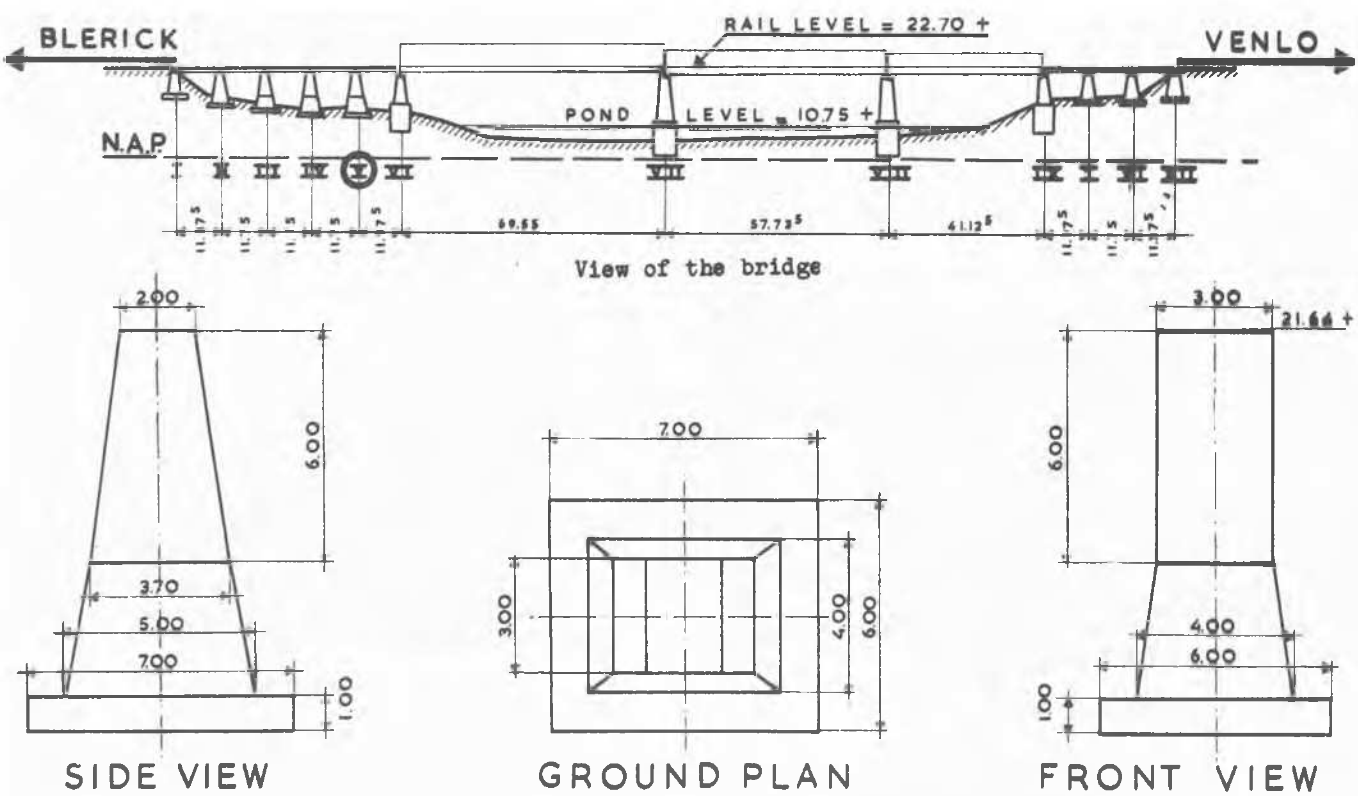
In 1945 when the bridge in the railway Arnhem - Venlo across the Maas was temporarily being repaired, some auxiliary piers ware built on the western bank. These consist of a bed and a body of the pier, both of them of concrete, and have a spread foundation. Most of the foundations rest on a formation consisting of river sand, but the foundation of pier 5 rests on a layer of clay.

A view and a ground-plan are shown in figl



Pier V.

FIG.1