NEW DEVELOPMENTS OF THE DUTCH CONE PENETRATION TEST

NOUVEAUX DEVELOPPEMENTS D'ESSAI DE PENETRATION A CONE ELECTRIQUE

НОВОЕ В ПЕНЕТРАЦИОННОМ ИСПЫТАНИИ ГОЛЛАНДСКИМ КОНУСОМ

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SYNOPSIS

The investigations of Begemann on the local friction, measured during the performance of the Dutch penetration test showed a caracteristic and reproducable ratio between the cone resistance and the local friction, measured close above the cone on a friction sleeve. The ratio was found to be caracteristic for the type of soil. With the mechanical cone the cone- and the friction resistance are measured discontinuously every 20 cm by means of a hydraulic gauge. It is difficult to determine the friction ratio because of the difference in depth of the cone and the friction sleeve, and because of the discontinuous reading of both values. The electrical cone makes it possible to measure the cone resistance and local friction continuously and to have the friction ratio computed automatically. With the so recorded friction ratio a more accurate friction ratio graph can be obtained from the cone penetration test, that makes a better comparison with the soil profile possible.

THE DUTCH CONE PENETRATION TEST

The Dutch cone test is performed by pushing a cone with a base of 10 cm2 with a velocity of 2 cm/sec in the soil and by measuring the force on the cone. For advancing the cone hollow rods are used with an outside diameter of 36 mm and an inner diameter of 16 mm in sections of 1 m. When using the mechanical cone penetrometer the load on the cone is transferred by means of solid inner rods with a diameter of 15 mm to the top of the string where it is measured with a hydraulic load cell and Bourdon gages. The cone can be advanced 8 cm by means of the inner rods and the value of the cone resistance is recorded for that interval.

After advancing the cone the outer tubes are pushed down 20 cm, over the last 12 cm of which cone and rods move together. The procedure is repeated and readings are thus obtained at depth intervals of 20 cm. Smaller steps are sometimes taken, with a minimum of 10 cm. A detailed description of the method is given by de Ruiter (de Ruiter, 1971). Begemann introduced the friction cone, that made it possible to measure the friction along a separate sleeve located about 25 cm above the cone. The sleeve has a wall area of 150 cm2 and a diameter of 35,6 mm. The sleeve can move together with the cone independently of the outer tubes. After advancing the cone by the inner rods over a distance of 4 cm the cone engages the friction sleeve and cone and sleeve move together over another 4 cm. The combined value of cone resistance and sleeve friction is recorded. Finally the outer tubes are pushed down 20 cm and take along the friction sleeve over the last 16 cm and the cone over the last 12 cm. In the electrical penetrometer the cone resistance and the local friction are both recorded by a load cell installed in the penetrometer. The electrical cone as used by Fugro has the same base area of 10 cm2 as the mechanical cone. The shape of the electrical penetrometer differs however from that of the mechanical being cylindrical instead of tapered. The friction sleeve is generally mounted directly above the cone; the sleeve has also a wall area of 150 cm2. The outer diameter is 3,56 cm so that the length of the sleeve is 11,2 cm. There is a principal difference between the penetration test with the mechanical cone and the test performed with the electrical cone. With the mechanical cone both cone resistance and local friction are measured by starting the movement of the cone and the sleeve from a stationary position. Before the next reading is taken the movement is interrupted. The electrical cone however is advanced simultaneously and continuously of a length of 1 m, this is the length of a single tube. There has been found no systematic difference between results of penetration tests with the mecnanical or the electrical cone as far as the cone resistance is concerned. The local friction however gives a marked difference between the results with the mechanical cone and those of the electrical cone.

