Federation of Piling Specialists

NOTES FOR GUIDANCE ON

THE EXTRACTION OF TEMPORARY CASINGS AND TEMPORARY PILES

WITHIN THE PILING INDUSTRY

This document has been produced in association with the HSE

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APPENDICES

GUIDELINES FOR THE EXTRACTION OF TEMPORARY CASINGS AND TEMPORARY PILES WITHIN THE PILING INDUSTRY

1.0 INTRODUCTION

The extraction of temporary casings and temporary works piles has long been common practice within civil engineering and the piling industry in particular. Temporary casings are regularly used in the construction of bored piles to both provide a guide for the auger and to support otherwise unstable soils. Perhaps the most common temporary works piles are sheet piles although ‘H’ piles and steel tubes are often used for temporary support being extracted on completion of the works, particularly in marine applications. The details of the extraction method, in particular for the removal of temporary casings used in the construction of traditional bored piles, has largely been selected on the basis of the judgement of experienced personnel and, in most cases, has been successfully concluded. However, if this judgement is incorrectly made the results can be catastrophic. For example, where a crane is being used the sudden failure of a hoist rope will in turn trigger a sudden release of load on the boom which may cause it to fail dramatically as it whips back hard against the stops and back over the cab (Figure 1). This may result in personal injury, or worse, significant damage to both equipment and the works under construction or even third party structures. At the end of the day a failure of the selected method will inevitably lead to delay and increased cost.

Figure 1

Since its formation in 1963 The Federation of Piling Specialists has always had as one of its main drivers the improvement of the Safety of both its members' operations and the Piling Industry as a whole. In general terms the F.P.S. has been most successful in this regard largely due to the work of the Safety and Training Committee. This committee, which meets on a quarterly basis, is open to the safety representatives of all member companies and is a forum where these representatives can meet to exchange experiences for the benefit of all concerned.

Reports of accidents and incidents, including RIDDOR reports with the names of individuals and companies removed, are sent to the FPS secretariat so that statistics identifying type of accident, cause, injury etc can be prepared and presented to the committee for analysis by the meeting. Specific accidents/incidents can then be reviewed to identify ways in which safety within the piling industry can be improved. The piling industry is extremely competitive in all respects however FPS members do not compete on safety but aim to share experiences for the benefit of all.

The FPS has, over the years, both produced a number of its own documents and made significant contributions to documents/standards produced by others, including the following:

- BRE Guide 'Working Platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground-supported working platforms'.
- FPS guidance: 'The Application of the LOLER Regulations to Piling Rigs'.
- FPS Notes for Guidance on PUWER (Regulations 11 and 12) in relation to Guarding and Cleaning of Augers on Piling Operations.
- FPS guidance: 'Lifting Operations on Piling Sites - Appointed Person Statement'.

This particular document considers the removal of temporary casings and temporary piles which is a common requirement of the industry and is an operation which may generate significant forces which are difficult to quantify. The extraction process may require the use of rigs, cranes, purpose built extractors, jacking systems or other means but whatever the system employed an assessment needs to be made of the specific operation being undertaken. The variables which contribute to the force required to extract a particular element are many, varied and difficult to calculate and are not only limited to the soils applying friction to the outside of the casing or pile. To date, in most cases, assessments have been made on the basis of experience, however, following recent occurrences within the industry, the Safety and Training Committee, together with the H.S.E., identified that a more rigorous procedure was required and that a set of guidelines which outlined the various factors which need to be considered would be a useful tool, hence this document.

It is noted that this document does not cover the extraction of augers during the construction of Continuous Flight Auger or other piles, for which the rig manufacturer's recommendations should be followed, nor does it cover the extraction of pokers during vibro compaction operations which should be assessed by the vibro specialist. Operations undertaken utilising mini-rigs (i.e. small drilling rigs in which the mast is directly supported by the ground) are also excluded from this document.

As with a number of previous documents produced by the FPS, this document has been produced in association with the HSE and the FPS thank them for their valuable input.

The document is commended to all those within the industry who may have reason to extract a pile or casing as part of their works, whether or not they are a member of the FPS, so that the industry can be more comfortable in the knowledge that this operation is being undertaken in a safe manner.

Chairman
Federation of Piling Specialists

2.0 SELECTION OF PILING METHOD

As to whether pile or casing extraction is going to be a requirement of the piling process stems from both the requirements of the designer of the permanent structure and the initial selection of the method of piling to be adopted. This selection is likely to have been made early in the evaluation of the structure as decisions would need to be made as to the requirement for piles, be they load-bearing and/or retaining. Consideration should be given to sacrificing temporary piles and/or casings by cutting them off below ground level on completion of construction thus avoiding extraction.

There are numerous piling systems on the market all of which have advantages and disadvantages, depending upon a number of factors. Pile selection can be a complicated issue but will essentially take into consideration the following:

- Safety – both during construction and in use, along with a consideration of potential re-use or removal
- Requirements of the proposed structure and applied loadings
- The ground conditions
- Environmental factors – including nuisance, effect on wildlife and habitat, noise and vibration, waste products (spoil), carbon reduction etc.
- Access to and location of site
- Proximity to existing assets (e.g. utilities, roads railways), in particular when the works are adjacent to operational railways
- Proximity to sensitive structures
- Cost

Pile types can generally be split between displacement or replacement techniques as shown in Figure 2 below:

