Anchors for testing piles

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'Action and reaction are equal and opposite' - it is a well-known fact, but provision of this reaction to allow for the testing of piles can be costly and difficult. Whether the pile test is 100kN or 10,000kN, naked or vertical, on land or over water, the reaction must be available to allow application of loading by normal jacking techniques.

Kentledge is generally the first type of reaction that comes to mind. It has long been considered the old favourite but clearly has economic and practical limitations particularly for high load and raker tests. Utilisation of anchors or tension piles may solve the practical problems and avoid the escalating costs associated with the haulage of kentledge. Where ground conditions allow mobilisation of high values of shaft friction, not at too great a depth, then tension piles may be favoured, particularly when the contractor has a suitable piling rig already on site. However, when such rigs are not available, or the test piles are founded deep through weak overburden, then anchors may provide the most attractive solution.

The initial consideration in the use of anchors is the clearance requirement between the anchors and pile such that the loaded anchor does not influence the pile behaviour. Published data on this topic is extremely limited but Figure 1 presents the most useful available guide. Positive debonding of tendons adjacent to the pile eliminate anchor/pile interference and ensure uniform load/extension characteristics and thus even load distribution among the anchors.

When designing the anchor system it is appreciated that the maximum anchor working loads are limited by the reaction requirements of the pile test, thus a relatively low factor of safety is acceptable. The 'Draft for Development for Ground Anchorages', recommends a safety factor of 1.4 when anchors are designed for use in pile testing.

Individual anchors may be designed in accordance with empirical rules although the designer must be fully aware of the influential nature of the construction techniques on the anchor capacity. Few guidelines for the design of a group of anchors are available but two possible approaches may be considered, each with its own possible limitations. If group capacity is estimated using the interacting inverted cone method, which is generally applicable to rock anchors only, then it appears that the group anchor failure mechanism may influence the pile behaviour. This is a probable shortcoming of this simplistic conservative approach to group anchor behaviour in which the rock shear strength on the cone surface is neglected. A more rational approach, generally applicable to soil anchors, is to ensure that the minimum anchor free length exceeds 5m and that there is provision for adequate spacing of the fixed lengths of the anchors such that each anchor will fail by an isolated 'tunneling' mechanism. Unless several rows of anchors are proposed a spacing of 2m is suggested. Although the construction of fixed anchor lengths at staggered depth can, in certain instances, be beneficial, it is not recommended in pile tests unless overloading of the shorter anchors is prevented. This can be achieved by the installation of tendons with the elastic modulus proportioned to the debonded length multiplied by steel area.

![Diagram](image)

**Fig. 1.** A consideration in the use of anchors is the clearance requirement between anchors and pile so that the loaded anchor does not influence pile behaviour.

### Anchor Distribution

The actual anchor layout and anchor inclinations at ground level are controlled by the number of anchors, the pile clearance requirements and the provision of a safe loading arrangement on the test rig. Fixed lengths of anchors founded within the pile length must be sited away from the pile as defined in Figure 1. This may be attained by either the use of a very low test rig or by raking the anchors away from the pile. The latter solution allows the use of a shorter test rig or the possible circular distribution of anchors raking in a radial direction. When anchors are founded below the pile toe then lateral clearance from the pile is reduced, again allowing the use of a shorter test rig and anchors with low take. The most common test rig arrangement involves a number of parallel beams allowing the installation of a single or double row of anchors and incorporation of a number of cross beams for the installation of outrigger anchors (Fig 2). Clearly the anchor distribution must be symmetrical about a pile centreline to ensure rig stability during the test. The use of anchors in a single line
through the pile centre is not recommended since lateral stability is often in doubt. Figure 3 illustrates the circular distribution of anchors but this arrangement is more generally applicable to very short anchor or tension pile systems where the anchor extension during loading is small.

In most instances the debonded lengths of the anchors are considerable. This inevitably results in large tendon extension. If these anchors are not prestressed the test rig may even lift as much as 200mm during testing. Such movement cannot be accommodated by the ram travel of a normal testing jack and therefore becomes unacceptable. Consequently a significant proportion of the anchor load should be prestressed against a bearing pad below the test rig prior to commencement of the pile test.

A typical supporting beam and bearing pad arrangement is shown in Figure 2. The bearing pad should be located some distance from the pile to prevent the ground bearing pressure influencing pile behaviour, although it should be realised that the bearing pressure will reduce to zero prior to application of the full pile load. In addition to uniform stressing of the anchors it is prudent to test a number of the anchors to full working load during these preliminary operations. Proof loading of outrigger anchors may jeopardise the stability of the test rig but in line anchors may be individually loaded quite safely.

TESTING RAKER PILES

The use of "stiff" tendons in short anchors or tension piles may allow reduction or omission of these pre-loading operations but the adequacy of the anchors or piles and their behaviour under load must be known prior to use.

The testing of raker piles may present special problems, particularly during test rig and support beam assembly. Figure 4 details a satisfactory system of raked anchors incorporating an inclined test rig to allow the completion of safe and economic pile testing. However, it should be noted that when pile rake becomes high, attention must be paid to the horizontal component of force present during the prestressing of anchors against the support beams and bearing pad.

SAFETY ASPECTS

Irrespective of preliminary operations and the test rig arrangement, it is essential that the rig
behaviour is observed and its stability assessed throughout the testing of a pile. The lift of the test rig away from the support beams should be uniform and the gap should be wedged as a precautionary measure. It is also frequently necessary for site personnel to be present at the pile cap to record pile settlement and load readings, thus the collapse of a test rig could have extremely serious consequences. Although anchors can frequently satisfy the reaction requirements of a pile testing operation, as with other systems, the safety aspects should always be checked and never assumed.

REFERENCES
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