FRICTION RATIO

There is found to be a correlation between the type of soil and the ratio of local friction to cone resistance as determined with the mechanical cone (Begemann 1965). The type of soil is defined by the percentage of particles smalter than 16 μ. The so called friction ratio was found to be constant for a particular type of soil, so that in a friction ratio versus depth plot a soil profile could be defined. By using the penetration test in this way a certain quantity of boringwork could be saved in field investigation. With the computation of the friction only reasonable results are obtained in rather homogeneous soil layers. If a great variation of layers occurs it is very difficult to take together the cone resistance and the corresponding value of the local friction. With the mechanical cone inaccurate results origins also from the fact that the local friction is obtained by subtracting the cone resistance from the combined value of cone resistance plus friction and because tne values of cone resistance and local friction are not measured exactly at the same level. A further development of the sustem is obtained by recording the cone resistance and the local friction on a punch tape. This makes it possible to perform the necessary computations with a computer and to plot tne results automatically. The digital installation with the puncher is mounted on the sounding truck and produces eigth channels in the tape. The installation now in use by the company of the author can produce three different tapes namely cone resistance combined with local friction, cone resistance only and cone resistance combined with total friction. Every 2 cm of penetration the values are punched in the tape. The tapes are labelled by the puncher, so that no confussion can result. The tapes are operated by a computor, type PDP-8E of the Digital Equipment Corporation, provided with a 4K memory with the possibility to extend it to 32 K. The computor is served by a frontpanel, teletype ASR33 and fitted with a high-speed reader. This provides a high working speed. The output of the computor feeds a plotter, type Calcomp with a stepincrement of 0,1 mm. With the above described system the graphs are automatically completely plotted with all the necessary texts on the sheets. The friction ratio graph can be produced also, by programming the computer with it. Because of the length of the friction sleeve of about 11 cm average value of 6 readings of the cone resistance is compared with one reading of the local friction. By doing this an accurate computation of the friction ratio is obtained with the average of the cone resistance over the full length of the friction sleeve.

TEST RESULTS

In fig. 1 the result of one of the tests is produced. On the graphs are plotted the cone resistance, the local friction and the friction ratio. The quotient of f/c x 100 is plotted on a scale of 1:1,25. For the upper sandlayer a value of 0,5-1% is found, corresponding with a value of 200-100 of the reciprocate value as given by Begemann. The same values are found for the deeper sand layer, where the lower values correspond with a somewhat coarser sand. The values found in the cohesive layer between the upper and lower sand layers give a greater scattering of the results. The hard peat layer found at the top of the deep sand has a very pronounced friction ratio and can be analysed clearly from the results. The friction ratio has a maximum value of about 14%, corresponding to 7 of the reciprocal value. For the layers between 9 m and 10 m - 12,3 m and 13,5 m - a low value of the friction ratio is found of about 0,5%. The above mentioned layers are according to the boring result consisting of sandy clayey silt with a content of particles 16 μ between 20 and 40%. The values for the friction ratio do not correspond with those derived from the relation ship given by Begemann. The reason of this difference may be found in the relatively smaller accuracy of the measuring system for the lower values of the cone resistance and of the local friction. Although the accuracy of the electrical cone is higher than that of the mechanical cone the test results give the indication that the normally used load cells with a total capacity of 5 t for the cone resistance and of 0,75 t for the local friction only give reliable results for a local friction greater than 0,5 kg/cm2 and a cone resistance greater than 10 kg/cm2. The friction ratio graph shows however much greater differences in the cohesive layers, than is found in either the cone resistance or in the local friction graph. If more sensitive load cells are used, more accurate results are expected to be achieved.

CONCLUSION

The determination of the friction ratio in the cone penetration test by means of registrating the values on a punch tape and operating them by a computor gives an accurate graph of the friction ratio with the depth. For soft layers however the accuracy of the normally used load cells is not enough to produce sufficient limited results, in such a way that a reliable determination of the soil layers could be obtained. The use of more sensitive laod cells is necessary in soft layers, in order to produce reliable results, for the determination the soil profile on the basis of the friction ratio.

