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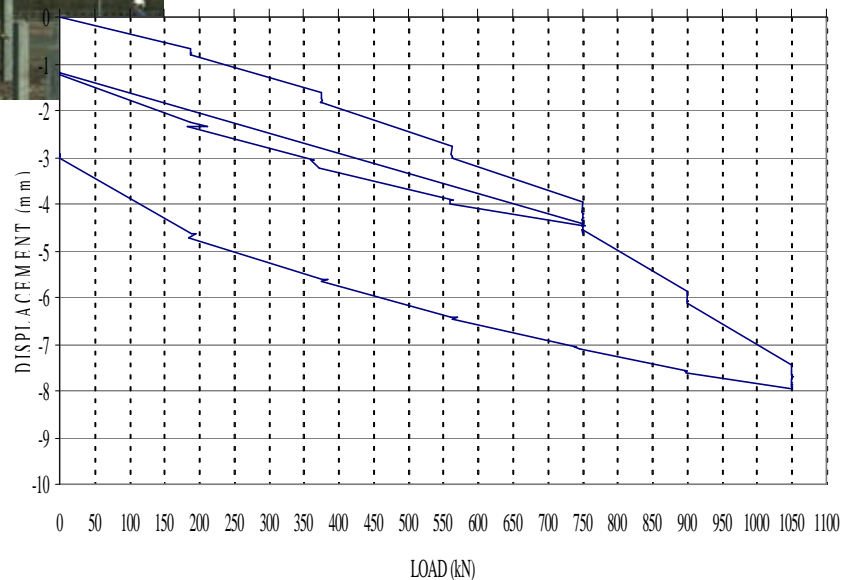
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Federation of Piling Specialists

Handbook on Pile Load Testing



Foreword

This handbook was published in March 2006 by the Federation of Piling Specialists (FPS) to provide guidance on the principles and practical issues that relate to load testing of bearing piles, and thereby to assist informed decisions about testing requirements on construction projects involving piled foundations.

The FPS anticipates that this handbook will be of particular interest to civil or structural engineers with little or no experience of piling who find themselves in the position of specifying load testing requirements on a project involving piled foundations. The target audience for this publication also includes main contractors, management contractors and young piling engineers.

The handbook was prepared for publication by a working group comprising the following representatives of FPS member companies: -

Bob Handley	Aarsleff Piling (Chair)
Jon Ball	Roger Bullivant
Andrew Bell	Expanded Piling
Tony Suckling	Stent Foundations

The Safety and Training Forum of the FPS were invited to review the final draft of the handbook, in particular the chapter on safety. Their suggestions and comments (for which the working group are most grateful) have been incorporated into the finished handbook.

The FPS acknowledges, with thanks, information and photographs contributed by the following: -

Aarsleff Piling
Dr. Michael Brown, University of Dundee
LOADTEST
Precision Monitoring & Control (PMC)
Roger Bullivant
Stent Foundations

Ken Cameron and Martyn Ellis of PMC carried out an independent review of the final draft of the handbook, for which the FPS wishes to express its thanks.

To the fullest extent permissible by law, the FPS, the authors of, and contributors to this handbook each disclaim all responsibility for any damages or losses (including, and without limitation, financial loss, damages for loss in business projects, loss of profits or other consequential losses) arising in contract, tort or otherwise from any action or decision taken as a result of using this handbook.

Chapter 1 Introduction

Year on year, load testing of bearing piles represents an estimated 4 to 6% of the total value of the UK piling market. The cost of load testing on individual contracts can vary from zero in many cases to as much as 10% of the value of the piling works. One aim of this handbook is to provide guidance on an overall strategy with the aim of promoting better specification, planning and execution of pile testing.

A lack of clear objectives often means that expenditure on load testing may be at best poorly allocated or at worst wasted. The testing requirements may well be set simply to comply with the relevant regulations and to follow “common practice”, rather than to promote “best practice”.

The ability of load testing to play an important part in value engineering and the geotechnical and structural optimisation of foundation solutions should be recognised not only in financial terms, but also with regard to sustainability.

It is important, therefore, that load testing of piles is factored into the project cost plan and programme at an early stage. The programme should allow sufficient time for an objective appraisal of the test results and subsequent design revisions/value engineering to be carried out.

A lack of clear objectives and understanding combined with poorly specified requirements can lead to problems that could have been avoided. Examples of such problems are: -

- Insufficient time to carry out tests and to evaluate the test results
- Lack of flexibility in the testing regime
- No provision for value engineering
- Unrealistic performance criteria specified
- Inappropriate test method specified
- Load test conditions are not representative of the working piles
- Piles infrequently loaded to failure

Pile load testing provides an opportunity for continuous improvement in foundation design and construction practices, while at the same time fulfilling its traditional role of design validation and routine quality control of the piling works. In order to achieve this improvement, data from pile tests has to be collected and analysed to enable the piling industry, both individually and collectively, to make the best use of resources.

To justify its cost to the industry, pile testing must have a value. The magnitude of this value will be increased through a better understanding of the process and its benefits.

In this handbook the Federation of Piling Specialists aims to provide guidance on issues that should be considered to enable better planning, specification and execution of pile tests, thereby increasing the value of the testing process.

Chapter 2 Safety

Key safety issues must always be considered in the planning and execution of pile load tests, including the following: -

2.1 Preparation and Maintenance of Test Area

- The area surrounding the test pile must be cleared of pile spoil, slurry and rubbish.
- A properly designed level platform of sufficient plan dimensions to support the testing equipment safely and with suitable access for operatives, transport vehicles and lifting plant must be provided. The working platform for lifting plant must be designed to withstand the loads applied by tracks or out-riggers.
- Construction plant that may be operating elsewhere on site must be excluded from the test area during the course of the pile test so that the test pile's performance can be accurately monitored in a safe environment.
- Electronic barriers with audible warnings can be used to keep the test area clear, and under no circumstances will any excavations be permitted within the exclusion zone.

2.2 Lighting

- Dependant upon the loading regime agreed it may be required that some operations are carried out during periods of poor natural lighting or darkness; the area must be adequately lit to enable the load test to be undertaken safely and for the test pile performance to be monitored throughout the full duration of the test.

2.3 Load application limits

- The maximum test load to be applied must be agreed in advance so that the test pile, pile cap (if required) and the load testing equipment (reaction piles/kentledge/hydraulic ram and pump/bi-directional load cell/rapid or dynamic test energy) can all be designed or chosen so as to apply the maximum test load safely.
- When it is the intention to test a pile to geotechnical failure, due consideration must be given to the capacity of the whole test system. If geotechnical failure of the test pile has not occurred on application of the maximum test load, then this fact should be accepted. Increasing the load beyond the safe design capacity of the test system must not take place.
- All supervisory site staff must be made aware of the specification and the loading regime to be followed, and also the agreed method statements and risk assessments relating to the load test.
- During the course of the load test the whole system should be monitored for eccentricities and appropriate actions taken if this becomes excessive.

- Systems using only two reaction piles are inherently less stable than those with three or more and consequently should only be considered where test loads are light and the ground conditions permit location of the reaction piles to more stringent tolerances than normal.
- If any anomaly occurs during the load test that could give rise to an unsafe situation, such as those illustrated in Figures 2.1 and 2.2, no further loading should be applied in order to prevent these happening. The test area should be cleared immediately and advice sought from the pile testing contractor.

2.4 Site operative instructions

The issuing of correct and concise instructions to suitably experienced site personnel is essential for the safe completion of a load test on a pile.

