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Guidance Note – Considerations For Specifying Crosshole Sonic Logging Tests

Purpose

Crosshole sonic logging in large diameter concrete bored piles and barrettes is a well-established integrity testing method in the UK. However, installing and joining reinforcement cages with loose steel sonic logging tubes is a highly hazardous activity for site operatives. Over recent years, the FPS has raised awareness amongst its members to improve the safety of this activity on sites. However, the need to place operative's hands at risk inside suspended reinforcement cages to physically connect loose sonic logging tubes is unavoidable.

On sites across the United Kingdom, FPS members are increasingly finding project specifications inappropriately specifying crosshole sonic logging or not permitting alternative suitable and safer integrity techniques. To further improve safety on site, this guidance note is directed to practitioners who write project piling specifications so that inappropriate crosshole sonic logging can be avoided, alternative safer integrity testing methods can be specified and where necessary, crosshole sonic logging can be specified more safely.

Furthermore, inappropriately specified crosshole sonic logging can actually be of questionable benefit and even cause many of the anomalies in piles which it detects**.**

Health and safety

Crosshole sonic logging requires the installation of three or more full length steel tubes in the pile or barrette. These tubes are usually loose fixed to the inside of the reinforcement cage. Many deep foundation schemes involve long, bored piles/barrettes dictating cages of two or three sections or more. The assembly of these cages requires the bottom section to be suspended in the pile bore/excavation. The next section is then lifted above into place and spliced. The spliced cage is then lowered into the bore/excavation, suspended and the process repeated for the next section of cage.

Piling contractors and reinforcement suppliers have made great strides in developing innovative, safe and simple to use reinforcement cage splicing systems. These have eliminated the need for hands to be inserted into the cage to attach bolted clips or cage fixing brackets. Cage splicing can safely be accomplished now with no need for anyone to put their hands at risk.

However, joining sonic logging tubes still presents a major hazard.

Sonic logging tubes are fitted within the reinforcement cage, loosely held to the inside of the longitudinal bars, helical links and lifting bands with brackets. This is essential as logging is sensitive to accuracy of positioning and divergence or convergence of adjacent tubes. The tubes are held up above

the splice with ties until released, when they are free to slide down a given distance in order to enable manual joining of the tubes. The tubes are usually a screw fit to be watertight and to bar the entry of grout and concrete.

At any time after release, a momentarily jammed tube can free itself and fall. A 60 kg tube falling say 1m under gravity can cause serious injuries. A team concentrating on one jammed tube amongst 20 plus spliced cage bars, can take their eyes of the alignment of another tube. Fixing brackets for the tube can spring off the more flexible cage and fall from height. There are many cases of tubes subjected to unexpected loads during handling and transportation as well as catching on other parts of the cage or on the ground, where brackets then fall out of the cage during the lift. Some near miss events describe tubes falling from the upper section all the way down the pile bore. Had this occurred in the open, a 60 kg tube would free-fall three or four metres.

Piling contractors and reinforcement fabricators have tried many times to solve the problem. Stirrup bars and impact blocks are welded into cages to act as stops for sliding tubes. Different ways of screwing the tubes together have been tried. Some tubes are still sealed by wrapping with adhesive tape. There is a new push fit system available, but the issue of safety versus appropriateness and effectiveness of the test method still remains.

Over the years operatives have lost fingers and thumbs in the course of this operation. Even facial injuries have resulted from tubes slipping and falling. In the preparation of a previous discussion paper one FPS member reported 3 serious injuries and 39 hazards, near misses and safety observations related to sonic tubes in the past 6 years. Another recalled 4 serious hand injuries from three linked projects, including a lost finger and broken bones.

Site operatives have suffered hand injuries when using stilsons to tighten tubes whilst keeping their hands out of the cage. In one case however the top cage section slipped unexpectedly and knocked the stilsons downwards at speed, pulling the users hands into the cage.

Constructability issues and cage congestion

Attempts have been made to develop quick, push-fit couplers for sonic tubes. These however are bulky and when combined with the bracketry, hoops and multiple bars in heavy cages, generate a problem for concrete flow around and through cages. In an attempt to make sonic logging safer, these push fit couplers unfortunately generate defects. The majority of investigated ‘anomalies’ identified can be shown to be caused by the sonic tubes and brackets themselves. This self-generating problem results in high cost and time-consuming investigations such as concrete coring, to find that there is no anomaly, or the anomaly has been caused by the tube and bracketry itself, particularly in dense cages.

