

# STRATEGIES FOR REDUCING CONSTRUCTION PROBLEMS ON ARCHAEOLOGICAL SITES

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Construction and Archaeology are two disciplines that are not often content with one another. At the same time, historically speaking, construction operations have resulted in the discovery of many important cultural artifacts, and the recently increasing desire to preserve those materials has resulted in many protective regulations. With the growth in population, urban sprawl, and tourism, the demand for construction is also growing. This will increase the probability of archaeological encounters during construction operations. This research study will focus on the preconstruction phase of a project with an emphasis on the owners responsibility to proactively anticipate preservation-related issues for a specific project rather than reacting to such issues when they happen. The study's goals and objectives are to evaluate preservation-related preconstruction considerations, developing strategies that affect the project specifications, and to devise alternative strategies for reducing construction problems in conjunction with archaeological constraints. Additional expenses associated with the strategies will be assessed as to the value they contribute to problem avoidance. Relevant case studies will be developed and examined that identify typical problems associated with archaeological encounters, document the challenges to construction practices with archaeological constraints and to appraise the methods by which the encounter problems have been resolved. Much of the intent of this study is to reveal any weakness in the preconstruction process with specific focus on historic and archaeological encounter avoidance planning. With the causes revealed, strategies can then be developed to reduce the problems during the construction project. Even at the early stages of the research, it is clear that focus on several factors need to be present prior to commencement of construction activities in order to reduce problems associated with archaeological encounters.

Keywords: Archaeology, Construction, FMEA, Preconstruction, Pre-investigation, Specifications.

## BACKGROUND OF THE PROBLEM

Throughout history, construction operations have generated chance encounters with archaeological remains. In the recent past, archaeological encounters have been more of a nuisance to contractors as they plow through the historic material to complete their project. Today, the general public is much more concerned with preserving our history. This has created a conflict between the construction and archaeological disciplines. Attempts are being made to address this divergence but other issues are causing this problem to become prevalent. To start with, the quantity of encounter

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incidences with archaeological material has the possibility to increase in conjunction with several factors. World population growth, the expansion of population in urban areas and increasing tourism multiplies the chances of construction related archaeological encounters. As shown in Figure 1, all of these factors have been historically increasing.

According to the UN Population Division (2004), the world population is projected to grow from 6.1 billion in 2000 to 8.9 billion in 2050, increasing therefore by 47 percent. The growth mainly centers on urban areas. According to Mannion (2002) by 2025 more of the world's population will live in urban areas rather than in rural areas.

Tourism is also exerting pressure on archaeological sites from several directions. First, the need to see ancient sites is having a direct impact on the deterioration via human contact. This exchange can take the form of touching and human respiration and in the form of environmental impacts when residing near the sites. Exposing the archaeological material to the elements of wind, rain and the sun also has a deteriorating effect. Lastly, as stated by Neto (2003) tourism is usually accompanied by considerable investments in infrastructure, such as airports, roads, water and sewerage facilities, telecommunications and other public utilities. The construction activities associated with this buildup has increased the chances of archaeological encounters during construction operations.

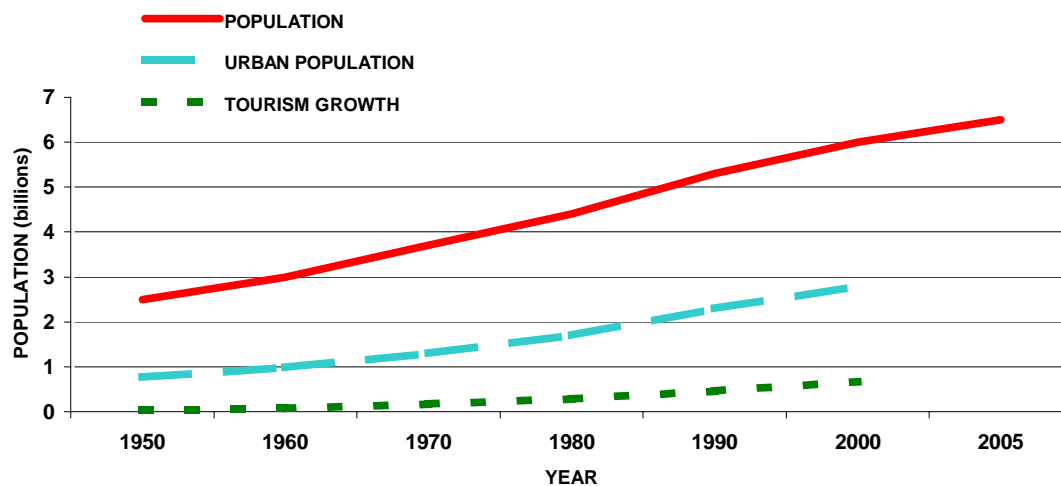


Figure 1 – World Growth Change

Source: *Population* – Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat

*Urban Population* – Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat  
*Tourism* – Travel Industry World 2000 Yearbook

In conjunction with the above referenced factors, construction activities have also historically increased. As shown in Figure 2, world construction spending has increased throughout the last three decades. Even with all the exposure to the affects of financial crisis and war, according to Crosthwaite and Connaughton (2005), Global construction spending reached nearly \$4.2 trillion dollars in 2004 with future growth rates expected to exceed 5% annually over the next four years.