- Where possible, standard testing equipment and loading procedures should be used. Consistency in the equipment set up and loading procedure will reduce the possibility of errors occurring, although the risk of complacency should not be overlooked. The relative plan position, vertical alignment and fit of the component parts of the set up should be checked to ensure that these are within permissible tolerances and prior to the application of load the set up should be checked for any eccentricity of loading. The equipment should be “self- stable”.
- Proper operative training and the use of written method statements for setting up/dismantling the test equipment and the application of the load are essential.
- The setting up and dismantling of kentledge tests involves operatives working at height and alternative methods of providing the reaction for the test load should be adopted wherever reasonably practicable.
- If the load test involves out of hours working, a safe system of operation should be established and agreed in advance. This may require a minimum of two people present on site during the duration of the test.
- Pile load tests harness significant amounts of energy and if this energy is not controlled in a safe manner it presents a significant safety hazard. Failures can occur rapidly with little or no warning. Site personnel must therefore be made aware that correct test procedures must always be followed.
- The use of readily available remotely operated methods of applying the load and measuring pile movement is recommended to avoid the site personnel being close to the testing equipment during the course of the test, particularly during the loading and unloading cycles of the test.
- The relative levels of the top of the test pile cap and the underside of the main reaction beam should be arranged so as to minimise the depth of any additional packing above or below the load train which might otherwise lead to some instability in this area of the test set up.



Figure 2.1 Failure of tension bar system in reaction pile



Figure 2.2 Platform bearing failure under kentledge test

Chapter 3 Testing Strategy

3.1 Strategy

This chapter concentrates on vertical load tests on piles. However, most of the recommendations in this chapter are equally valid for load tests on raking piles, tension piles and for the lateral load testing of piles. It is essential to seek expert advice for these types of pile test.

The strategy for pile testing needs to be established at the time the piles are being designed. For most projects the main purpose of pile testing is either to validate the design before construction and/or to check compliance with the specification during construction. However in some cases there are benefits in using testing for design development or research to provide the best solution. Testing strategies can therefore be divided into four main categories: -

- Design validation
- Quality control
- Design development
- Research

The scope of testing will depend on the complexity of the foundation solution, the nature of the site and the consequences if piles do not meet the specified requirements. The pile designer therefore needs to assess the risks and develop the testing regime accordingly. The main risks are: -

- insufficient site investigation
- lack of experience of similar piles in similar ground conditions
- insufficient time to verify the pile design and realise any savings
- cost and programme implications of undertaking the pile tests
- cost and programme implications of a foundation failure

For simple structures on a site where the ground conditions are well understood and there is pile test data from adjacent sites that have used similar piling solutions, then the risks are low and pile load testing can usually be restricted to routine checks for compliance or can even be omitted.

For situations where the ground conditions or structural requirements are complex, or there is little experience of similar piling work, then careful evaluation of the piling proposals is essential prior to embarking on the main piling works. Here the testing regime may need to be considered in two phases comprising preliminary pile testing before the main piling works and then proof testing of working piles.

The testing strategy for pile testing should address a project-specific set of stated objectives, which should include the following: -

- to minimise risk by investigating any uncertainties about the ground conditions, contractor's experience or new piling techniques
- to optimise the pile design in terms of size, length and factor of safety

- to confirm any pile installation criteria such as founding strata identification, pile set or pile refusal criteria
- to assess buildability, site variability, pile uplift, soil remoulding along the pile shaft or relaxation at the pile toe
- to check that the pile performance meets the required load/settlement behaviour during loading
- to assess environmental impacts of noise, vibration or pollution

In Table 3.1 below the level of risk is related to the characteristics of the piling works. The pile testing strategy varies according to this level of risk.

Characteristics of the piling works	Risk level	Pile testing strategy
Complex or unknown ground conditions. No previous pile test data. New piling technique or very limited relevant experience.	High	Both preliminary and working pile tests essential. 1 preliminary pile test per 250 piles. 1 working pile test per 100 piles.
Consistent ground conditions. No previous pile test data. Limited experience of piling in similar ground.	Medium	Pile tests essential. Either preliminary and/or working pile tests can be used. 1 preliminary pile test per 500 piles. 1 working pile test per 100 piles.
Consistent ground conditions. Previous pile test data is available. Extensive experience of piling in similar ground.	Low	Pile tests not essential. If using pile tests either preliminary and/or working tests can be used. 1 preliminary pile test per 500 piles. 1 working pile test per 100 piles.

Table 3.1

For pile tests in situations where the risk level is high, consideration should be given to using instrumentation within the pile, employing either strain gauges or fibre optics.

Where piles are required to carry very heavy loads, it may be uneconomic to carry out full scale standard load tests. In such circumstances, consideration can be given to carrying out tests on smaller diameter piles using the same method of construction (as provided for in EC7 for example), provided the results of the tests can be extrapolated with some degree of confidence to predict the load settlement characteristics of the larger piles. The test piles should be founded at the same level and in the same soil as the works piles. Alternatively, a bi-directional pile test with an O-cell cast into the pile can be used.

For rapid loading and dynamic pile tests it may be necessary to increase the applied loads to the pile in order to overcome the ground damping effects. Calibration with static load tests is preferable, depending on the prevailing ground conditions.

For preliminary pile tests it is preferable to place the test pile(s) close to a borehole so that the test results can be reliably evaluated.

Where the ground conditions are reasonably uniform over the site area, working test piles should be located in positions that will give the best possible coverage of the area to be piled.

Where ground conditions vary across the site, the number of test piles may have to be increased in order to check the pile characteristics in different areas of the site.

Care should be taken when choosing the test pile locations to ensure that there is sufficient space available for the reaction system to be installed without interference with other piles on the site. Consideration should also be given to the location of test piles in relation to the work in progress on the site while the tests are being carried out. Vibrations from other works can interfere with the test pile results and a test being carried out at an inconvenient location will disrupt other works on site.

For projects with a very large number of piles, say over 1000, the number of test piles can be reduced below that recommended in Table 3.1, once the pile designer can demonstrate confidence in the ground conditions and the pile construction method.

3.2 Acceptance criteria

The Performance Specification must state the maximum settlement permitted on an individual pile during load testing at the design verification load (DVL). It is the responsibility of the Engineer, when choosing this settlement value, to assess the effects of pile group action and the sensitivity of the structure to differential movement.

For insensitive buildings, the maximum settlement permitted at the head of an individual pile during load testing at DVL should be 10mm plus the calculated elastic shortening of the pile shaft, for piles less than 1000mm diameter. For test piles greater than 1000mm diameter a value in excess of 10mm may be appropriate.

Maximum settlement at loads greater than DVL should not be specified for insensitive buildings.

If the measured pile settlement exceeds the permitted value then the pile designer and the piling contractor should investigate the causes and undertake appropriate remedial action, if any.

Chapter 4 Testing and Specification

4.1 Types of pile test

The various available methods of testing piles are best characterised by the duration that the force is applied to the pile and the strain induced in the pile. Tests involving large forces applied for long periods of time such as static load tests are used to assess pile load capacity and small energy low strain tests are used to assess pile integrity. In high strain dynamic and rapid load tests, although the force is comparable in magnitude to a static test, it is applied over a much shorter period than in a static load test. Careful consideration is therefore needed in the interpretation of the dynamic effects in order to derive static load capacities.

The various types of test and their application are summarised below. More details of individual testing methods are included in Chapter 5 'Load Testing Methods'.

The static load test relies on a suitable reaction system from which to apply loading to the pile under test. Typical reaction systems are described in Chapter 5.

Instrumentation may be built into preliminary test piles to investigate the load transfer mechanism during the test. Piles may be equipped with strain gauges, push rods, load cells and other devices to enable the designer to isolate key pieces of information and improve the analysis of the test result and confirm or refine the design approach. This type of equipment is normally of a specialist kind and requires careful selection, installation and additional monitoring. It is preferable to have specialist advice on the installation, monitoring and testing of any instrumentation.

At present, the most frequently used types of static load testing are the Maintained Load Test (MLT) and the Constant Rate of Penetration Test (CRP). Both manual and automated test methods are suitable for either type of test.

For further information on the MLT or CRP load test procedure refer to the ICE Specification for Piling and Embedded Retaining Walls.