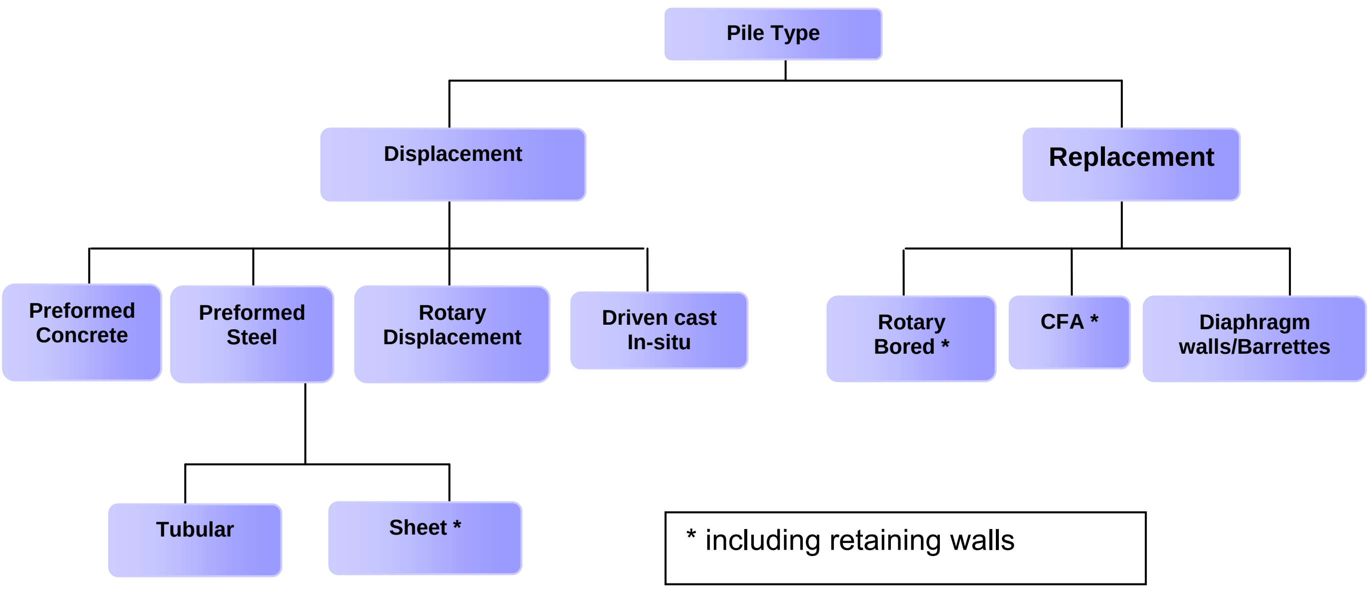

Figure 2

With both approaches there may be a requirement to extract temporary steel casings/piles or other elements from the ground as part of the construction process.

2.1 Displacement Techniques

2.1.1 In general terms the requirement for extraction will be less for displacement techniques, particularly with precast concrete and rotary displacement piles, however there are situations where this is not the case and safe working practices will need to be considered:

2.1.2 Driven Cast In-Situ Piles – Whilst the end product is a concrete pile the installation method requires the driving and extraction of a temporary steel casing over the full depth of the pile and the load likely to be required to enable extraction of this casing would need to be a consideration during the selection of the technique (refer to section 3 of this document).

2.1.3 Temporary Driven Steel Piles – In some situations temporary steel piles are driven either as retaining walls, as framing piles or to provide load bearing support for temporary works. In these cases whilst extraction is always envisaged, piles may be in the ground for long periods of time and therefore further consideration will be any additional friction generated with time. The types of pile may include Steel Sheet Piling, Steel Tubular Piling and Steel H Piles.

2.1.4 Preformed (Precast) concrete piles - this technique does not use temporary casings, the piles are not usually extracted and therefore not normally applicable to this document.

2.1.5 Timber Piles – These are not commonly used but on occasions are specified in, for example, ports and harbours. Extraction may be required where ports are being re-developed and this extraction can be challenging due to the lack of information on the original installation, including pile depth, and uncertainty over the extent to which the wood may have degraded with time.

2.2 Replacement Techniques

2.2.1 Rotary Bored Piles – These piles will use lengths of temporary casing to act as a positional guide at the surface and as support to the open bore over sections of unstable ground. These pile types will generally be used where:

- pile diameter/depth/load bearing capacity exceeds that of the capability of available CFA rigs
- pile bores extend in to hard strata
- steel reinforcement is required to extend beyond that depth which it is possible to place using CFA techniques
- it is a cost effective solution

For this system temporary casings are usually in the ground for only a few hours. Significant frictional forces may, however, be generated over time which may be relatively insignificant for short small diameter casings but for long larger diameter casings are likely to be critical to the selection of the extraction method adopted.
Further, where secant piles are being formed using this technique an additional consideration will be the friction generated from boring through adjacent concrete piles.

2.2.2 CFA and Cased CFA – With these techniques there will be little or no requirement for separate extraction as removal of augers and casings is undertaken by the piling rig as part of the piling operation and should be undertaken in accordance with the rig manufacturer's recommendations. As augers and casing, where used, are attached to the rig both extraction and rotation may be used during the pile formation.

2.2.3 Rotary Displacement – again this technique does not generally use temporary casings and, as for CFA piles above, augers are usually extracted by the rig so the manufacturer's recommendations should be followed.

2.2.4 Piled walls – contiguous or secant pile retaining walls may be formed by a combination of the above systems so the specific extractions systems apply. With respect to secant pile walls, care should be taken in the extraction of temporary casings of 'male' piles should the casing become jammed against the set concrete of the adjacent 'female' piles.

2.2.5 Diaphragm walls – extraction in this process normally limited to the extraction of stop-ends. Whilst stop-ends which are released by peeling them away from the set concrete are more commonly used, occasionally extraction involving the use of jacks and / or cranage may be employed.

A Flow Chart identifying the pile selection procedure and in particular the relevance of Casing Extraction within this process is included under Appendix A of this document.

3.0 ASSESSMENT OF EXTRACTION LOAD

3.1 Before attempting the removal of any temporary casing or pile from the ground, it is recommended that an assessment of the required extraction force is carried out.

3.2 This assessment is not straightforward in so far that there are a significant number of variable factors which need to be considered, some of which have limited absolute parameters. An understanding of the forces generated will be required, however, in order to assess the most appropriate method of extraction and to ensure the operation is carried out both safely and successfully.
The assessment will generally be made on the basis that the extraction force will be applied along the axis of the pile using, for example, the piling rig, a service crane or casing extractor. Should this not be the case then a further allowance will be required taking the line of the extraction force into consideration. Rotational forces may also be used to aid extraction and should be considered, as should the use of a vibrator.

