CONTRACT REPORT

DET NORSKE VERITAS

COMMENTS ON THE TENSION PILE PLANNING STUDY CNRD 13-1

81222-1 6TH OCTOBER, 1981

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CONTENTS:

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1. SUMMARY

The final reports on the Tension Pile Planning Study, CNRD 13-1, Ertec Inc. report No. 81-204, and Veritas report No. 10-0587, both dated 28th August, 1981, has been reviewed. Our comments with respect to the field tests that are to be carried out by Ertec Inc., are:

- The soil investigation program should be somewhat increased with respect to number of tests and type of tests. We think the opportunity of unusually good sampling conditions (fixed platform) should be utilized.

- Prediction of the large scale test pile capacity and deflection behaviour is necessary for design of loading arrangement and to ensure that the pile stiffness is as preferred compared to the actual tension pile. The pile flexibility will influence the testing program and results.

- A detailed testing program is missing. We do not fully agree with the general descriptions that are outlined in the report. More attention should be put on the number of cycles and stress level applied up to failure. A detailed program should be proposed at the earliest stage possible for a discussion of all aspects.

Concerning the laboratory model pile tests, that are to be carried out by Veritas, we have the following comments:

- The loading program proposed seems to be close to what our intensions of such a test program would be.

- The tests can easily be repeated and give the opportunity of parametric studies. We think, however, the tests can only aim at general conclusions with respect to the behaviour of

NGI

laboratory model piles in clays under cyclic loading. One should not expect that the tests provide results that can be extrapolated to the actual pile and soil conditions directly.

2. TESTS PROPOSED BY ERTEC INC.

2.1 FEASIBILITY OF FIELD TESTS

The principle of using one large scale test pile and a number of small scale segment test piles may be useful. The alternative to this could be instead of pile segment tests to drive a number of uninstrumented piles of smaller diameter (Ø 20 cm) to full depth and perform a test program on these piles. The effect of the axial stiffness of the pile can be taken into account.

2.2 FIELD TEST SITE SELECTION

We are agreeable to the selection of site, West Delta, Block 58.

The boring profile, plate 12, indicates three different intervals with possible homogeneous clays.

Depth interval 8 - 12 m:

$$\left.\begin{aligned} w &= 72\% \\ w_p &= 30 \\ w_L &= 87 \end{aligned}\right\} \quad I_p = 57 \qquad I_L = 0.74$$

Depth interval 30 - 47 m:

$$\left.\begin{aligned} w &= 40\% \\ w_p &= 24 \\ w_L &= 57 \end{aligned}\right\} \quad I_p = 33 \qquad I_L = 0.48$$

Depth interval 53 - 62 m:

$$\left.\begin{array}{l} w = 60\% \\ w_p = 30 \\ w_L\ 0\ 90 \end{array}\right\} \quad I_p = 60 \qquad I_L = 0.50$$

2.3 RECOMMENDED FIELD TEST PROGRAM

Phase 1, small diameter segment tests

The segment tests should preferably be carried out in the three above-mentioned depth intervals with homogeneous clays.

Items to be considered and possibly tested out,

- effect of degree of soil displacement, open ended - closed ended pile,
- reconsolidation time,
- combination of number of cycles and stress level to failure,
- cyclic period, drainage during testing (possibility of measuring cyclic pore pressures),
- regain in capacity after different degree of cyclic loading (preshearing effect, increase or decrease in capacity),
- stress/or strain/controlled tests.

It will not be possible to cover all this in the testing program, and preference must be given to what is considered to be the most important ones. It was mentioned in the meeting 9th September, 1981, that 3 pile segment probes may be available for simultaneous testing. The number of depth intervals to be tested and the required consolidation time before each test will determine the

NGI

time schedule. In our opinion a couple of months may be required, instead of two weeks as indicated in the program.

We will draw special attention to step 6 (page 64) in the testing program as it may reflect some of the basic philosophy. It reads:

"Step 6. Load to failure in tension, followed by a number of cycles to failure alternating between tension and compression, until the cyclic degradation process is completed."

The effect of full degradation is only of interest for the upper part of a flexible pile. The basic study should in our opinion be related to the effect of cyclic loading in relation to stress level and number of cycles. If possible it should also include effect of one - or two-way cycling, cycling period and drainage taking place during testing. Long term test (creep test) on the pile segments should also be considered.

Phase 2, large-scale test pile

The static load test immediately after driving is in our opinion not of very great importance and should be omitted if not done within a couple of hours after driving. Driving resistance may give adequate indication of the static bearing capacity of the pile at the end of driving.

The static capacity of the pile prior to "second test series" which is cyclic loading, is however, very essential. For a stiff pile the capacity can be determined with small strains if the rate of deformation immediately after each loadstep is plotted. The test could then be terminated at small strains, possibly without influencing further test results too much.

The test pile with 12,7 mm wall thickness will be rather flexible, and it may prove difficult to determine the static capacity without influencing the results of further testing.

NGI

Advantages and disadvantages of using a stiffer test pile should be evaluated.

The detailed program for "second test series" has not been worked out yet. Discussion of this program should in our opinion be carried out at a very early stage, and the program worked out in detail. As only one test pile is available, the program and sequences of testing becomes very important. Preliminary calculations of capacity and deflection should be done based on present knowledge of site conditions. Proposals and discussions of testing program both for segment tests and test pile, should be started on this basis, and may be subject to alteration as more soil information becomes available. It is possible that Ertec and NGI have somewhat different views on how the tests should be run, and this should therefore be discussed at an early stage.