4.1.1 Maintained Load (MLT) Test

In the MLT, the load is applied to the pile in discrete increments and the resulting pile movement/settlement monitored. Subsequent load increments are only applied when the minimum specified time period has elapsed and the rates of induced settlement are below the specified criteria. The normal U.K. practice is to load the pile up to DVL, then to unload back to zero loading. Subsequent load cycles are applied, taking the loading to specified values above the DVL depending on the requirements of the test. The test will normally last between 24 and 48 hours excluding erecting and dismantling the test equipment.

The MLT method is normally the most suitable in determining the load/settlement performance of a pile under working loads and at 1.5 times working load conditions.

4.1.2 Constant Rate of Penetration (CRP) Test

In the CRP test, the load required to cause a pile to penetrate into the ground at a constant rate is monitored until either the maximum specified test load is achieved or "failure" of the pile occurs. The performance of the test takes less than 24 hours excluding erecting and dismantling the test equipment.

The measured penetration of the pile is plotted against the load applied, the purpose of the test being to determine the ultimate bearing capacity of the pile, particularly for piles constructed within predominantly cohesive material and deriving their capacity mainly in shaft friction. However, due to the high rate of loading, the measured maximum soil resistance may over-predict the ultimate capacity.

4.1.3 Bi-directional Load Cell

Another form of MLT uses a bi-directional load cell. This system is usually only applicable to conventional auger bored piles carrying high axial loads. The method is described in detail in Chapter 5, and involves a load cell or cells placed in the pile bore either at the pile base or part of the way up the pile shaft during the concreting operation. In the test the cell is hydraulically expanded so the upper part of the pile reacts against the lower part.

4.1.4 Rapid Load Test

Rapid Load Tests use a combustion chamber to provide a rapid load application to the pile head. The length of the stress wave in these tests is sufficiently long to encompass the whole pile and therefore there is no need for complex wave equation analysis when interpreting the results. However, in common with the dynamic load test, effects of creep and pore water dissipation can influence the results although to a slightly lesser extent because the rate of loading is lower.

4.1.5 Dynamic Load Test

These methods are based on monitoring the response of a pile subjected to hammer blows applied at the pile head. The measured response parameters are subsequently analysed to give predictions of the soil resistance that would be mobilised by the pile under static load conditions, based on stress wave theory.

The analytical models of the pile/soil interaction have been further developed to provide prediction of the load/settlement performance of the tested pile.

Developed initially for use with driven piles and now universally accepted, dynamic load testing of cast in place piles is now quite widely used to predict the static soil resistance and the load/settlement behaviour. The test method is similar to that used on driven piles with the monitoring of hammer blows and subsequently analysing the pile response to the stress wave propagation. A separate hammer or drop weight is usually brought to site to allow the dynamic load to be applied to a cast in place pile.

Due to the very high rate of applied loading, dynamic load testing cannot take into account time-related effects such as consolidation, relaxation or creep; consequently care should be exercised in reviewing the results of tests carried out in soils which may exhibit these features. However, the use of dynamic testing after calibration within a particular geological profile will allow more comprehensive testing at low cost in comparison to static testing. Typically a dynamic test will take about 15 minutes to perform on a precast concrete pile using the piling rig hammer to 30 minutes on a bored cast in place pile requiring the use of a separate drop weight.

4.1.6 Summary

Table 4.1 on page 12 summarises the types of pile load tests as described above.

Test Type	Reaction System	Maximum Test Load	Advantages	Disadvantages
Static Maintained Load (MLT)	Reaction piles (Rock anchors may provide an alternative reaction system for piles end bearing in rock)	30MN (generally)	Suits all soil conditions and pile types. Manual and automated systems available. Piles can be instrumented. Tension and lateral testing possible.	Reaction piles/kentledge and frame are required. Kentledge tests are relatively expensive. Setting up and dismantling the test equipment involves operatives working at height. Long duration.
	Kentledge	3MN (generally) In both cases higher test loads are possible.		
	Bi-directional load cell	27MN per cell	Very high test loads achievable. No reaction system required.	Relies on sophisticated pile instrumentation and analysis. Suits bored piles only. Relatively expensive and long duration.
Static Constant Rate of Penetration (CRP)	As for MLT	As for MLT	Suits all pile types. Manual and automated systems available.	Reaction piles/kentledge and frame required. Kentledge tests are relatively expensive. Limited to cohesive soils. May over predict ultimate load.
Rapid Load Test	Combustion chamber	30MN	No reaction system required. Fast test.	May require calibration with static test. Caution required in cohesive soils and in chalk. Unsuitable for piles in excess of 40m deep. Suitable for testing pile groups and piles of variable or unknown pile shaft profile, e.g. CFA piles or re-used piled foundations.
Dynamic	Piling hammer or separate drop weight	3MN (generally, but can be greater) Hammer weight should be in the range 1 to 2% of load to be proved.	Fast and relatively inexpensive. Suitable for both driven and bored piles. Correlation with static tests on bored piles generally good.	May require calibration with static test. Results may be unrepresentative in soils that exhibit relaxation (reduction of end bearing in Coal Measure Mudstones for example). Correlation of dynamic and static results on piles in cohesive soils and chalk must consider time-related effects and the length of pile tested.

Table 4.1

4.2 Specification

4.2.1 Test Procedure

All load tests should be carried out in accordance with the ICE Specification for Piling and Embedded Retaining Walls.

4.2.2 Maximum Test Load

Load tests on preliminary or non-working test piles, in advance of or during the early stages of the piling works, are normally carried out to DVL plus 1.0 or 1.5 times the specified working load (SWL). DVL is the working load plus allowances for soil induced forces such as downdrag or heave, and any other particular conditions of the test such as a variation of pile head casting level.

Load tests on working piles are normally taken up to a maximum load of DVL plus 0.5 times the specified working load. This is sufficient to verify the load settlement characteristics of the piles under service conditions.

4.2.3 Concrete and Reinforcement

The strength of the concrete in the pile must be considered in all cases where a load test is to be carried out, in order to ensure that the concrete is not over-stressed during testing. This is particularly important with preliminary test piles where the stresses in the concrete may be very high. Preliminary test piles are often loaded to between two and three times their normal specified working load and this may call for higher grades of concrete than those to be used in the works. There is no evidence to suggest that this affects the bearing capacity of a pile within the limits of normal concrete strength. Enhanced reinforcement may also be required in preliminary piles to prevent structural failure under such loading conditions.

For working pile tests, the test should not proceed until compressive tests on works cubes have confirmed that the concrete strength is at least twice the concrete stress in the pile at the maximum specified test load. It is also necessary to ensure that the trimmed head of the pile is in intimate contact with the pile cap with a horizontal, clean and well formed joint.

Common examples of factors contributing to unsuccessful static load tests are: -

- Pile cap not concentric with pile shaft
- Poorly formed joint between pile head and pile cap
- Poorly designed/insufficient reinforcement in pile head or pile cap to withstand bursting stresses
- Pile cap concrete of inadequate strength or poor quality

Pile head preparation of bored/CFA piles undergoing dynamic load testing is critical. Unless the pile has a permanent liner, the pile shaft must be built up 2 to 3 pile diameters above ground level at the pile position within a thin-walled liner, suitably reinforced and finished with a smooth flat surface normal to the pile axis. A pair of diametrically opposed windows, 200mm square, must be cut into the liner to reveal smooth concrete surface to which the gauges can be attached. CFA piles subject to dynamic load tests will require the main reinforcement to extend to the pile toe. The heads of piles undergoing rapid load tests will require similar pile head preparation to that necessary for static load tests.

Chapter 5 Load Testing Methods

5.1 Maintained Load Tests in Compression

This method of testing involves the use of a reaction system to allow the application of a load to the test pile for an extended period of time. It therefore follows that when under test, there can be a very significant amount of energy contained in the system and as such they can be deceptively hazardous. It is therefore strongly recommended that only experienced, specialised personnel are employed to carry out the process.

The ground conditions will generally dictate the method of application of the reaction, which falls into three categories. Each method should be carried out using a suitably robust load transference system.