3.3 There are a significant number of factors and variables that influence the resistance to the extraction of a casing or pile. It is important that all the relevant factors are reviewed, however briefly, as part of the extraction force assessment.

An initial assessment should be carried out on a project specific basis and should form part of the pile selection process early in the pile design stage of the project to avoid abortive work. This frequently occurs at the time of tender for the specialist works. At pile construction stage, often contract stage for the specialist works, a suitable and sufficient assessment should be carried out to ensure safe methods of extraction are utilised and included into any project method statement and risk assessment. The constituent parts of the required extraction force for casings and piles are summarised in Figure 3 below, simplified into three key types (denoted case A, B and C for the purpose of this document).

Case	Type	Extraction Resistance	Examples
Case A	Temporary Steel Casing	• Frictional forces/adhesion on external surface (casing/soil) • Frictional forces/adhesion on internal surface (casing/concrete) • Self weight of casing	Temporary steel casing for rotary bored piles. Driven cast in-situ pile
Case B	Closed Ended or Solid Pile	• Frictional forces/adhesion on external surface (pile/soil) • Self weight of casing or pile • Weight of concrete, water or other infill	Closed ended steel pile Steel H or Sheet pile
Case C	Open Ended Pile	• Frictional forces/adhesion on external surface (pile/soil) • Frictional forces/adhesion on internal surface (pile/soil) • Self weight of pile • Frictional forces/adhesion on internal surface (casing/concrete) • Potential weight of soil or concrete plug	Driven tubular steel pile

Figure 3

3.4 The key factors to be considered may be further summarised, but are not limited to those summarised in Figure 4.

Potential Factors to be Considered
Geometry of casing/pile (diameter, length, self-weight etc.)
Friction on outside of casing/pile (soil friction) *Including but not limited to:* • external surface roughness • method of installation ('mudded in', oscillated, vibrated, screwed etc.) • use of oversize cutters/casing shoe • soil type • ground water level • surface area • time elapsed from installation • verticality
Friction on inside of casing/pile (soil friction) *Including but not limited to:* • internal surface roughness • soil type • surface area • time elapsed from installation • verticality
Friction on inside of casing (wet concrete) *Including but not limited to:* • concrete mix • internal casing roughness • time elapsed from placing of concrete

Figure 4

In undertaking these assessments it should be remembered that soil properties may have changed either by the very act of placing the casing/pile (for example vibration may densify the soil) or during the period that the casing is in the ground (for example by surcharge or change in ground water levels.

3.5 Once all the various required factors have been assessed the actual calculation of extraction resistance can be a relatively straightforward operation, albeit various basic assumptions would need to be made. It is therefore essential that this process is carried out by a suitably experienced and competent person.

The following equation details the basis of any such calculation;

$$F_{ext} = SW + Qs_{ext} + (Qs_{int} \text{ or } Qs_{conc})$$

Where F_{ext} = extraction resistance
SW = self weight of casing or pile
Qs_{ext} = friction on external surface (casing/pile to soil)
Qs_{int} = friction on internal surface (pile to soil)
Qs_{conc} = friction on internal surface (casing to concrete)

See Figure 5 below.

Note: where relevant an allowance for the potential weight of a soil plug must be added.

3.6 An example calculation for a 'Case A' situation is included under Appendix B of this document. The approach adopted and values derived are for guidance purposes only and users of this document should adopt their own parameters and approach.

3.7 A factor should ultimately be applied to the assessed 'extraction resistance'

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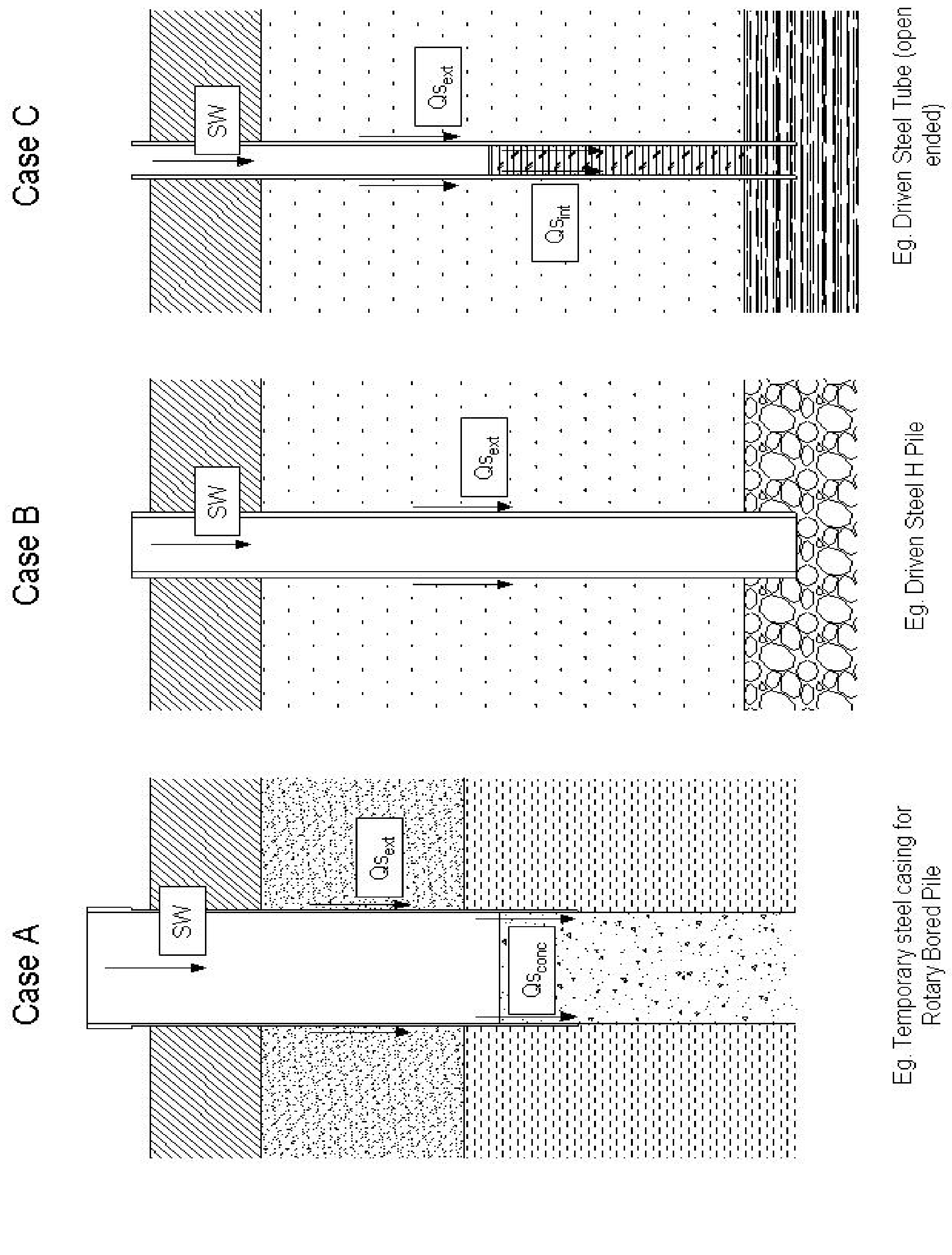