Reinforcement in CFA piles are plunged into a column of fluid concrete and for cages over 12m in depth, a vibrator is often used. This vibrating enables the cage to penetrate the concrete to depth. However, the sonic logging tubes can be shaken loose and be no longer parallel with each other or the sonic logging tube connections can be loosened allowing the concrete to enter and block the tube, thus

rendering the tubes useless. In addition, a cage with sonic logging tubes will not be able to be plunged as deep as a cage without sonic logging tubes. For these reasons, installing deep sonic tubes into CFA piles should be avoided wherever possible or advise sought from the FPS members before specifying them.

The assurance value of visual inspection, boring records, concreting records and Koden/sonic calliper records etc. should not be accorded a lower status than a single indirect integrity test with problematic traits. These other tests and assurance methods are readily available and should be considered of equal validity.

Unfortunately, 'cut and paste' piling specifications from one project to another are resulting in a requirement to undertake crosshole sonic logging unnecessarily and in some cases in piles of too small a diameter, resulting in sonic logging integrity tests of high cost but zero assurance value.

Considerations for specifying sonic logging

The FPS reminds designers that CDM 2015 states designers must: eliminate foreseeable health and safety risks to anyone affected by the project (if possible); and take steps to reduce or control any risks that cannot be eliminated. Also, to communicate, cooperate and coordinate with all contractors to take account of their knowledge and experience of building designs.

The designer (or specifier) should therefore take account of the following in the order of ELIMINATE, SUBSTITUTE, REDUCE:

ELIMINATE

- Sonic logging has traditionally been used in support fluid piles where the pile bore cannot be inspected prior to concreting. The specifier should therefore avoid specifying crosshole sonic logging in dry stable rotary piles, which can be visually inspected before concreting, or for CFA piles in stable ground conditions e.g. stiff clay.
- Sonic logging small diameter piles should be avoided. Sonic logging tubes must have a minimum clear separation of 300mm (but preferably more) between tubes. This is to reduce the more significant effect of delays (e.g. from transmission through non concrete materials like water in the tubes) on the sonic transmission velocity. Interpreting results for close tube spacing can still be challenging. Close tube spacing has been investigated indicating that the total possible cumulative error in FAT readings (i.e. concrete variability, access tube effect, FAT picking, sampling error) can make meeting FAT acceptance criteria difficult for tube spacing up to 800mm. Also, for small diameter piles there is little concrete to test between tubes. Therefore practically, crosshole sonic logging is only suitable for piles of not less than 750mm diameter but more commonly not less than 900mm diameter.

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SUBSTITUTE

- Can alternative integrity testing methods be applied? For example: thermal integrity testing, sonic echo/impulse response acoustic methods. Refer to FPS Guidance Note on Current Integrity Testing Methods.
- Where reinforcement cages are heavily congested i.e. closely spaced bars, bundled bars, laps, couplers and box outs, it should be recognised that effective concrete flow will already be challenging and consideration should be given to alternative integrity testing methods or reducing the amount of integrity testing.

REDUCE

- Consider the ground conditions for the potential to give pile/barrette defects. Do the ground conditions comprise soft/loose soils over deeper stable soil (e.g. soft clay/ saturated sand over stiff clay / rock). Thereby allowing sonic logging tubes to be installed only over the upper part of the pile/barrette which may be within a single cage length, which then avoids the need for connecting sonic logging tubes.
- Can a testing frequency of 100% be reduced? Are the ground conditions and piling methodology consistent across the project so that the integrity testing strategy can initially verify the pile/barrette construction then adopt a reduced frequency as a check on remaining pile/barrette construction.
- For very large diameter piles (i.e. >1.5m diameter) consider if the number of sonic logging tubes can be reduced. While guidance suggests one sonic logging tube for every 0.30m of pile shaft diameter, sonic logging is effective up to a maximum tube separation of approximately 1.5m.
- If the pile/barrette has inclinometer or base grouting tubes, these should be used for sonic logging to minimise the number of sonic logging tubes. Inclinometer or base grouting tubes of greater than 50mmID can utilise a cable centraliser system to reduce the lateral sonic probe movement.

Conclusion

Crosshole sonic logging in large diameter concrete bored piles and barrettes is a well-established integrity testing method in the UK. However, installing and joining reinforcement cages with loose steel sonic logging tubes is a highly hazardous activity for site operatives. The FPS would like to remind designers that CDM 2015 states designers must: eliminate foreseeable health and safety risks to anyone affected by the project. The specifier of the required integrity tests for a project, must therefore take account the health and safety risks of installing sonic logging tubes.

The FPS seeks to eliminate all unnecessary cross hole sonic logging through increased awareness of the risks and providing this guidance note to assist specifiers to ELIMINATE, SUBSTITUTE and REDUCE cross hole sonic logging and the hazard of joining tubes.