5.1.1 Reaction Piles

Ground conditions, pile type and site constraints often make the use of reaction piles economical. A number of reaction (anchor) piles can be placed surrounding the test pile and will provide the required tensile capacity and act as reaction against the compression test pile. Transfer of the forces involved is carried out by a series of beams, bars and couplers as illustrated in Figure 5.1. The beams are placed over the piles and securely connected by the couplers to high strength threaded bars cast into the anchor piles and specifically designed for the purposes of the test.

As only a relatively small amount of equipment is required, the site footprint is relatively small. The size of the testing apparatus is generally a function of the pile size and loading to be applied. Reaction piles should be placed at a sufficient distance from the test pile so as to avoid any interaction of soil resistances. In broad terms an area of at least 8m x 5m is required for the test.

Measurement

Once assembled the deflection of the pile is measured using a number of dial gauges, or electronic transducers arranged around the pile. The gauges are supported on a reference beam attached to the ground at a suitable distance. Directly above the test pile, along its axis, the load train is placed (see Figure 5.2). This consists of a jack, packer plates and load measurement device in the form of a calibrated pressure gauge, mechanical proving ring or ideally, a digital load cell.



Figure 5.1 30MN reaction pile test

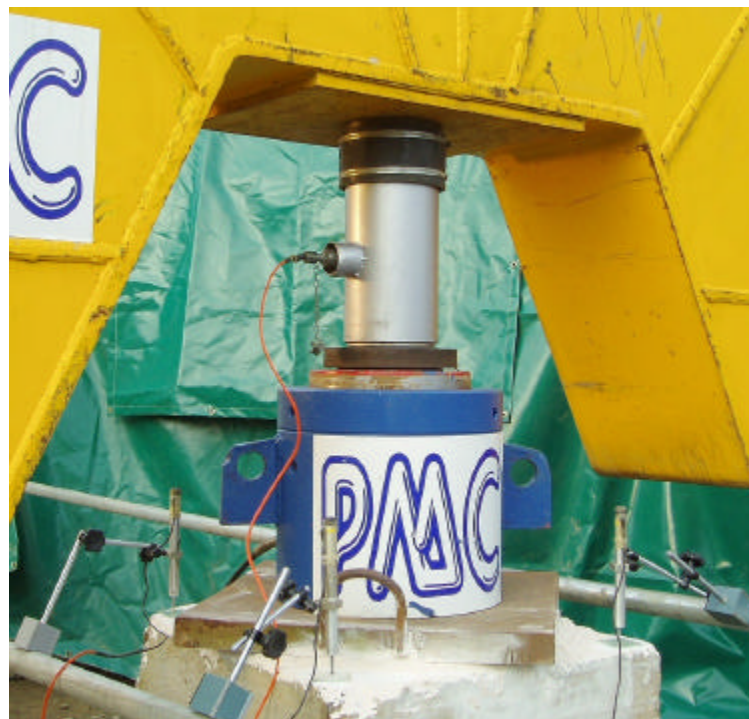


Figure 5.2 Load Train

5.1.2 Kentledge

Should the ground conditions or site constraints preclude the use of reaction piles, the alternative is to use kentledge. A frame is assembled over the pile to be tested on top of which an amount of weight (a minimum 110 to 120% of maximum test load) is safely stacked. This generally takes the form of concrete blocks of regular dimensions and weight although steel ingots can be used provided that their weight can be assessed with reasonable accuracy. The size of the testing apparatus is generally a function of the pile size and loading to be applied. In broad terms an area of at least 15m x 15m is required for the test (see Figure 5.3). At the time of assembly, the presence of the additional cranes and associated transport deliveries will increase this working area. Consequently this is the most costly and disruptive method of providing a reaction for load testing of piles in compression.

Measurement

This method uses the same method as found in the reaction piles arrangement, as illustrated in Figure 5.2.



Figure 5.3 3MN kentledge test

5.1.3 Bi-directional Method

This system is usually only applicable to conventional auger bored piles, and involves a load cell or cells placed in the pile bore either at the pile base or part of the way up the pile shaft during the concreting operation (see Figure 5.4). In the test the cell is hydraulically expanded so the upper part of the pile reacts against the lower part. Schematic details of the testing system are illustrated in Figure 5.5.

Where the cell is at the base of the pile, the soil at the base provides the reaction. More than one cell can be provided to test different sections. There must however always be sufficient shaft resistance from the pile section above the load cell to provide the necessary reaction force to stop the pile being forced out of the ground.

Interpretation of the results is needed to derive a load/settlement plot and this can be complicated. The test arrangement needs to be carefully designed to make interpretation as straight forward as possible.

As there is no reaction frame assembly only a small working area is required, dictated by the independent method of measurement.

Measurement

The load is quantified by measurement of the hydraulic pressure of the jack cast into the pile. The reinforcement cage also allows the installation of extensometers to measure movement.



Figure 5.4 Load cell in reinforcement

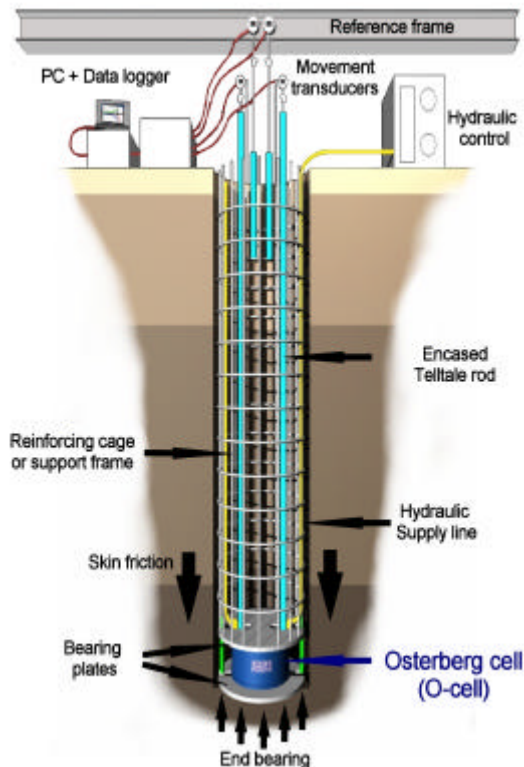


Figure 5.5 Schematic details of system

5.1.4 Rapid Load Testing

This involves the assembly of a relatively small counterweight over the top of the test pile and a controlled fast burning charge is then ignited in the mechanism. After combustion is complete a hydraulic or mechanical catching mechanism safely brings the counterweight to rest. Other methods provide extended duration of force by the use of springs and large

hydraulic hammer. The method is rapid allowing a large sample of piles to be tested and the working area required is again a function of the magnitude of load required. Smaller tests can be undertaken using a crawler mounted system (see Figure 5.6), while large scale tests require an area in broad terms of at least 3m x 3m plus a working area for a large attendant crane (see Figure 5.7).

Measurement

The charge controls the force imparted to the pile, which in turn is measured by a load cell contained within the apparatus. Deflections are recorded by laser reference source and photovoltaic cell or indirectly by an accelerometer.



Figure 5.6 Crawler mounted 1MN test



Figure 5.7 3MN capacity test

5.1.5 Dynamic Load Testing

In order to carry out this method of testing an impact hammer is required. The hammer should ideally be sufficiently large to fully mobilise and therefore characterise the dynamic pile capacity without damaging the pile, and in the case of driven piling will usually be the same hammer as used to install the pile (see Figure 5.8). Dynamic load testing of bored cast-in-place or CFA piles will generally require the use of a separate hammer or drop weight (see Figure 5.9).

Dependant upon the method employed, electronic gauges are attached to the pile as illustrated in Figures 5.10 and 5.11. The gauges measure the acceleration of the pile (and therefore (indirectly) velocity with a knowledge of the pile properties) and strain within the pile just below the head as the hammer strikes the pile. The information is then recorded in the associated site computer. A variation of the method involves deflection measurement directly by laser theodolite.

In addition to access for the piling hammer/drop weight only minimal access is required to attach the gauges, provided that the pile shaft protrudes at least 2 to 3 pile widths/diameters above ground level; this safeguards the gauges and allows the propagation of a uniform stress wave.