Points to be considered:

- Static tension to be applied. Magnitude and duration of each load step.

- Cyclic loading.

  a) Two way cycling, loading and unloading from static load (all tension load).

  b) Period. Storm conditions in the Gulf has to be considered. Wave period, duration of storms (the ability of total and pore pressure cells to record during a cycle).

  c) Preferable number of cycles up to failure.

  d) Drainage during testing period.

  e) When to stop the test. This will depend on further testing program. It is possible that a limited number of cyclic loading at moderate stress level (preshearing) will improve the capacity, while a loading to complete failure will reduce future capacity. This has to be evaluated on basis of phase 1 results.

NGI

f) The relative pile stiffness should be evaluated.

g) Relative soil displacement during test pile installation will be larger than for the actual platform piles. The solid part of the test pile is approximately 20% of the cross area. Partially plugging has to be evaluated and measured.

From what is said under "second test series" on page 64 and 65 we have the impression that Ertec intends to apply few cycles and adjust the program depending on the results obtained. They possibly intent to cycle to full degradation and then apply a static pull out test. Our proposal will rather be to plan for more cycles and to stop cycling when indication of failure occur and then maintain a static tension load up to the time of the third test series (creep effect). The third test series should be comparable to the second test series and follow the same pattern up to indication of failure.

In the report received so far no evaluation of the static tension capacity of the test pile and the corresponding deflection along the pile before failure has been given. We feel the want of these estimates. The result will be the basis for design of the loading arrangement and the evaluation of the pile stiffness being as preferred.

2.4 SOIL SAMPLING AND TESTING PROGRAM

As research project intending to give basic information and results it is important to determine the soil properties as comprehensive as possible. This can be done by in situ tests and laboratory test on both undisturbed, disturbed and remoulded samples.

Pore pressure. In order to interpret the test results it is necessary to know the natural pore water pressure and the effective

NGI

overburden pressure. The possibility of underconsolidation has been mentioned.

4 to 5 piezometers distributed down to approximately 65 m depth should be installed and read during the testing periods.

Cone penetration test. Standard equipment should be used, 10 cm^2 electrical cone with friction sleeve. Preferably two tests should be done with spacing 10 to 20 m, one on each side of the test pile.

In addition we consider it to be very useful to carry out a piezocone test. This should (preferably) also include measurement of in situ permeability at 4 - 5 m depth.

Vane test. As it may prove difficult to obtain undisturbed samples due to gas in the soil, it is important to have in situ vane shear strength values. The tests should be carried out with standard vane and procedure. Readings should be taken at one metre depth intervals along the entire pile length. Remoulded strength should also be recorded, giving the sensitivity.

Similar to the cone testing we consider it useful to carry out 3 vane tests at 10 - 20 m spacing, in order to evaluate the homogenity of the sediments and the repeatability of the vane test results.

Pressiometer test. It is possible that pressiometer tests will be more frequently used in the future for projects of this type, but we will at present not insist on this type of test being carried out.

Soil sampling program

The main purpose of obtaining undisturbed samples will be to determine the preconsolidation pressure, p'_c, and the overconsolidation ratio, in addition to the shear strength parameters and the compressibility.

NGI

Undisturbed samples are best obtained by using a fixed piston sampler, and the fixed platform offers a good opportunity to use this type of sampler.

The diameter of the sampler and the number of samples will depend on the intended laboratory program.

The full program would require approximately 3 days it is said, but we assume 2 - 3 weeks will be necessary for in situ testing and sampling down to 70 m depth.

Laboratory testing program

As classification and reference tests we envisage the following tests carried out; natural water content, plastic limit, liquid limit, bulk density, specific gravity, organic content, grain size distribution and fall cone tests on undisturbed and remoulded samples giving sensitivity.

Other tests that should be carried out are,

- consolidation tests with direct measuremen of permeability,
- triaxial tests with pore pressure measurement and plotted as stress paths,
- simple shear tests.

At least simple shear tests should include cyclic loading.

Special tests should also be carried out on disturbed and remoulded reconsolidated samples. Ring shear test may be carried out in order to determine residual friction angle.

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3. TESTS PROPOSED BY VERITAS

We are agreeable to the model pile test program proposed in Chapter 6 of Task 3, "Laboratory test planning". Veritas' philosophy with regard to effect of cyclic loading on the mobilization of skin friction along a pile wall seems to be close to NGI's. We think it is important to put the attention on the number of cycles and the stress levels applied, in order to evaluate the remaining capacity for different loading histories, and not only the residual capacity after repeated two ways failure loadings, even if the latter also is of interest.

Instead of only multistage cyclic tests we would recommend some tests carried out with selected static load levels superimposed by a constant cyclic stress amplitude.

Tests with different combinations of static level and constant cyclic stress amplitude may give a more basic relationship between the static level, cyclic level, number of cycles and the effect on the skin friction. Decision on number of cycles on the different stress levels has to be made in the multistage tests. The tests recommended here can also serve as a guide for the loading procedure of the multistage tests.

The tests proposed by Veritas have the advantage that they can relatively easily be repeated and thus provide good testing conditions for parametric studies. More general effects of cyclic loading on clays can be analysed. We think, however, one should not expect that these tests will provide results that can be extrapolated directly to the actual test piles and soil conditions. As a tool for measurements of characteristic behaviour of clays surrounding a pile under cyclic loading, one may install the test pile as well in remoulded and reconsolidated clay sample as in "undisturbed" samples.

for the
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