science summary

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Piling in layered ground: risks to groundwater and archaeology

Summary SC020074/TS

Land developers should consider using less damaging methods of piling when laying foundations for new buildings, to minimise the disturbance to buried archaeological artefacts and groundwater flow, according to a new study funded by the Environment Agency and English Heritage.

With the government target to build 60 per cent of new housing on brownfield sites, adequate foundations must be provided for new buildings and structures, for example by installing piles into the ground. However, previous work by the Environment Agency suggests that the construction of piles can increase the risk of near-surface pollutants migrating to underlying aquifers, while English Heritage has found that soil displacement from piling can damage the underlying archaeological record.

The new study, carried out by the Department of Civil and Structural Engineering at the University of Sheffield, modelled the behaviour of soils during the installation of different types of piles - driven piles and continuous flight auger (CFA) piles – to establish the extent of displacement and deformation of soil surrounding the piles.

Models were built in a 250 mm test chamber which could simulate vertical and horizontal stresses on the soil. Cylindrical and H-section piles were driven through layers of sand and clay, and CFA piling was similarly simulated. The permeability of the layers was measured before and after piling, and finally the models were dissected to observe how the layers had deformed. Separate tests were carried out in a half-section cell, where photographs could be taken through a viewing window as the piles advanced. This test series included some tests on square section piles.

The report, *Piling in layered ground: risks to groundwater and archaeology*, found that well-constructed CFA piles caused much smaller deformations of the surrounding soil than driven piles.

For piles driven through layers made predominantly of clay, vertical displacements typically extended up to 1.5 pile diameters from the centreline of a cylindrical pile but were mostly concentrated within a radius of 1 pile diameter.. H-section piles caused smaller displacements than cylindrical piles of comparable width; the opposite was true for square piles. Vertical displacements are accompanied by horizontal ones but these are less likely to cause archaeological damage.

In terms of groundwater disturbance, the models suggest that solid cylindrical piles would be expected to seal when driven through a sufficient thickness of clay, that is, a thickness of about two pile diameters. H-section piles, on the other hand, could not be relied on to seal because of partial plugging with overlying soil. Plugging of the piles depends on several factors including the size, relative density and crushability of overlying soil particles. However, it would be difficult to predict its extent in practice.

Square section driven piles would be likely to seal as well as the cylindrical ones, according to the report. For CFA piling, the results suggest that well-constructed CFA piles should seal adequately in clay layers with a thickness of two pile diameters or more.

For solid piles driven through thin clay layers (less than two pile diameters thick), and for H-section piles driven through thicker clay layers, the movement of groundwater in the presence of a hydraulic gradient could be substantial. Over time, for example, groundwater perched above a thin clay layer might seep away into the underlying strata as a result of driven pile construction. This, in turn, could spread contamination or damage the preservation of archaeological artefacts.

However, further work is recommended to experimentally verify that the parameters established with the models are valid in the field.

For example, in the models, deformations of the clay were ductile in nature, but if clay was heavily overconsolidated in the field, it would behave in a more brittle manner and could develop rupture surfaces, especially if it was naturally fissured. Further research is recommended to explore this aspect for brittle clays.

To establish the impact of piling on buried historical deposits, three sources of information were searched: archaeological records held in Sites and Monuments Records (SMRs), published papers and reports, and site photographic archives held in the Museum of London Archaeological Archive.

The review of archaeological sites revealed a range of limited to extensive damage from piling. For example, at one site bored piles passed close to wooden structural remains, but excavation showed the wood to be undisturbed other than where the pile had touched it. At the same site, similar piles passed through a Roman mosaic floor without apparently disturbing the mosaic tiles beyond the footprint of the pile. In contrast, where a large diameter augered pile sleeve was used, the pile passed through a thin beaten earth floor that subsequently disintegrated or distorted over a distance of about half a metre around the two metre diameter pile sleeve.

For archaeological remains, the report concluded that driven piles could be expected to drag down the adjacent soil within a maximum radius of about two pile diameters (or widths). Pre-augering would not necessarily reduce the impact of subsequently driven piles.

In favourable ground conditions, the report found that augered piles can have remarkably little impact on archaeological remains. However, where a sleeve is used during augering, driving of the sleeve ahead of the auger risks damage akin to that caused by driven piles.

This report will help Environment Agency and English Heritage staff to more reliably assess the risks to groundwater and archaeological records from piling in contaminated and layered ground. It will also be of use to local authority planners and site developers who wish to minimise the environmental impacts of their redevelopment schemes.

This report is also relevant to archaeologists, and indeed calls on archaeologists to collect more records on the impact of piling (and other construction techniques) on archaeology when suitable opportunities arise.

This summary relates to information from Science Project SC020074, reported in detail in the following output:

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