A large number of piles can be tested in the course of one day using dynamic load testing methods.

Analysis of data

Once the data has been recorded, it can then be analysed by suitably experienced personnel using associated programs to provide the information on mobilised soil resistance, pile integrity and hammer performance.



Figure 5.8 Dynamic load testing of driven precast concrete piles



Figure 5.9 Dynamic load testing of cast-in-place pile



Figure 5.9 Strain gauge and accelerometer bolted to precast concrete pile
The arrangement is repeated on the opposite pile shaft face



Figure 5.10 Bored cast in place/CFA pile head preparation with window cut in liner to allow strain gauge and accelerometer to be attached to the pile

Chapter 6 Results and Interpretation

The ICE Specification for Piling and Embedded Retaining Walls sets out the requirements of reporting the results of a load test.

6.1 Maintained Load Tests

6.1.1 Results

The results of an MLT on a bearing pile will comprise records of time, load and settlement for the specified loading and unloading cycles and the periods of maintained load.

Computer controlled methods of load application and measurement in conjunction with electronic transducer systems of settlement measurement enable accurate records of the behaviour of the pile to be made and stored. Manual application of the load and the use of dial gauges to measure settlement are becoming less frequently used as the remote computer controlled methods provide a great improvement in operator safety and consistency in carrying out the test procedure.

Whichever method of settlement measurement is used in the test, the results should also include, where required by the particular specification, regular precise level measurements taken on the datum beams onto which the electronic transducers or dial gauges bear, as variations in temperature may cause some movement in these datum beams which may distort the measurements.

The load test records will normally be presented in tabular form with pile settlement recorded as the average of the displacement transducers or dial gauges at any point in time. Modern methods of data storage allow the easy calculation of cumulative settlement and increase in settlement during loading cycles (or recovery during unloading cycles), the latter being required to verify that limiting rates of movement have been achieved prior to increasing or decreasing the load on the pile. In addition to the numerical results, a graphical plot of load versus deflection and a separately plot of load and deflection versus time should also be included in the test results.

6.1.2 Interpretation of Results

Before embarking upon a detailed analysis of a set of load test results certain fundamental issues should be considered: -

- Are the results accurate and consistent, or have they been subject to distortion by some external influence such as weather effects or adjacent activities?
- Are the results in accordance with the designer's expectations?
- Does the pile performance satisfy the specification, and if not what remedial actions are required?

If a pile fully mobilises the soil resistance during a load test intentionally taken to failure or when an unexpected premature failure occurs, the ultimate bearing capacity of the pile should be as defined in the ICE Specification for Piling and Embedded Retaining Walls.

In the case of pile load tests that have not been taken to the point of failure of the pile/soil interface, estimates of the failure load can be made using methods devised by Davisson, Butler & Hoy, De Beer, Fuller & Hoy, Vander Veen, Brinsch Hansen, Mazurkiewicz or Chin, all of which were compared by Bengt Fellenius in his paper published in Ground Engineering in September 1980. It is not surprising to note a variation in predicted failure load of 30% between the lowest predicted load (Davisson) and the highest (Chin) in a comparison of the analysis of the same set of test results illustrated in the paper.

The Chin method also attempts to separate out components of shaft friction and end bearing, but is only moderately successful when one or other of these components predominates, in which case a review of the form of the load settlement plot will give a reasonable indication. Acquisition, storage and manipulation of data by computers has enabled more meaningful predictions of failure loads and proportions of the two components, provided that a reasonable amount of end bearing is mobilised during the test. Fleming (1992) is the most recent authoritative paper on this subject.

6.1.3 Recognising Problems from Test Results

In the event of a pile not performing as anticipated during an MLT, the shape of the load settlement plot may give some indication of the reason for this. Tomlinson gives examples of typical load settlement plots for a number of soil conditions and construction irregularities in his book "Pile Design & Construction Practice".

Examples of some commonly encountered problems are outlined in Table 6.1 below: -

Problem	Reactive measures
Exceeding the permitted settlement specification.	Can structure accept the extra movement?
Preliminary test failing to prove required factor of safety.	Review design parameters and construction records; can the factor of safety be reduced?
Displacement pile has been lifted off its seating by ground heave and re-seated during the load test.	Re-drive preformed piles if predominantly end-bearing; if friction piles check that settlement at DVL & DVL + 50%SWL is within acceptable limits.
Soft toe results in excessive settlement or failure	Review construction records; redesign piles to increased FOS on shaft/wall friction; construct piles to deeper toe levels; consider a reduced SWL.
Structural failure in preliminary load test	Check concrete cube strengths (should be done before the test)

Table 6.1

It is important to appreciate that some margin between expected values of the load settlement characteristic and the specified values is required to allow for natural variations in ground conditions.

Equally important is an understanding that piles deriving their load bearing capacity primarily in end bearing will usually settle more than those carrying the same pile head

load in shaft friction. The settlement of any pile will be influenced by pile type and length as well as founding stratum soil type.

Elastic shortening of relatively highly stressed long piles of slender cross section will contribute to greater settlements, up to as much as 25mm at working load in some cases.

6.2 Rapid Load Tests

6.2.1 Results

These test results take the form of an 'equivalent static load test' load deflection curve after extraction of the dynamic loading effects, and the data is very similar to that obtained in a constant rate of penetration test.

6.2.2 Analysis

Two main types of analysis of the field data may be employed, the unloading point method (UPM) and the non-linear soil dependant approach.

The UPM identifies the point where the pile has zero velocity (unloading point) and assumes that the pile resistance at this point is equivalent to the static pile resistance. By considering the pile resistance between the peak applied load and the unloading point a damping constant is found which is used to remove the rate dependent component of the rapid load test. There are other variants of UPM such as the modified unloading point method (MUPM) and the segmental unloading point method (SUPM). These methods were developed for long piles (<40m) or piles with rock sockets and rely on embedded instrumentation.

For skin friction piles in clays, ultimate capacity can be predicted using a non-linear velocity dependant relationship as proposed by Randolph (2003), which has its origins in the Smith wave equation analysis. This approach requires soil specific empirical damping factors which may be obtained from high speed laboratory testing or back analysis of rapid load tests.

6.2.3 Interpretation of Results

Rapid load testing is well suited for use in a proof load testing regime, and when used correctly provides a quick and cost-effective method of verifying that both test and working piles will meet a performance specification. However the method does have certain limitations, such as: -

- The test loads may need to be specified to mobilise the toe resistance of the pile. These loads may be significantly greater than the loads required in a static test due to rate effects (damping).
- The UPM analysis technique performs well in granular soils but may over predict pile capacity by up to 50% in cohesive soils. However adjustment factors are available to correct UPM results in different soil types.
- Non-linear viscous parameter based analysis performs well in cohesive soils but is limited by the need for soil specific damping parameters.

- The predicted load deflection curve will not take into account creep or consolidation effects.

Notwithstanding these limitations, the rapid load testing method has been used worldwide since the late 1980's and in the UK since the mid 1990's. Although currently not so widely used in the UK as in the United States and Japan, draft codes of practice for ASTM and the Japanese Geotechnical Society have now been formulated. Guidance on its use and analysis has also been produced for the US Transportation Research Board and the Florida Department of Transportation.

6.3 Dynamic Load Tests

6.3.1 Results

The results of stress wave analysis carried out for piles that have been dynamically load tested are normally presented as graphical presentations of the matching of measured force and velocity traces against time, with a simulated load deflection curve for the pile head and the pile toe. A graphical and tabular distribution of mobilised soil resistance is also provided, together with pile stresses and hammer energy. CASE® analysis can be performed also, but provides less information.

6.3.2 Analysis

Two types of analysis of the field data are possible, CASE® and CAPWAP®/SIMBAT®.

