Construction impacts on *in situ* preservation of archaeological sites and artefacts

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Summary

Recent research has highlighted a number of construction activities that may have significant impact on the survival of buried archaeological remains and their evidence. For some of these activities it is clear that alternative methods should be sought where archaeological conservation of a site is required. In other instances, however, no scientifically collected data exists to evaluate hypothetical, or anecdotal concerns over particular construction techniques that produce a high degree of damage. In this paper we review some of the potential physical, hydrological and geochemical changes associated with modern construction methods that can impact deleteriously upon archaeological sites and artefacts. The principal aim of this paper is to demonstrate that reviewing the extent of our conservation science knowledge is essential to the development of future research strategies.

Introduction

In the 5th Framework Programme, City of Tomorrow, there has been a great deal of valuable research into the risks to cultural heritage and how to mitigate against them. Despite sustainable development being one of the objectives of key action 4, almost all the work has been concerned with the portable heritage and standing buildings, with none directed at the buried cultural resources on which many of our present day European towns and cities are built. In this paper we wish to set out some of the risks to archaeological resources from modern developments, and suggest ways forward to a better understanding how these risks can be managed in the future.

There is increasing pressure in many cities and towns for new development. Modern infrastructure such as underground car parks or urban transport systems can be very destructive if they do not take account of the buried heritage. Newly constructed buildings and specifically, tall offices, will often have foundations and services that impact on below ground archaeological deposits to a much greater extent than any building in the past centuries.

Managing development impacts

There are two main methods by which these impacts can be managed, either through archaeological excavation of the site, or preserved *in situ*. The introduction in England of Planning Policy Guidance note 16: Archaeology and Planning, positively encouraged the preservation of nationally important archaeology remains *in situ* (DoE, 1990). Since this point, however, concern has been raised that some aspects of this process may be responsible for damaging archaeological remains (see for example BIDDLE, 1994; CAPLE, 1998; NIXON, 1998). As much of this preservation takes place under new buildings, it is difficult to assess what the effects of specific mitigation measures have been. Installation of monitoring points to collect hydrological and geochemical data (redox and pH) before, during and after development will help to indicate if there are any changes in the burial environment and at what point the change occurs (see for example DAVIS, 1998). However, if the data suggests that the ground environment has changed and the archaeological evidence is threatened, it will not be possible to dismantle the development to save it. Therefore, it will be many years before we are able to assess the success of our mitigation methods.

In the last few years, work has begun on assessing the impact of construction activity on buried archaeology. English Heritage have been instrumental in setting up much of this work, in particular, a soon to be published report on the *Study of the Mitigation of Construction Impact on Archaeological Remains* (DAVIS, forthcoming). Drawing heavily from this report, and other recent research commissioned by English Heritage and carried out by one of the authors (Dr Jim Williams), we discuss a range of pre-construction and construction impacts on buried archaeological materials. These impacts fall into three main categories: physical disturbance, and the effects of biological or geochemical changes on archaeological materials.

Understanding the potential for damage

The effect of physical disturbance may occur either through the removal of archaeological deposits, or through their *in situ* modification, both of which lead to a loss of contextual information, and reduction in the potential for archaeological investigation and interpretation. In cases where heavy loads are imposed, sediment deformation may be accompanied by damage to fragile artefacts (SHILSTON, 1998). Biological and geochemical effects impact most dramatically upon the preservation of archaeological materials. Anoxic environments (lacking oxygen), which are usually waterlogged, provide locations for excellent preservation of organic material, as aerobic bacteria that are the cause of most organic breakdown are inactive (CORFIELD, 1998). The re-introduction of oxygen into these systems will cause the re-activation of microbial activity, leading to the decay of organic material (CAPLE, 1998). Corrosion of buried metals is usually inhibited by anaerobic conditions, and the re-introduction of oxygen can initiate the corrosion process. Equally, changes in pH or redox may also cause a de-stabilisation in the passive layer, reducing corrosion resistance (EDWARDS, 1998). Both metallic and organic materials will be affected by changes in the hydrological regime, particularly the reduction of anaerobic conditions.

Pre-construction impacts

Before construction starts, impacts on buried archaeology can still occur. During site investigation, holes are dug and boreholes drilled, both of which cause physical disturbance, but can also increase oxygen ingress to previously undisturbed layers, potentially increasing decay and corrosion. Drilling fluids and backfill material in the boreholes may also be chemically damaging. Larger scale interventions also occur before construction, particularly the remediation of any contamination, and the preparation of the ground. Sometimes this consists of stripping off topsoil and any vegetation, other times it will involve ground improvement and stabilisation, possibly the insertion of concrete or stone columns. Again, the likely impacts will result from physical disturbance, and hydrological and geochemical changes. De-watering of sites can have very serious impacts both on the site and also adjacent areas. It can lead to deposits drying out and cracking, allowing oxygen to enter, and stimulating biodegradation.