Figure 5

4.0 SELECTION OF METHOD FOR EXTRACTION

Having selected the pile system to be adopted and, where extraction is a part of the process made an assessment of the forces involved, the decision then has to be taken as to the method of extraction to be used.

This will largely be dependant on the piling method selected and the rig and equipment already available on site.

It is noted that extraction by the use of cranes alone, without for example a vibrator or extractor, is not recommended. The HSE considers this to be an unsafe practice and should be considered only for relatively short 'lead' lengths of temporary casing which would be dependant on diameter and length of casing, capacity of crane being used and following an assessment of the extraction load.

The following section gives guidance as to how the selection of the extraction method may be approached.

4.1 As seen in Section 1 above, the necessity for temporary support during foundation works may require the use of:

- steel casings during the construction of bored piles.
- steel casings for driven cast in situ piles.
- sheet piles to support excavation throughout the construction phase.

For the purposes of this section of the document the reference to 'temporary casing' may also, where relevant, refer to other methods.

4.2 The decision to use temporary casing to support the pile bore will be made during the pile design/selection process. The diameter, depth and type of casing are largely dependent upon the soil strata through which the pile is to be constructed. This selection process must also take into account the resistance of the soil to both installation and extraction. The forces to overcome extraction are generally greater than for installation and so will normally be the over-riding factor in the selection of the method ultimately to be adopted.

4.3 Installation

4.3.1 Pilot hole

It is common practice for a pilot hole of a limited depth to be formed. This will be an open bore to locate the casing at the pile position.

4.3.2 Mudding Up

Where the near surface soils do not allow an open bore to be formed, the technique of 'mudding up' may be used. The mudding up process requires the soil material to be formed into slurry by 'mixing', sometimes having added bentonite powder. This slurry supports the bore until the temporary casing is installed.

The temporary casing is inserted into the bore and rotated/vibrated to a depth sufficient to allow the rotary table of the piling rig to reach over the top of the casing and take over its installation until it has reached the required depth.

4.3.3 Rotation

Where shorter sections of casings are required it is common to attach these to the underside of the rotary table and use a casing drive adaptor (or Twister bar attached to the Kelly bar where this is not available). The rig will be positioned over the pile (or pilot hole) and the casing screwed into the ground to the required depth. Installation is governed by the available power of the piling rig and available height under the rotary head.

Longer casings may be installed in this manner by ‘telescoping’ the casing to a smaller diameter pile inside an oversized upper casing section. Practicalities may, however, require the upper sections to remain in place after pile construction.

4.3.4 Vibration

Longer casings may require the use of a crane suspended high frequency casing vibrator to place the casing to a depth suitable for the piling rig to move over the top and drill out. Whilst long casings may be placed by vibrator, the extraction forces required to recover them from the ground may be of such a magnitude that the casing becomes permanent.

When assessing the size and configuration of the crane being used to handle vibrators the total weight of the vibrator together with jaws, hydraulic clamps and hydraulic hoses must be included. Further, the method of laying down a casing/pile following extraction must be considered.

4.3.5 Driven cast in-situ

Steel casings driven as a temporary support are closed ended (fitted with a driving shoe). A hammer or vibrator of suitable energy will be used to ensure the required pile depth/resistance is achieved. An important factor in the diameter and installation depth of driven cast in-situ piles is the ability to extract this temporary casing with the equipment used to drive it. This should be considered both during the pile selection process and at the time of equipment selection for a specific project.

4.3.6 Rotation/oscillation

Ground conditions and the desire to avoid the use of drilling support fluids may require the use of long temporary casings. Where the use of conventional single ‘thin walled’ casing reaches a limit due to rigidity for rotation or extraction, double walled segmental casing is used. This utilises shorter segments of casing joined together by locating lugs and is installed to the required depth by:-

- Direct rotation from the piling rig.
- Rotating through oscillation i.e the use of a separate casing oscillator which imparts small see-saw rotational movement together with a downward jacking force.

This system may also be used for the construction of secant pile walls.

4.3.7 Jacking/Push Piling

The jacking of tubular and sheet piles into the ground is becoming more common as a means of providing both temporary and permanent support. There are proprietary systems developed specifically for this method of operation using hydraulic rams to push the piles into the ground. These systems can also be particularly effective in the removal of temporary piles. The mode of operation must be considered taking due account of the manufacturers instructions.

Figure 6. Propriety Jacking System in use with sheet piles.

4.4 Extraction

Although important, the manner of installation must not be used solely to govern the system for extracting casing. Extraction must be considered in isolation to ensure a safe method is adopted.