CASE® analysis calculates the dynamic resistance of the soil and using an empirical damping factor relates this to the static resistance. The value of the damping factor can be determined from the soil type at the pile toe to provide an early indication of soil resistance on site at the time of testing, or back-analysed from the stress wave analysis to determine a site specific value for sites with a reasonably consistent soil profile. CASE® analysis is more suited to end bearing piles than friction piles.

CAPWAP®/SIMBAT® analysis involves the manipulation of a number of variables in the program to obtain the best match between the force and velocity traces of the measured and computed stress wave. These variables are static resistance, soil damping and soil elasticity or quake, each being adjusted on the shaft and the toe of the pile.

Whereas CASE® analysis will only predict total mobilised soil resistance, CAPWAP®/SIMBAT® stress wave analysis will proportion this resistance between shaft friction and end bearing, as well as providing a predicted immediate load deflection curve.

6.3.3 Interpretation of Results

Dynamic load testing is well suited for use in a proof load testing regime, and when used correctly provides an extensive and cost-effective method of verifying that piles will meet a performance specification. However the method does have certain limitations, such as: -

- The mobilised static soil resistance will not necessarily represent an “ultimate capacity” as full mobilisation of toe resistance often requires so much energy to

create the necessary movement per hammer blow that the pile may be damaged during testing.

- Predicted soil resistances will generally be within plus or minus 15% when compared with the results of a static load test. However, in certain soil conditions a less satisfactory degree of correlation may be experienced.
- The predicted load deflection curve will not take into account creep or consolidation effects, nor can it accurately model the onset of failure of the pile/soil interaction.

Common reasons for apparently poor correlations between dynamic and static load test results include: -

- Comparing results from different piles
- Time related set-up/relaxation effects
- Comparing piles of differing length
- Incorrect assumptions of soil type

Notwithstanding these limitations, the dynamic load testing method has been used in the UK since the early 1980's, during which time it has gained widespread acceptance within the industry, becoming particularly popular in off-shore construction where traditional methods of load testing piles are impractical.

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Federation of Piling Specialists



Pile Testing Data Sheets

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FPS Testing Datasheet No	Name	Main Purpose	Target Audience
1	Guidance for the Principal Contractor	To inform the site team what the testing contractor will need to do on site	Members of the Principal Contractor, main contractor, specialist groundworker working on a piling site
2	Pile testing - interpretation	To help ensure that those interpreting the results of a pile test are competent to do so	Testing contractor, piling contractor and the Engineer
3	Training programme for pile testing technicians	To provide a basis for measuring competence of those carrying out pile testing	Testing contractor and piling contractor
4	The purpose of the pile load test	To encourage a relevant strategy for pile load testing	Designer of the piles and the specifier of the pile load test
5	Pile load testing - what each type of test should realistically achieve	To improve the knowledge of what static, dynamic and rapid load tests can and cannot do	The specifier of the pile load test
6	Pile load testing - basic information to be provided to the Testing Contractor	To improve the quality of information flow between the piling contractor and the testing contractor	Contract engineers working for the piling contractor
7	Pile load testing - test cap	Many pile tests fail structurally rather than due to a geotechnical type failure, and a suitable test cap is essential to help prevent structural problems during testing	Contract engineers working for the piling contractor
8	Pile load testing - working platform	To ensure that the working platform is safe to use throughout the testing activities	Members of the Principal Contractor, main contractor, specialist groundworker working on a piling site
9	Pile load testing - lone working	To inform of the minimum standards required for safe pile load testing by a lone worker	Testing contractor, piling contractor and the Principal Contractor
10	Pile integrity testing - a good practice guide	Explains how the Principal Contractor and testing contractor should work together to ensure effective and timely results	Members of the Principal Contractor, main contractor, specialist groundworker working on a piling site
11	Pile integrity testing - basic information to be provided to the Testing Contractor	To improve the quality of information flow between the piling contractor and the testing contractor	Contract engineers working for the piling contractor
12	Pile integrity testing - why it is important to allow enough time between pile testing and pile cap construction	The Principal Contractor may get frustrated if not all of the tests are positive first time, due to a lack of awareness that the test result may not be an instant pass or fail	Members of the Principal Contractor, main contractor, specialist groundworker working on a piling site
13	Pile integrity testing - terminology	To encourage a consistent description for each stage of evaluating the data	Testing contractor, piling contractor, the Engineer and the Principal Contractor
14	Pile integrity testing using Cross Hole Sonic Logging	To encourage a consistent criteria for evaluating the data	Testing contractor, piling contractor and the Engineer
15	Pile testing - safety	To highlight specific hazards for pile testing	Members of the Principal Contractor, main contractor, specialist groundworker working on a piling site



Federation of Piling Specialists Testing Datasheet No 1

Guidance for the Principal Contractor

It is an essential requirement that the specialist testing contractor is allowed to work in a safe way and fully in accordance with their own procedures.

1. Static Load Testing of Piles

Introduction

The piling work on this site may require one or more pile maintained load tests. These tests can be of two types:

- **Preliminary Test:** This is a test carried out on an expendable pile in advance of the main piling work. The pile is usually tested until it fails and the results are used to refine the design of the subsequent working piles.
- **Working (or Proof) Test:** This is a test carried out on a working pile and the test load is usually limited to 50% over the design load to avoid overstressing the pile or the ground. This test is to check that the piles are capable of bearing the loads imposed on them.

The test piles (and reaction piles/anchorages, if any) will be installed by the piling contractor. The loading test will be carried out by a specialist testing contractor. After installation, any concrete cast-in-situ piles are left for a minimum period of 7 days or until the concrete has gained sufficient strength.

Pile Protection between Installation and Testing

Between installation and testing, the test pile and reaction piles/anchorages must be protected from damage and interference, specifically:

- Reaction piles are normally reinforced with prestressing bars which protrude from the piles to allow connection to the test beams. The bars are formed from high grade steel which can be damaged by heat or bending. The test area must therefore be **barriered off** from plant movement and no hot work allowed in the vicinity. In the unfortunate event of a bar being bent, it must never be straightened, but the piling contractor should be informed so that they can re-end the bar. This may require the breaking down of the pile.
- No excavations must take place around reaction piles/anchorages as these have been designed assuming ground level remains undisturbed. Excavations or loosening of the ground can cause these to pull out, stopping the test. A repeat test will severely disrupt your program!

Testing

The testing contractor will need road access from the public highway to the test location for the lorries which contain test beams and the data-logging cabin. The lorries will need to be able to park adjacent to the test pile to enable the data cables to run from the data cabin to the test assembly without interference. The lorries will also need to be able to park a safe distance from the test area.

The area around the test must be made suitable for the technician to safely work, i.e. levelled, hard-cored and without trip hazards or excavations.

An exclusion zone will need to be established around the area of the test, clearly marked and signed. This zone then becomes a **restricted** area.

During the test, no work that could cause vibration should be carried out adjacent to the test as the measurements being made may be affected.

The Principal Contractor can usually mitigate the disruptive effects of complying with the above requirements by careful selection of the location of the pile(s) to be tested.

Overnight Working Attendance

The Engineer's Specification for the load testing normally requires the load to be maintained and measurements made continuously from the commencement to the completion of the test over a period of about 20 hours. This will invariably mean that monitoring will continue overnight. The testing contractor's risk assessment addresses the issue of lone working, however the Principal Contractor will need to also make the following provision outside of normal working hours;

- General site illumination.
- Access and egress will need to be maintained and security provided where appropriate.
- Although the technician will provide his own food and drink which he can consume in the data cabin, access to toilet and washing facilities must be provided in accordance with the Health and Safety at Work Regulations.
- An emergency contact number should be provided to the technician.

The testing contractor will normally try to commence the test before lunchtime so that the "6 hour hold" which comes about 12 hours into the test is reached before midnight, thus minimising the work needed overnight.

2. Dynamic and Rapid Load Testing of Piles

Introduction

The test pile will be installed by the piling contractor. These tests do not require reaction piles/anchorages. The loading test will be carried out by a specialist testing contractor. After installation, any concrete cast-in-situ piles are left for a minimum period of 7 days or until the concrete has gained sufficient strength.