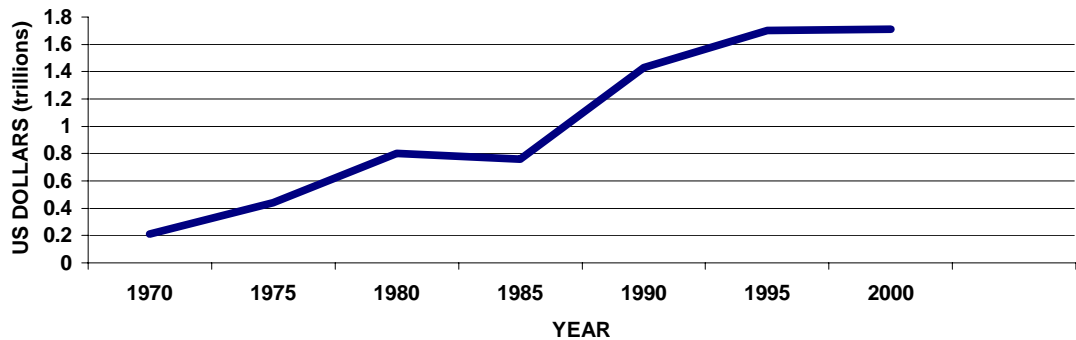


Figure 2 – World Construction Spending

Source: United Nations Department of Economic and Social Affairs, Economic and Social Development

The increase in construction activities will consequently increase archaeological encounters during construction operations. With the requirements for preserving cultural sites and materials becoming more stringent, the encounter problems can overburden and overextend a construction project.

What are the specific problems associated with archaeological encounters? The problems exist in two phases of a project; the preconstruction and the construction phase. In the preconstruction phase, the contractor has to deal with the constraints of the specifications adjusted to local laws and environmental impact issues. This can cause modifications (constraints) to the method and materials and create increased risk in competitive bidding situations. In the construction phase, redesign, delays and work stoppage due to archaeological encounters can cause loss of production, idle equipment and legal disputes. This study will focus on the preconstruction phase with particular examination of the factors that contribute to the constraints placed upon the contractor and the resulting consequential outcomes. It is theorized that developing strategies to address the issues in the preconstruction phase will assist in reducing the construction problems.

## OBJECTIVES OF THE STUDY

Despite the existence of planning guidelines on the topic, there has been little systematic research in the UK or anywhere else on the characterization and assessment of archaeological constraints to help form proper strategies for reducing the impact on contractors' work. This study will focus on the preconstruction phase of a project with an emphasis on the owners responsibility to proactively anticipate preservation-related issues for a specific project rather than reacting to such issues when they happen. Therefore, a system approach to identify and link preconstruction factors relating to archaeological constraints is necessary to minimize the impact of anticipated potential problems. The goals and objectives of this research are to develop strategies linking preconstruction factors that affect the project specifications and to devise alternative strategies for reducing construction problems in conjunction with archaeological constraints.

## **METHODOLOGY**

### **Preconstruction**

Currently, the owner and their representatives proceed through a process of generating contract documents (contracts, plans, specifications, etc.) to be used for bidding and eventual incorporation into the legal agreement with the contractor. Much of this is standard practice, however; problems inherent with the system continue to create difficulties during the construction phases of the project. It is clear that contractor issues if reviewed prior to construction, can minimize the impact of project problems. To analyze the circumstances, examination utilizing case studies will be developed and examined that identify specific construction challenges and types of problems. The research will also appraise how the archaeological constraints were managed from a retrospection point of view. The study population will include owners, the owners representative, local authorities, the contractor and other affected entities. The case studies will also employ examples of four different countries. This will increase the global perspective by including a mixture of industrial and developing countries as part of the research. The steps used to achieve the goals and objectives are:

- 1) Identify and define typical problems associated with archaeological encounters
- 2) Document the challenges to construction practices with archaeological constraints relating to preconstruction and construction factors.
- 3) Seek and appraise the methods by which the encounter problems have been resolved.

### **Specifications**

The owners representative incorporates into the specifications the environmental impact statement, local laws and regulations and specific owner instructions. The burden is then placed upon the contractor to fulfill the obligations of the contract within a specified time limit. The problem with this is that it does not address the impact these constraints have upon the contractor. Input from the contractor is lacking and is necessary.

As an example of these constraints, modification of equipment is often practiced to limit damage to archaeological material. Lambrick and Doyle (2000) in an Irish Heritage Council document specifies that the type of machine and method used determines the outcome of the archaeological monitoring exercise. An example method statement maintains that topsoil stripping will be carried out using a mechanical excavator with a toothless bucket. Other plans are less specific. A construction framework environmental management plan identifies issues relating to possible method and task adjustments for an Australian tunnel project (2004) including vibration and archaeological considerations.

