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Dynamic Detections of the Quality of Piles

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SUMMARY

The aim of this paper is to present an economical,time-saving and nondestructive dynamic method to replace the conventional static loading test for the detections of the bearing capacity and the quality of piles. On this basis,a method for evaluating the stress distributions in the cap-beam on piles is recommended. This can be of service to the construction analysis,decision making and implementation of the quality assurance in practice.

1. VERTICAL DETECTIONS

1.1 Determination of the Bearing Capacity of Friction Piles

The basic procedure for evaluating the bearing capacity of a friction pile is to measure the vertical frequency f_v and/or the velocity v_o of the pile excited by a vertical impact. Substituting f_v and/or v_o into the following formulae [1], [2], we can get the bearing capacity P_a of the pile:

$$P_a = \frac{0.06687\ (Q_1 + Q_2)\ (f_v)^2}{K \cdot g}$$

or

$$P_a = \frac{0.03\ f_v^2\ (1 + e)\ W_o \sqrt{H}\ K_v}{K \cdot v_o}$$

By the latter,the information of soil and pile is unnecessary in the calculation. This method has stood a number of comparison tests and more than three thousand trials in practice.

1.2 Stresses in the Cap-beam on Piles

By the use of static testing,the influence of the variability of the behavior among piles on the stress distributions in the cap-beams is very hard to inspect. We know more or less the why,and endevour to know the how,but published articles on this problem were very scarce [3]. This uncertainty causes the waste of money by unduly raising the factor of safety. Until 1977,Dr. A. Evangelista et al presented some experimental evidence about the influence of the variability of piles on the design of cap-beam [4]. According to these data,statistic analysis showed that the scattering of stresses was found to be rather significant. The value of this pioneering contribution should be highly appreciated. It revealed quantitatively the influence in that case. However,the principal method used by them in determining the bearing capacity

of piles was the static loading test. This will prevent us from simulating their research in engineering practice,on account of the cost and the time consumed in the test,in addition to the possible damage to the piles.
On the basis of dynamic testing of piles,the calculation of the practical stresses in the cap-beams can be carried out as follows: The compliance of the pile Y_{kk} may be resonably expressed as

$$Y_{kk} = \frac{1}{10P_a}$$

The deflection coefficient V_{ki} of the cap-beam is

$$V_{ki} = \frac{c^3}{6EI} \left(\frac{S_k}{c} \right)^2 \left(\frac{3S_i}{c} - \frac{S_k}{c} \right)$$

Y_{kk} in combination with V_{ki} froms the displacement coefficient δ_{ki}:

$$\delta_{ki} = V_{ki} \text{ , and } \delta_{kk} = Y_{kk} + V_{kk}$$

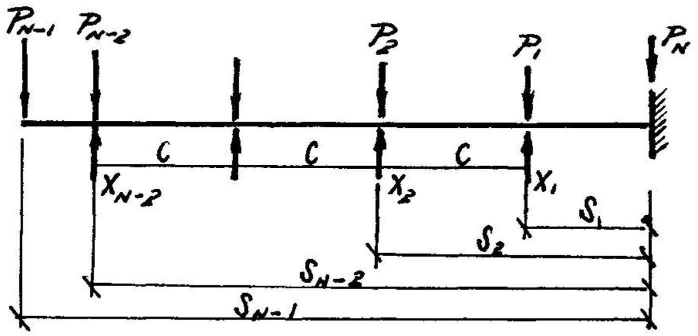

Fig. 1 The sketch of a pile-foundation

A pile-foundation shown in Fig. 1 can be properly simulated by a Winkle-type model. The corresponding simultaneous equations in the contracted form can be written as

$$\begin{cases} X_1 \delta_{k,1} - X_2 \delta_{k,2} - \cdots\cdots - X_{N-2} \delta_{k,N-2} - S_k \varphi_o - \Delta_{kP} - Y_o = 0 \\ \qquad (k = 1,2,\ldots\ldots N-2) \\ \sum_{1}^{N-2} X_i - \sum_{1}^{N} P_i = 0 \\ \sum_{1}^{N-2} X_i S_i - \sum_{1}^{N-1} M_P = 0 \end{cases}$$

This can be solved by a personal computer. There is a program available. The output is the axial forces (X_i),bending moments (M_i),shearing forces (Q_i) and settlements (Y_i) at pile heads as well as their diagrams. It is quite possible to perform the dynamic testing to determine the bearing capacities P_a of all the piles under the cap-beam. However,if only some of the representative piles have been tested,these experimental data can be dealt with by least square. By means of random number generator of a computer, 100 or more random distributions of possible compliance of the piles can be generated. The corresponding superposed stress diagrams of the cap-beams can be drawn consecutively by the computer to show the possible extent of the influence due to the variability of the behavior of the piles,as illustrated in the Poster. The author has made use of these diagrams in designing work in lieu of conventional approximate calculations. Both economy and safety are secured.

2. HORIZONTAL DETECTIONS

2.1 Determination of Horizontal Parameters of Piles

By means of horizontal dynamic testing, 16 parameters of a pile can be determined with K_x and β,which are in terms of measured horizontal frequency f_x [1], [2] :

$$K_x = 25.29 \frac{f_x^2 W_e (1 + e) L' \theta}{v_o T} K_h ;$$

$$\beta = \sqrt[4]{\frac{K_x}{3 \eta EI}}$$

2.2 Detection of Cracks

The cracks in the upper portion of a pile can also be detected by the dynamic method. Soon after a horizontal impact is applied to the pile head,a waveform will be recorded by the oscilloscope in the form of one of the three categories (cf. the Poster). According to the shape,amplitude,frequency and the time-decaying of the waveform,we can predict the presence and the extent of the cracks. Among thousands of engineering piles detected by this method,more than two hundred piles were unearthed to check the reliability of the criteria. The accuracy was found to be 95%. So, this method enjoys wide support in China.

3. ACKNOWLEDGEMENTS

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