4.4.1 Hydraulic Piling Rig

The modern self erecting hydraulic piling rig offers a readily available method for the removal of temporary casings and piles. For casings, if they have been spun (rotated) into the ground, sometimes with the added ability of the rig to also provide a crowd force, the ability to rotate in combination with the rigs extraction capabilities are likely to be preferable for their removal. The additional ability to measure and monitor rotational torque and extraction forces on some piling rigs gives an immediate indication of the reduction in friction on the casing prior to pulling with the piling rig. The ability to pull while still rotating makes this preferable where soil conditions can generate high friction resistance over the length of the casing.

Under this method of extraction the forces required to move the temporary casing or pile are transmitted to the working platform through the piling rig. These extraction forces must form part of the loading criteria provided by the piling contractor to the designer of the working platform. A working platform certificate should be in place before any work commences on site. The FPS working platform certificate (WPC) details the requirements for design, construction and maintenance.

The piling rig is attached directly to the casing/pile to be extracted by one of the following means: through the rotary table, by use of a 'twister bar', by hydraulic clamps, by the use of wire rope strops and shackles, through a purpose-built adaptor. Extraction is then undertaken by applying load to the main hoist and/or hydraulic ram. Extraction is ultimately limited to the capacity of the piling rig and the manufacturer's instructions must be followed accordingly.

Figure 7. Hydraulic Piling rig with casing adaptor fitted to rotary table.

The limiting factor for this method of extraction is generally the length of casing which can be accommodated under the rotary table together with the available extraction force.

4.4.2 <u>Crane Mounted Piling Rig</u>

The same principles of extraction apply with the disadvantage that rotational torque is not readily measured and the available height under the rotary table limited.

With reference to both the above methods, the casing must have been completely freed within the pile bore before a lift crane is connected to the casing to remove it from the pile bore.

4.4.3 Driven Cast In-situ Piling Rig

Extraction of the steel support tube is carried out using the installation rig. The process involves attaching the driving hammer to the tube and striking the tube with upward blows whilst utilising the available 'pull' through the main hoist.
In addition to the assessment of the forces required to break the frictional soil bond, consideration must also be given to the stability of working platform to resist the extraction loads.

4.4.4 Sheet Piling Rigs

Sheet Piles will generally be extracted using similar equipment to that used during installation.

- With leader rigs the vibratory hammer will attach to the top of the pile and withdraw the pile directly from the ground. The use of chains attached beneath the hammer should be limited to the lowering of the pile to the ground upon extraction and only as recommended by the rig manufacturer.
- Piling systems used to push/jack piles into the ground can be particularly effective in the safe removal of steel and sheet piles. In this case the unit attaches itself to a number of installed sheet piles and uses the reaction of these piles to withdraw, using hydraulic rams, a single sheet pile.
- When the pile has been completely freed, only then should it be removed and laid down by an attendant crane.

Figure 8. Hydraulic Piling Rig

4.4.5 Crane

The straight pull of a casing using the main hoist of a crane or an excavator dipper arm should only be considered for short lead length casings or casings/piles which have already been freed by other means. The potential remaining frictional resistance must be assessed together with the self-weight of the casing and associated lifting accessories. This information must be used in the selection and configuration of the crane or excavator.

Extraction of longer casings/piles using a crane will most likely require a reduction in potential frictional forces to bring the load on the crane to within acceptable levels. Methods for reducing friction on casings prior to extraction may include:-

- Rotation by the piling rig
- Rotation and extraction by the piling rig
- Use of a propriety pile extractor
- Use of a vibrator
- Use of a jacking system

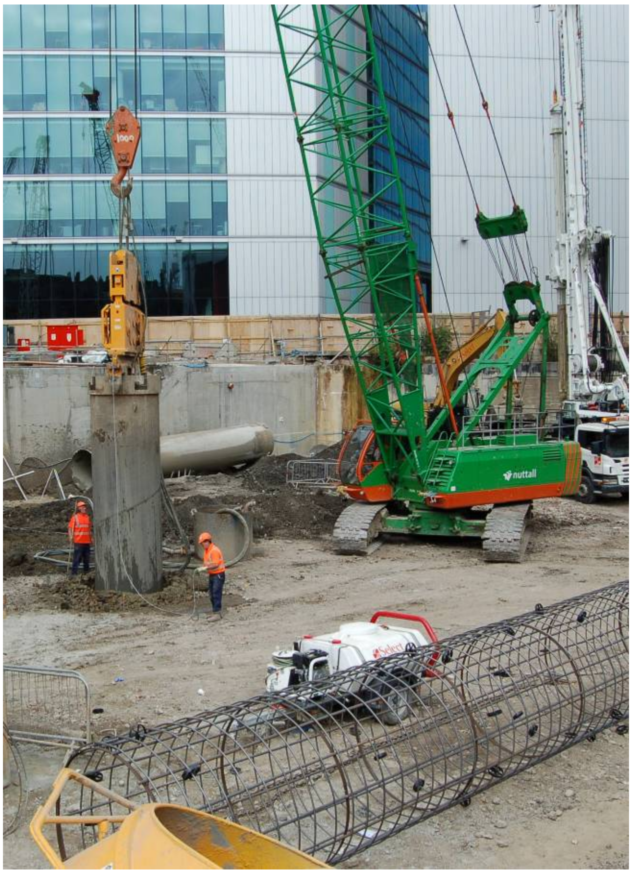


Figure 9. Crane suspended vibrator being used for placing of a temporary pile casing.

Where the extraction forces cannot be accurately assessed or greater certainty is required, tests must be carried out in a controlled manner under the direct supervision of a competent person in accordance with the Lift Plan. Determination of the forces involved may require the use of the crane instrumentation system and/or a digital load cell placed on the hook of the crane.

4.4.6 Casing/Pile Extractors, Oscillators and Jacks

The use of casing extractors is generally limited to segmental casing as the clamping forces required to 'hold' the casing may deform conventional single thin walled temporary casing.

Casing is rotated either by the piling rig or oscillator depending upon the rotational torque required to move the casing in the ground. Vertical extraction will depend upon the ability of the piling rig to lift the string of casing. Where this is beyond the capability of the piling rig the casing will be jacked out of the ground using the oscillator or specially designed jacking equipment.