Pile Protection between Installation and Testing

Between installation and testing, the test pile must be protected from damage and interference.

Testing

The testing contractor will need road access from the public highway to the test location for the lorries which contain the testing equipment. The lorries will also need to be able to park a safe distance from the test area. Craneage or piling rigs will also need safe access to the test location.

The area around the test must be made suitable for the technician to safely work, i.e. levelled, hard-cored and without trip hazards or excavations.

An exclusion zone will need to be established around the area of the test, clearly marked and signed. This zone then becomes a **restricted** area.

During the test, no work that could cause vibration should be carried out adjacent to the test.

The Principal Contractor can usually mitigate the disruptive effects of complying with the above requirements by careful selection of the location of the pile(s) to be tested.

Overnight Working Attendance

These tests will not normally be carried out at night.

3. Integrity Testing

It is normal practice to carry out a test on the integrity of the piles after they have been trimmed to cut-off level. To enable this test to be carried out, the Principal Contractor should note that:

- The pile need to be trimmed down to cut-off level.
- A safe access needs to be provided for the test technician to gain access to the head of the pile.
- The pile cap/ground beam excavation must be clear of any standing water.
- The pile cap or ground beam reinforcement must not be in place.
- Although a thin layer of blinding can be in place around the pile, it must neither cover the pile nor be greater than 75mm thick.

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Federation of Piling Specialists Testing Datasheet No 2

Pile Testing - Interpretation

Pile Load Testing

Normally the specialist testing contractor undertakes the load test, takes measurements and then reports the factual data.

The pile designer (whether piling contractor, Engineer, or another party) then interprets the factual data within the context of the design as they should have full knowledge of all the relevant information.

This note is applicable to those interpreting all types of pile load test (including static, dynamic and rapid tests).

Competence requirement for persons interpreting a Pile Load Test

There are no formal academic qualifications available for interpreting the results from a pile load test, but the following attributes should be demonstrable by any person carrying out such an interpretation;

1. The person must be able to demonstrate competence in the testing method and an understanding of the limitations of the method in relation to the intended use of any results obtained.
2. The person must be able to evaluate the results within the context of the design.
3. The person must be able to communicate findings obtained from the test to a third party who is possibly not competent in pile testing.

Pile Integrity Testing

Normally the specialist testing contractor undertakes the test, takes measurements and then reports the factual data with an assessment of the results.

The piling contractor should also carry out an assessment of the results and act upon any anomalies.

This note is applicable to those interpreting all types of pile integrity test (including sonic echo, transient dynamic response and cross hole sonic logging).

Competence requirement for persons interpreting a Pile Integrity Test

There are no formal academic qualifications available for interpreting the results from a pile integrity test, but the following attributes should be demonstrable by any person carrying out such an interpretation;

1. The person must be able to demonstrate competence in the testing method and an understanding of the limitations of the method in relation to the intended use of any results obtained.
2. The person must be able to demonstrate an understanding of their own company procedures.
3. The person must be able to evaluate the results within the context of the design.
4. The person must be able to communicate findings obtained from the test to a third party who is possibly not competent in pile testing.

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Federation of Piling Specialists Testing Datasheet No 3

Training Programme for Pile Testing Technicians

Any company undertaking pile testing should have a training scheme in place in a form similar to that below. This is to be substantiated by company training records.

Trainee Pile Testing Technician	
Name:	
Training Programme	Person responsible for arrangements
Induction	
Company Policies & Procedures	
Company - General Site Rules	
Company Reporting Routes	
Roles and Responsibilities	
Environmental Awareness Training	
Spill Kit & Fire Extinguisher Training	
1 Day Construction Site Safety Awareness Training	
CSCS Touch Screen Awareness Study	
CSCS Touch Screen Test	
Safe use and wearing of PPE & Safety Harnesses	
Slinger / Signaller	
Manual Handling	
Safe Use of Equipment Briefing / Familiarisation	
Site Experience	
Accompanied Pile Testing	
Pile Testing unaccompanied	
Reviews / Reports	
Initial	
Interim	
Issue of company competence card	
Records	
Log book	

Note: not all of these are applicable for every type of pile test

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Federation of Piling Specialists Testing Datasheet No 4

The Purpose of the Pile Load Test

To encourage an appropriate strategy for pile load testing it is recommended that the pile designer informs the pile tester the type and purpose of the specified pile load test. This could be one or more of the following;

- To be a preliminary or expendable test pile (with or without an extended CRP test at the end)
- To be a proof load test on a working pile
- To measure test pile load-settlement behaviour at the Design Verification Load
- To measure test pile load-settlement behaviour at a load different to the Design Verification Load
- To measure the ultimate capacity of the test pile
- To predict the ultimate capacity of the test pile
- To check workmanship of the test pile
- To investigate the integrity of the test pile

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Federation of Piling Specialists Testing Datasheet No 5

Pile Load Testing - What each test type should realistically achieve

Static

1. The test is carried out to a specified method of applying a static load incrementally to the test pile head and measuring the pile head deflection under the applied load.
2. Static load testing will give information about the deflection versus time and load versus deflection characteristics of the pile.
3. The test results should be presented graphically in the form of load and deflection versus time and load versus deflection. The results should also be presented in tabular form.
4. The load versus deflection curve will provide the pile designer with data to assess the suitability of the pile to support the structure.
5. If the pile fails to meet the specified performance criteria during the test the data can be analysed to indicate the mode of failure.

Dynamic

1. The test is carried out to a specified method of applying a dynamic load to the head of the pile using a pile hammer or drop weight. The resulting pile head forces and displacements are measured (or derived from other parameters) versus time and this data is subsequently analysed.
2. If carried out on a driven pile during driving the test will provide information on pile hammer performance, pile driving stresses and the bearing characteristics of the pile during and at the end of driving.
3. If carried out on a driven pile by restriking the pile, at some time after initial driving or on a cast in place pile, the test will give information about expected pile performance under static load.
4. The test results should include the measured (or derived) force and velocity versus time graph, the computed static load versus deflection (and if required the load distribution along the pile shaft and pile end bearing). All test results should be presented graphically and numerically.
5. Depending upon site factors the test can be used on its own or in conjunction with static load testing to assess the suitability of the pile to support the structure for which it was designed.
6. The test also provides information that can be used to interpret pile integrity.

Rapid

1. The rapid load test is carried out to a specified method of applying a load to the pile head utilizing a reaction system and a rapid-burning fuel. The resulting pile head forces and displacements are measured versus time and are subsequently analysed using computer software.
2. The test results should include the measured force and velocity versus time graph, and if required the computed static load versus deflection. All test results should be presented graphically and numerically.

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Federation of Piling Specialists Testing Datasheet No 6

Pile Load Testing – Basic information to be provided to the Testing Contractor

General

Full site address
Site location map
Contract identification number
Principal contractor name
Engineer's name
Client/Employer's name
Number of pile tests
Type of pile test
Testing specification
Any particular site restrictions and site specific safety rules
Details of site induction(s)
Piling contractor's office and site contact details
24 hour piling contractor's contact details

Pile Information

Identification (number and location)
Pile diameter or width
Piling technique
Ground conditions
Specified Working Load (SWL)
Design Verification Load (DVL)
Unfactored Negative Shaft Friction Load (NSF)
Peak Test Load
Design Factor of Safety
Platform level at pile position
Pile cut-off-level
Test pile head level
Vertical test pile or raking, tested in compression, tension, or laterally
Pile length in ground
Level of pile toe
Dimensions of any permanent casing or cast-in steel members
Whether test pile incorporates any instrumentation
Details of reaction arrangement
Bar size provided in any reaction piles
Test pile cap details
Date and time of casting concrete pile cap

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Federation of Piling Specialists Testing Datasheet No 7

Pile Load Testing – Test Cap

General

Dimensions for the test cap should be agreed with the testing contractor prior to its construction. The test cap must be designed and constructed so that it;

- Is concentric with the centre of pile (with a stated allowable tolerance)
- Is able to safely transfer all the vertical and any other induced forces from the cap into the pile
- Comprises a continuous uniform section without any inclusions.