Construction impacts

The impact of construction activities depends principally on the size of the building and the type of foundation design. If basements are excavated this will obviously reduce the amount of material that can be preserved *in situ*. Although shallow foundations, such as strips or pads, do not penetrate deeply into the ground, they do usually require the excavation of large areas of the site, and even if the most significant archaeology is still buried, excavation of the soil will reduce amount of protection for the deposit. The imposition of heavy loads on these footings could reduce water flow through the deposit, and also cause deformation or breakage of fragile artefacts. As these foundations often comprise reinforcements and poured concrete, there is also a possibility that migration of this alkali material will change the soil pH.

On larger developments, piled foundations are often used as they enable tall and complex buildings to be built, particularly on weak and poorly consolidated soils. As piles reduce the amount of material excavated from sites, they thus promote further sustainability of our cultural heritage resource, and are increasingly being used as part of the *in situ* preservation process. Their configuration is often determined to minimise the damage to archaeological evidence. The potential footprint of piles on the archaeology is often considerably less than strip or pad foundations, however, there is the possibility of sediment deformation adjacent to the pile (discussed below). In England, the generally accepted norm is to allow a 5% loss of archaeological evidence to allow for piling and other construction activities. This is based on a study of development in the City of York, but this does not necessarily reflect the prevailing conditions elsewhere (ARUP, 1991).

Piles can be divided into two types, displacement and non-displacement piles. Displacement, or driven piles are potentially more damaging to archaeology because, as their name implies, they displace the ground adjacent to the pile. This can vary in different soil conditions, although we are still not in a position to suggest which archaeological sites would suffer minimal damage, and which would be far more disturbed. In some cases, sediment deformation up to twice the diameter of the pile has been recorded (DALWOOD, 1994). A further concern is the degradation of the construction material, either weathering of concrete piles or the corrosion of metal piles, and the effects that such material in solution may have on sensitive archaeological deposits.

It is also possible that the insertion of the pile will cause changes in the permeability around the pile/soil interface (HAYMAN, 1993; BOUTWELL, 2000), resulting in the creation of a preferential pathway for oxygen transport or other contaminants (ENVIRONMENT AGENCY, 2001). Deposits can also be affected by contaminants being driven down with pile. Non-displacement piles are bored or augered and the concrete cast *in situ.* This technique usually results in less sediment deformation, but this can take place when obstructions become caught in the auger and are rotated. If this occurs the area often has to be excavated to remove the obstacle. Further geochemical impacts can also result with this technique, in particular the introduction of liquid pile grout can lead to contamination, and changes in soil pH, and there is a potential for long-distance migration of the grout into voids and further water-borne transportation. On sensitive archaeological sites, particularly those that are waterlogged, continuous flight augered piles or CFA piles are preferred. This is a type of cast *in-situ* pile which provides an environmentally preferred solution to the problem of constructing piles in water bearing or unstable soils. The auger is inserted into the ground, and when the pile depth is reached, it is withdrawn, bringing up the soil or arisings, and at the same time pumping concrete into the hole left behind. Used in conjunction with metal sleeves to reduce migration of liquid pile grout, this technique is often preferred on waterlogged archaeological sites, or those of particular sensitivity.

Mitigation

There are no off-the-shelf mitigation methods that will fit all sites, and often the best way to avoid future damage to archaeological material is to reduce ground disturbance in areas where significant archaeology is located. Early consultation between developers and archaeologists can, for example, ensure that construction activities with the highest impacts, such as lift shafts, piles or service trenches are positioned to avoid areas with the greatest archaeological sensitivity. As discussed above, it is also felt that certain non-displacement piling techniques, for example sleeved continuous flight augered piles, are less likely to cause damage than driven piles. This has yet to be tested empirically, although model scale research is planned to start in the near future. What is needed at this point is a better understanding of how individual construction activities impact on specific types of archaeological deposit.

One of the principal reasons that we have so little information about what happens to *in situ* preservation schemes is that this is a relatively new approach, and few sites have been excavated where *in situ* preservation was part of the development strategy of the site. However, there are many sites where construction activity in the last fifty years has taken place in the presence of archaeology, where some of it remains *in situ* below developments. When these sites are excavated in advance of new construction, this is the ideal time for information about the past affects of construction to be collected. However, there is no strategy for this and, as a result, little more than anecdotal evidence is ever recorded. English Heritage is currently creating such a strategy for the excavation of previously developed sites, which should be in place within the year.

It will list, as we have here, some of the likely impacts on the buried archaeological resource, suggest ways in which these impacts should be recorded during evaluation excavations and provide a mechanism through which this information can be fed back to other researchers and heritage managers. At a site specific level, the interpretation of the effect of past construction activities on archaeological deposits and artefacts will provide *a priori* evidence for future behaviour under new developments. The strategy will also detail methods for recognising both physical and geochemical construction impacts. Physical impacts will be measured through targeted and thorough archaeological recording of previous construction activities (for example see DALWOOD, 1994). A greater understanding of the biological and geochemical effects of construction can be gained through the analysis of organic and metallic material recovered from archaeological deposits impacted by construction activities. These analyses are likely to draw upon techniques such as those proposed by Murphy and Wiltshire (1994), and Kenward and Large (1998), for the evaluation of the conditions of preservation of plant and insect remains respectively. Assessment of the state of corrosion of buried metal artefacts through x-radiography could also be employed to provide stepped categorisation of corrosion activity. Through comparison with the state of preservation of material from areas of the site unaffected by past development, the impact of construction activity could be evaluated.