Only once segments of casing have been removed from the string to the extent that the casing has been freed, extraction may be completed using the piling rig or crane.

Figure 10. Purpose built casing extractor.

Similarly for pile extraction, propriety extractors must be used to free the pile prior to the rig or crane lifting the freed pile.

Figure 11. Crane extracting a length of segmental casing from a propriety oscillator

Note: It is recommended that the first casing or pile extraction on a project is undertaken under the direct supervision of an experienced supervisor, senior foreman or contract engineer.

In conclusion a general rule which must be adhered to is that a combination of extraction tools must not be used unless the system has been properly designed. For example a piling rig and a crane should not be used in tandem. Alternatively a system with an oscillator and crane working in tandem may be employed providing the system has been properly designed, method statements and risk assessments undertaken.

5.0 OPERATIONAL SAFETY

5.1 Method Statement and Risk Assessment

This section has been compiled to assist in identifying some of the factors which should be considered in producing the Method Statement and Risk Assessment which must be undertaken prior to the commencement of the works.

The various methods which may be employed are summarised under Section 3 above of this document.

5.1.1. In comprising a Method Statement and Risk Assessment the following are some of the factors which should be considered:

- Piling rig selection
- Crane selection
- Crane configuration
- Piling platform
- Lifting accessories
- Controlled test of extraction method selected
- Site access
- Site constraints
- Other site operations
- Proximity to public
- Proximity to roads, railways etc
- Proximity to utilities underground and over ground (e.g. power-lines)
- Contingency should initial method not be successful
- Training/qualifications of site team
- Briefing of site team
- Site working hours

5.2 Selection of Crane

The selection of crane will be determined after assessing the load, taking into account the guidance given in Section 2 of this document. The following should also be considered:

5.2.1 Line pull / capacity………the crane block should be rigged multi-sheaved
5.2.2 Radius at which the crane will be working
5.2.3 Site Access
5.2.4 Size/dimensions
5.2.5 Ground bearing pressure
5.2.6 Whether ‘free-fall’ operation is a requirement
5.2.7 Effect of any limitations to operations e.g. overhead power line, railways

On arrival at site the crane:

5.2.8 Must have a current 12 month report of thorough examination and recorded weekly inspections.
5.2.9 Must be fitted with a Rated Capacity Indicator (RCI) which clearly shows the operator the radius of the equipment and the corresponding safe working load.

On completion of erection of the crane the following should be in place:

5.2.10 Pro-forma signed-off by the fitter/rigger or person responsible for its erection stating that the crane has been inspected and is ready for use.

5.2.11 Pro-forma signed-off by a Competent Person (Foreman or authorised person) stating that the crane instrumentation has been independently checked and is configured correctly.

5.2.12 A suggested pro-forma for bringing together Design Considerations and Crane Selection is included under Appendix C of this document.

5.3 Lift Plan

Whenever cranes are to be used in association with the extraction of temporary casings or temporary piles in the ground as described in the introduction to this document, a Lift Plan must be produced to cover the method of extraction.

The Lift Plan must be produced and signed off by an 'appointed person' as required under LOLER 98 and as described in FPS LOLER guidance note.

The Lift Plan should cover all aspects of safety as described in section 4 of the FPS LOLER document but with particular emphasis on extraction. As a minimum it should assess the following:-

5.3.1 Consider if the temporary casing/pile can be extracted by the same method as it was inserted.

5.3.2 Extraction of the temporary casing/pile must never exceed the safe working load (SWL) of the lowest denominator, be it the crane, the lifting accessories or the lifting point.

Note: enhanced safety factors should be considered at this stage, especially where either the load cannot be accurately determined and/or impact/vibratory loading may be a factor

5.3.3 The maximum force, taking into consideration the above factors, must be clearly stated in the plan

Note: If when the maximum force is reached, the 'frictional bond' has not been broken and the casing/pile freed, then the method of extraction should immediately be reviewed.

5.3.4 The Lift Plan must also include the procedure for laying down the casing or pile on completion of the extraction process.

Note: Where a crane suspended vibrator or extractor is being used, then the casing or pile must be properly attached to the vibrator or extractor by means of a wire rope sling to prevent it falling should the jaws of the vibrator or extractor be released by accident.

5.4 **Selection of Lifting Accessories**

The selection of these (e.g. shackles, slings, chains) will also be determined by assessment of the load. Note the following:

1. Lifting accessories must have a current six month thorough examination certificate.
2. Lifting accessories must be clearly marked with the safe working load.
3. Lifting eyes (holes formed in casing to take a shackle or other device) should be designed and fabricated by competent persons and subject to regular inspections.

Note: As noted under 5.3.2 above enhanced safety factors should be considered.

5.5 Test Extraction

It is recommended that at the commencement of a contract, especially where significant extraction forces are anticipated, the first extraction is undertaken ‘as a trial’ in the presence of an experienced engineer or supervisor/senior foreman.

5.6 Working Platform Certificate

A Working Platform Certificate (W.P.C.) must be in place prior to any operations commencing and must include for loadings resulting from attendant carnage as well as piling rigs.

5.7 Permit to Dig

A Permit to Dig should be in place for all pile construction operations.

5.8 Tool Box Talks

All persons involved in the extraction operation, in particular the rig or crane operator, must have been properly briefed by means of a Tool Box Talk or other process.