The design and/or the method statement should be made available to the Principal Contractor or Engineer upon request.

If not constructed integral with the pile then the ICE Specification for Piling and Embedded Retaining Walls requires concrete test cubes to be taken from the concrete used to cast the cap.

Dynamic Testing

Specifically for a dynamic load test the cap must also be designed to withstand bursting under impact.

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Federation of Piling Specialists Testing Datasheet No 8

Pile Load Testing – Working Platform

Why it is important to adequately maintain the working platform until the end of all piling activities

- The working platform provides access for all piling plant, labour and testing activities
- The working platform must be designed, constructed, maintained and repaired so as to always provide the safe access for all piling plant, labour and testing equipment
- The working platform must have a specified design life, which is to begin before the piling contractor starts work on site, and must not end at least until all piling works (including pile construction, load testing, investigation of any non-conformances and the repair or replacement of any piling works) are completed
- The FPS Working Platform Certificate, or similar, is to be used
- If the working platform is to be constructed or removed in phases whilst any piling works are still ongoing, then the extent of these works shall be clearly described to, and agreed with, the piling contractor
- Note that pile load testing will require safe access to the test pile position for lorries, craneage and labour, both for erection of the test and for the dismantling of the test afterwards.

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Federation of Piling Specialists Testing Datasheet No 9

Pile Static Load Testing – Lone Working

Procedures for Lone Working during Static Pile Load Tests

- 1 Pile maintained load testing usually requires the imposition and maintenance of a load on a pile while its settlement or other characteristics are monitored. The loading and unloading can typically take 12 to 24 hours, however longer test periods are sometimes necessary. Part of the load test therefore may occur overnight.
- 2 During night-time work, the Principal Contractor's responsibilities for safety and security must be maintained, including: welfare facilities, site and personal security, lighting (both area and task), pedestrian walkways to the working area and emergency preparedness.
- 3 Should the pile test behave in an unpredictable manner suggesting failure of the ground, structural failure of the pile itself or failure of the loading system, the test should be terminated and no change in loading applied until a proper engineering assessment has been carried out. The test technician should not attempt to correct the test equipment whilst alone.
- 4 During any period where a lone worker is to be employed, the testing contractor must provide a lone worker risk assessment to the piling contractor, including procedures to cover for possible injury or ill health.
- 5 Prior to carrying out any work alone, the technician must exchange contact phone numbers with the piling contractor's supervisor. Similarly the piling contractor's supervisor must exchange contact numbers with the Principal Contractor's site manager.

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Federation of Piling Specialists Testing Datasheet No 10

Pile Integrity Testing - A Good Practice Guide

- 1 Pile integrity testing is normally carried out after the piling contractor has left site. It is important therefore that the piling contractor provides the Principal Contractor with a specified contact person who will arrange for testing to be carried out when requested.
- 2 The contract documentation will normally specify how many visits to site are allowed to carry out the integrity testing or the minimum number of piles to be tested at each visit. This aspect can be usefully addressed during the pre-start or subsequent progress meetings.
- 3 It is good practice for the Principal Contractor to be provided with guidance on the preparation of piles for testing, specifically that:
 - The pile needs to be trimmed down to sound concrete.
 - Safe access needs to be provided for the test technician to gain access to the head of each pile.
 - The pile cap/ground beam excavations must be clear of any standing water.
 - The pile cap or ground beam reinforcement must **not** be in place.
 - Although a thin layer of blinding can be in place around the pile, it must neither cover the pile nor be greater than 75mm thick.
- 4 Where the integrity test results indicate there is an anomaly in the pile, the Principal Contractor should be advised at the earliest opportunity so that potential problems can be promptly addressed. It should be noted that anomalies identified at the time of testing may be re-evaluated after processing of the data. Hence, sufficient time in the Principal Contractor's programme should be allowed for dealing with any potential anomalies.

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Federation of Piling Specialists Testing Datasheet No 11

Pile Integrity Testing – Basic information to be provided to the Testing Contractor

General

Full site address
Site location map
Contract identification number
Principal contractor name
Engineer's name
Client/Employer's name
Number of pile tests
Type of pile test
Any particular site restrictions and site specific safety rules
Details of site induction(s)
Piling contractor's office and site contact details

Pile Information

Identification (numbers and locations)
Pile diameter or width
Piling technique
Ground conditions
Platform levels
Cut-off levels
As-built pile lengths in ground for every pile to be tested
As-built levels of pile bases
As-built toe levels of pile reinforcement
Dimensions of any permanent casing or cast-in steel members
Details of any flared heads or enlarged pile bases

The following information may be requested after the test;

- concrete overbreak or undersupply
- records of construction or concreting sequence

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Federation of Piling Specialists Testing Datasheet No 12

Pile Integrity Testing - why it is important to allow enough time between pile integrity testing and pile cap construction

- Pile integrity testing is an important part of the pile construction process
- There is a small risk that the pile might be damaged after construction, either by the ground itself or by the following site activities
- When pile damage or an anomaly has been identified, it is important that the appropriate measures are then carried out;
 1. the integrity test result must be reviewed by a competent person
 2. the pile construction record must be reviewed and compared to the pile integrity test result
 3. if after data processing there is still doubt regarding the pile quality, an inspection must be made, normally requiring excavating around the pile or coring through the pile
 4. if a problem is found to exist, remedial measures will then need to be designed, approved and installed
- Hence, it is important that the site programme is designed to allow the time for reporting the pile test results and for any subsequent checks and remedial actions, if any, to be carried out

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Pile Integrity Testing - terminology

Different testing contractors use slightly different terminology for the assessment of piles. Terminology similar to that below is recommended;

Assessment by the testing contractor	Description	Site actions required to be carried out by the main contractor
OK	Pile acoustically satisfactory	None - proceed
Trim and re-test	Anomaly identified at pile head	Trim pile to sound concrete and schedule a new integrity test with the testing contractor
Review	Acoustic review needed after detailed analysis or upon receipt of further information	Contact piling contractor Piles to be left alone unless agreed with piling contractor

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Federation of Piling Specialists Testing Datasheet No 14

Pile Integrity Testing using Cross Hole Sonic Logging

Criteria for Evaluating Data

Cross Hole Sonic Logging evaluates the concrete quality in piles by passing an acoustic signal between a transmitter lowered into an access tube and a receiver lowered into a second tube.

The most common criteria for evaluating the data are the First Arrival Time (FAT) and the signal energy. Quantitative evaluation of concrete piles using the limits below is recommended;

Evaluation	Increase in FAT		Reduction in signal energy
Good	0 to 10%	and	< 6 dB
Questionable	11 to 20%	or	6 to 9 dB
Flaw	21 to 30%	or	9 to 12 dB
Defect	> 31%	or	> 12 dB

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Federation of Piling Specialists Testing Datasheet No 15

Pile Testing - Safety

Specific hazards for pile testing may include but are not limited to the following;

1. Load Testing

- Manual handling of items of test equipment.
- The forces induced in the test equipment during testing can be very large indeed. Thus a clearly marked and signed exclusion zone must be created around the test area and access restricted.
- During the test the following substances may be used: batteries, oxygen free nitrogen, petrol/diesel and hydraulic oil. The appropriate COSHH sheets are to be made available upon request.
- Working at height during erection and dismantling of the test equipment.
- The area around the test must be made suitable for the technician to safely work, i.e. levelled, hard-cored and without trip hazards.
- Safe and maintained access to the test area for lorries and plant.
- Lifting operations.
- Use of Working Platform Certificate for the platform within and around the test area.
- No excavations must take place around the test area.
- Specific arrangements for lone working.

2. Integrity Testing

- A safe access needs to be provided for the test technician to gain access to the head of the pile.
- The pile cap/ground beam excavation must be clear of any standing water.
- The pile cap or ground beam reinforcement must not be in place otherwise there will not be safe access for the technician and protruding tie wire can cause injuries.

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