Conclusions

We cannot fossilise our historic towns and cities, development will continue and archaeological evidence will be put at risk. We can reduce this risk by understanding the threats, and the most effective method for this is the collection of data relating to previous construction activity on archaeological sites. This can feed into mitigation measures for individual sites, as well as inform national and international strategy on *in situ* preservation. However, these risks can also be reduced by making sure that archaeological considerations are built into the overall planning of new buildings, and with ideas of sustainability underpinning mitigation methods. Where possible, buildings should use previous foundations, as this reduces the amount of new raw materials used, as well as limiting below ground excavations. Equally, by removing basements, or other large areas of intervention from the designs, or relocating them to less critical parts of the development, the impact on archaeology can be further reduced, allowing such deposits to be preserved *in situ* and managed sustainably for the future.

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SHILSTON D.T. and FLETCHER S.L., 'Geotechnical engineering for the *in-situ* preservation of archaeological remains', in *Preserving archaeological remains in situ. Proceedings of the conference of 1st–3rd April 1996,* ed. M. CORFIELD, P. HINTON, T. NIXON and M. POLLARD, Museum of London Archaeological Service, London, 8–15, 1998.

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Jim Williams is the Archaeological Science Advisor (East Midlands) at English Heritage. His regionally based responsibilities include providing archaeological science advice for archaeological excavations that take place in the six counties of the East Midlands. Included in this advice are methods for recording the condition of buried archaeological materials, and the *in situ* preservation of nationally important remains. Before joining English Heritage in 2002, he worked as a post-doctoral research associate in the Department of Civil and Structural Engineering, University of Sheffield, researching the physical and geochemical impacts of construction on archaeological deposits. Previous to this he finished a PhD in Archaeology, also at the University of Sheffield.

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Mike Corfield has recently retired as the Chief Scientist at English Heritage. In that capacity he was responsible for developing strategies for research concerned with the Historic Environment. He is now working as an independent consultant, and his main interests remain with the identification of threats to cultural heritage, and seeking ways of mitigating them. In this context he has sought partnerships for English Heritage with academic and industrial partners in England and elsewhere. Mike's background is in conservation, he was County Conservator in Wiltshire for 14 years and Head of Conservation at the National Museum of Wales for five, ultimately as Head of Conservation. He joined English Heritage in 1991 as Head of Artefact Conservation, became Head of the Ancient Monuments Laboratory in 1996, and Chief Scientist in 1999.

Artifact preservation is one of the most important considerations when planning or implementing any action that will result in the recovery of material from a marine archaeological site. It is the responsibility of the excavator or salvor to see that material recovered is properly conserved. The conservation phase is time consuming and expensive, often costing more than the original excavation. But archaeological sites are also places. If we are to identify and understand the nature and implications of certain physical relationships with locales established through past human thought and experience, we must do it through the study of place.Â The Institute advances awareness, education, fieldwork, preservation, publication, and research of archaeological sites and cultural heritage throughout the world. Your contribution makes a difference. Donate. 2001. In-situ preservation of artefacts in Nydam Mose: studies into environmental monitoring and deterioration of wooden artefacts, in P. Hoffman, J.A. Spriggs, T. Grant, C. Cook & A Recht (ed.) Proceedings of the 8 th ICOM Group on Wet Organic Archaeological Materials Conference, Stockholm 2001: 213â€"23.Â Calculation of treatment times for corroded marine iron artefacts undergoing in-situ conservation with sacrificial anodes through monitoring the pH and corrosion potentials. International Journal of Nautical Archaeology.Google Scholar. MacLeod, I.D. & H. Steyne. 2011. Managing a monitor â€" the case of HMVS Cerberus in Port Phillip Bay: integration of corrosion measurements with site management strategies. Hydrological controls of in situ preservation of waterlogged archaeological deposits. Earth-Science Reviews, Vol. 78, Issue. 1-2, p. 59.Â The Importance of Analysing Waterlogged Wooden Artefacts and Environmental Conditions when Considering their In Situ Preservation. Journal of Wetland Archaeology, Vol. 6, Issue. 1, p. 65.Â Climate Change and the Conservation of Archaeological Sites: A Review of Impacts Theory. Conservation and Management of Archaeological Sites, Vol. 13, Issue. 4, p. 293. CrossRef. Archaeological conservation is a profession devoted to the preservation of the archaeological record including large-scale features such as sites, structures, and landscapes, as well as artifacts. Archaeological conservation is guided by ethical principles that derive from the understanding that these materials are "primary resources for understanding and interpreting the past."[1]. Archaeological remains are found throughout the world in areas of past and current human habitation.Â At many archaeological sites complexes of buildings or monuments are found in relation to one another and remain in situ while smaller objects may be removed from the site for further study and safe storage in secure depots.