6.0 GLOSSARY OF TERMS

The terms used within the document have the following meanings:

- **Bond** – Term used to describe the frictional resistance between a casing/pile and the surrounding soil and/or concrete
- **Cased CFA** - As CFA above but steel casing is installed at the same time as the auger to provide support to the open bore
- **Casing Shoe** – Specialised end to a length of casing which is reinforced and has a number of cutting elements such as tungsten tips allowing the casing to cut through in situ soils….may be left in the ground on extraction of casing
- **CFA** – Continuous Flight Auger – a method of drilling piles where an auger extending over the full length of the pile is screwed into the ground and concrete is pumped through a central hollow stem
- Crowd force – downward force applied by a piling rig
- **F_{ext}** – Extraction resistance
- **FPS** – Federation of Piling Specialists
- **Free** – casings, piles are considered to be 'free' if the casing or pile would otherwise descend back into the ground under its own self weght
- **HSE** – Health & Safety Executive – Official body in UK responsible for enforcing Health and Safety legislation
- **Jacking** – Method of installing/extracting a casing / pile where hydraulic pressure is applied via hydraulic jacks.
- **Kelly bar** – the element providing the drive from the rotary table to the drilling tool (auger, bucket etc)
- **Lead Casing** – the initial length of casing placed in to the ground - may be fitted with a cutting shoe
- **LOLER** – Lifting Operations and Lifting Equipment Regulations 1998
- **Mudding Up** – Technique used near surface where soil material is mixed into a slurry which supports an open bore whilst temporary casing is installed
- **Oscillated** – Method of installing sections of casing using short see-saw movements together with a downward jacking force
- **Pilot Hole** – An open bore formed over a limited depth used to locate the casing at a pile position.
- **PUWER** – Provision and Use of Work Equipment Regulations 1998
- **Qs_{conc}** – Friction on internal surface (casing/pile to concrete)
- **Qs_{ext}** – Friction on external surface (casing/pile to soil)
- **Qs_{int}** – Friction on internal surface (casing/pile to soil)
- **RIDDOR** – Reporting of Injuries, Diseases & Dangerous Occurrences Regulations
- **Rotation** – Method of installing/extracting casings and piles where the casing is rotated and downward pressure is applied allowing a cutting shoe to cut through the in situ soils
- **Segmental Casing** – Where casing cannot be installed in a single length, then short sections of casings joined together using propriety bolts/studs can be used
- **'Silent pile technology'** – Term used to describe a range of equipment used to install steel sheet, tube and H piles. The method utilises reaction from previously installed piles to hydraulically press the casing/pile into the ground
- **Straight pull** – Method of extracting a casing/pile where a rig or crane is connected to the casing and extracts it from the ground with no additional methods for breaking the bond with surrounding soils.
- **SW** – Self weight of casing or pile
- **SWL** – Safe Working Load – the load capacity of a crane or lifting accessory with a defined factor of safety

- **Temporary pile or casing** – Any element inserted into the ground to provide bearing capacity or lateral support which will not be incorporated into the permanent works. For example tubular steel piles installed to support temporary frames, used to guide the installation of permanent piles and temporary casings used in the construction of bored piles.
- **Temporary Support/Temporary Works** – On some projects a series of guides or supports are installed prior to the main piling works in order to provide access and ensure accuracy and safety. These temporary works can be substantial in their own right and consideration must be given to their extraction on completing the works.
- **Twister Bar** – Adaptor fitted to the end of a Kelly bar to enable the Kelly bar to be attached to the casing
- **Vibrated** – Method of installing/extracting casings and piles where high frequency vibratory impacts are used to drive the casing/pile through the in situ soils
- **Working Platform Certificate** – Initiative of the FPS which details the requirements for the design, construction and maintenance of a working platform taking account of the planned operation and the site conditions. (Can be downloaded from www.fps.org.uk)