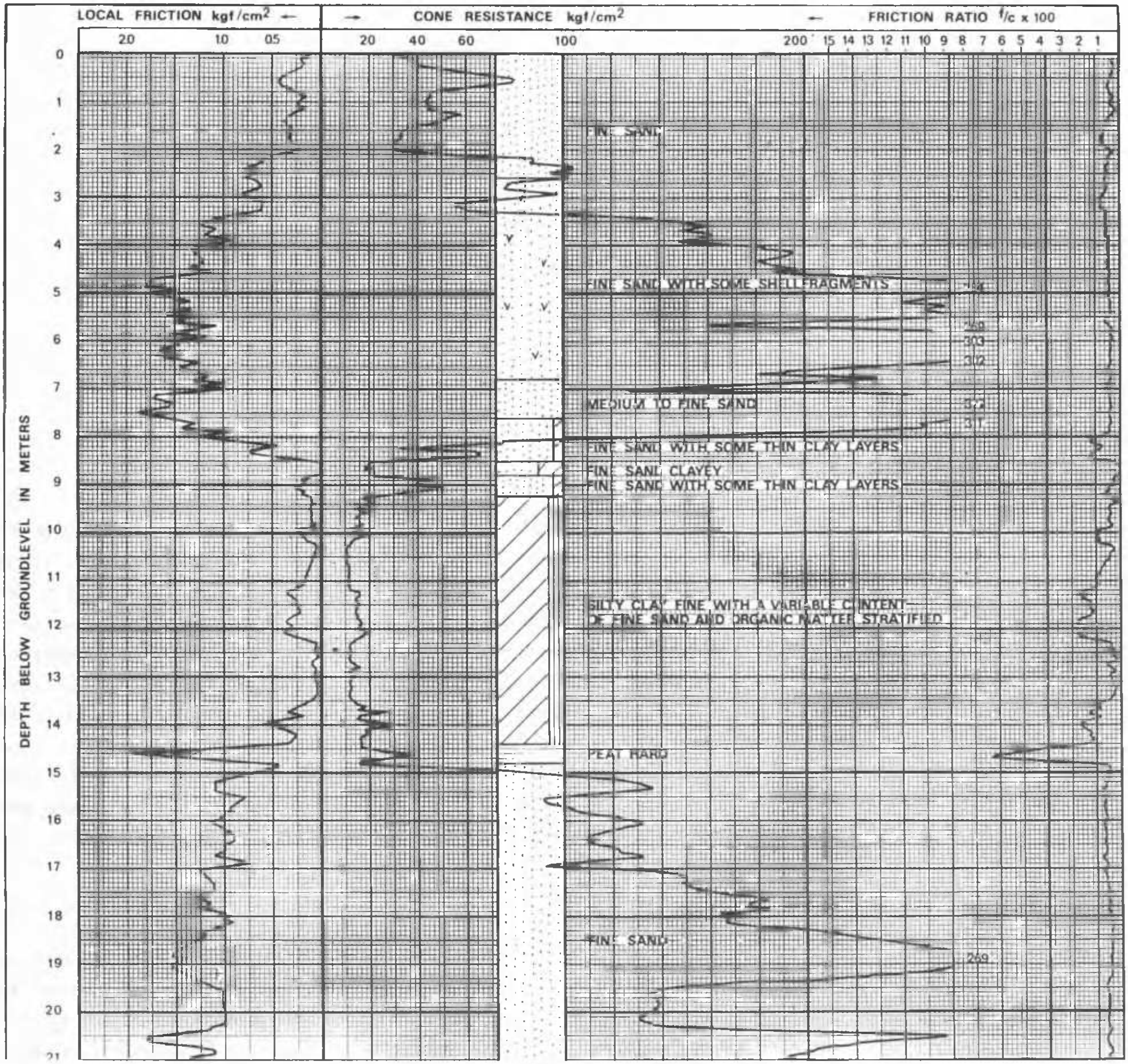

Fig. 1 Cone penetration test with local friction and friction ratio.

The tapes with the cone resistance can be used easily for performing other computions on the test results, such as determining the bearing capacity of end bearing piles in dense sand layers.

REFERENCES

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