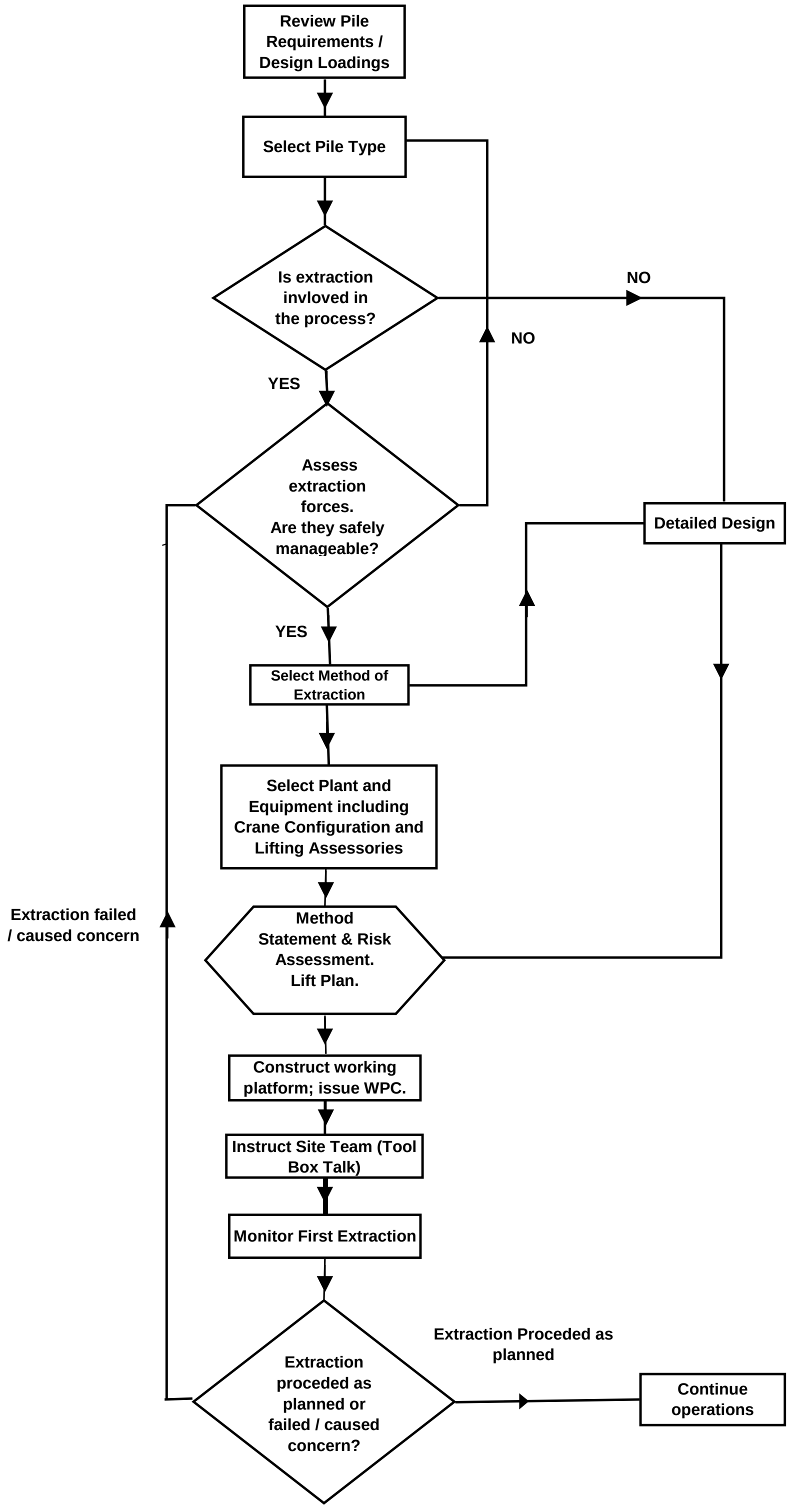
7.0 REFERENCES

- LIFTING OPERATIONS AND LIFTING EQUIPMENT REGULATIONS 1998.

- FPS Code of Industry Best Practice LIFTING OPERATIONS AND LIFTING EQUIPMENT REGULATIONS 1998.

- BRE Guide 'Working Platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground working platforms'.

APPENDICES
APPENDIX A – Flow Chart



APPENDIX B - Sample calculation

The sample calculation below is intended only as an example of how the calculation may be approached, it is not in itself a definitive form and only covers the most simple of requirements. The approach adopted and values derived are for guidance purposes only and users of this document should adopt their own parameters and approach. The FPS accept no responsibility for any errors, omissions or misunderstanding arising from its use.

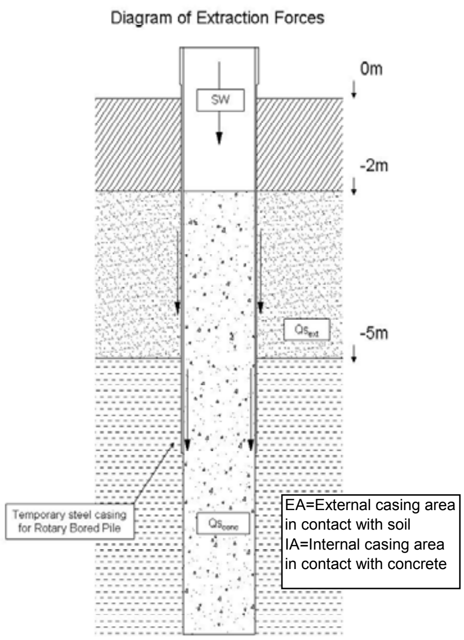
Project:	Project No. : 123456789		Page No. 1 of 1
Title: Example Casing Extraction Force Calculation - Case A	By: ABC	Checked: ABC	Date:

Project within London

900mm dia. casing is to be installed to a depth of 6m during the installation of rotary bearing piles, concreted to -2m.

Ground conditions beneath the site are generalised as follows (see diagram below);

0 to 2m Made Ground (predominantly granular)
2 to 5m Terrace Gravel (N=25, $\phi'=34^o$)
5m London Clay (cu=75kPa)
(groundwater encountered at -2m)



Method of casing placement.
0 to -2m open bore
-2m to -5m screwed in
-5m to -6m screwed to seal into clay
900mm OD (25mm thk) x 7m

Extraction resistance, $F_{ext} = SW + Qs_{ext} + Qs_{conc}$

SW = Casing self weight
SW = 4000kg, equivalent to 40kN

<u>External friction</u>, Qs_{ext};

0 to -2m ignored (bored oversize)

[-2m to -5m]

$Qs_{ext} = EA \times \sigma'_{vo} \times \tan\delta$ (where $\delta = 0.75\phi$)
$Qs_{ext} = \pi \times 0.9 \times 3 \times 51 \times \tan 25 = 200kN$

[-5m to -6m]

$Qs_{ext} = EA \times \alpha \times c_u$
$Qs_{ext} = \pi \times 0.9 \times 0.5 \times 75 = 106kN$

<u>Internal friction</u>, Qs_{con};

$Qs_{con} = IA \times \gamma_{conc} \times h \times \mu$ (where μ is taken as 0.1)
$Qs_{con} = \pi \times 0.85 \times 4 \times 23 \times 2 \times 0.1 = 49kN$

Therefore, $F_{ext} = 40 + 200 + 106 + 49 =$ **<u>395kN</u>**

(See Clause 3.7)

APPENDIX C - Design Considerations/Crane Selection Pro-forma

Site: **Review by:**
Pile Type:

This sample pro-forma is designed to be used simply as a check list to assist the engineer(s) undertaking the crane selection in concluding the crane capacity / configuration to be provided. Enter figure or X / √ where appropriate

A Casing / Pile Geometry
- type
- size
- length
- thickness

- self weight

B Friction on Outside of Casing / Pile (Soil Friction)
Including but not limited to:
- external surface roughness
- method of installation
- use of oversize cutters or casing / pile shoe
- soil type
- surface area
- time elapsed from installation
- verticality

C Friction on Inside of Casing / Pile (Soil Friction)
Including but not limited to:
- internal surface roughness
- soil type
- surface area
- time elapsed from installation
- verticality

D Friction on Inside of Casing / Pile (Wet Concrete)
Including but not limited to:
- concrete mix
- internal casing roughness
- time elapsed from placing of concrete

E Extraction Method Selected
- total theoretical extraction force
- extractor / vibrator to be used

F Crane Selection
- crane to be used to exctract / only when pile freed?

- weight of pile
- weight of vibrator / extractor where selected
- weight of assessories

- total crane lift capacity to be catered for
- radius at which crane operating
- length of casing/pile, assessories, vibrator/exctractor where used

- check laying down of casing / pile

G Conclusion

Crane type / capacity:
Crane configuration;
boom length
no falls

Signed Design Engineer: --
Signed Contract Enginer: ....
Approved Construction Manager: ---------------------------
Date: --

The FPS do not accept any liability for errors/omissions
in the above example proforma