The modifications can also include constrained methods of how to perform a construction task. A U.S. Department of Transportation, Federal Highway Administration (2003) publication reported that a contractor was required to saw cut and lift out old existing pavement, instead of using air-driven machinery, to minimize vibration disturbance. Vibration disturbance seems to be a leading problem relating to urban construction and historic material.

Adjusting to these specifications can cause increased risk due to unknown, reduced production and efficiency. Even such common practices as dewatering a worksite area could be restricted according to a ICOMOS Irish Committee (2000) publication,

as the procedure of lowering the water table could dry out organic material, so their archaeological effects must be considered inside and immediately outside the site. The impact on production can lead into increased costs.

Special materials may be required or restricted in their use. A section of the California Environmental Quality Act (CEQA) (1994), states that materials covering archaeological sites should not be chemically active. According to CITGO Petroleum Corporation (2000), the use of products such as petroleum based form oil is listed as harmful to human, animal and aquatic life. Any spillage or seepage could be detrimental to archaeological artifacts. Although construction materials are becoming more environmental friendly, there are still parts of the world where environmentally harmful construction materials are used.

### **Developing a Strategy**

The use of methods and materials is controlled by the specifications and to some degree, the contractors ingenuity. Technological advances have assisted the contractor to become more efficient and competitive but its use has been limited with archaeological constraints. Several methods to address issues in a proactive manner can be used.

A technique used in the manufacturing process has great success in reducing potential problems utilizing a procedure entitled Failure Mode and Effect Analysis (FMEA). It attempts to identify potential problems and incorporates avoidance solutions in the process. Although this method is generally not used in the construction industry, recent research has attempted to improve the process by incorporating a broader inclusion of factors suitable for use in the industry. For example, Rhee and Ishii (2003) even though using a manufacturing basis, has introduced cost as a measure of risk as part of the FMEA process. This has wide ranging implications including design, site pre-investigation and methods/materials use. Rhee and Ishii adds the statement that the most expensive failure is which originates during the design stage and does not get detected until operation. Mecca and Masera (2000), includes FMEA in an IT approach to construction project planning phases that requires data integration, specifications and instructions, coming from different knowledge domains. As part of the their study, Mecca and Masera intends to develop an IT system that supports planning during the elaboration of the project specifications and site preparation.

In conjunction with this concept, pre-investigation of a potential site should use improved methods of inspection. As an example, Roberts, et. al. (2002) outlines work being done by the University of Nottingham on Augmented Reality (AR) with GPS/INS integration, allowing the possibility to visualize archaeological artifacts underground. This leads to many possibilities including incorporating GPS assisted excavation, ground penetrating radar and satellite imagery to enhance information on site pre-investigation. Although this type of investigation will need to be reviewed on the additional cost to the owner, there is a value component for diminishing contractor constraints and reducing delays and work stoppage.

### **SIGNIFICANCE OF THE STUDY**

As stated previously, there has been little systematic research in the UK or anywhere else on the characterization and assessment of archaeological constraints, so that proper strategies for reducing the impact on contractors work can be formulated. No study has been performed to review the problems specific to archaeological

constraints associated with construction activities in the initial stages of a project. Much of the intent of this study is to reveal any weakness in the preconstruction process with specific focus on historic and archaeological encounter avoidance planning. With the cause revealed, strategies can then be developed to reduce the problems during the construction project.

### **Contributions**

The study contributions includes both intellectual, practical and policy applications.

- Intellectual
  - Documentation of the archaeological constraints and problems so that the data can be analyzed and used not only for this study but for any future research.
  - Document the methods on how the problems were resolved to reveal current problem solving methods.
  - Highlight and utilize current and past research that relates to the subject.
- Practical
  - Develop functional strategies for use in the planning of a construction project.
  - Utilizing accepted methods of problem solving integrated into a current planning practice.
  - Utilizing existing technology in the use of site investigation.
  - The group conducting the study comprises a multi-disciplined background of construction and archaeological experts applying experience to prevention.
- Policy
  - The strategies can be an important ingredient in improvement of current preservation policy by addressing issues that have been overlooked.
  - The strategies can be part of the guidelines in the development stage for countries that are currently formulating their preservation policies.
  - The study can bring attention to countries that have no preservation policies.
  - The study will bring to the attention the need for contractor participation in the early stages of a project.

### **Benefits**

Devising the strategies will be aided by facets in the construction process that can be of benefit to the aim of avoiding or reducing archaeological problems, such as pre-planning, site pre-investigation, qualified owner representation, and others. This is good for the owner and contractor because claims and disputes caused by archaeological constraints can be reduced. This is also good for the archaeologist and the public, as it reduces the destruction of important historic material.

## CONCLUSION

The increasing demand for construction will continue to cause major problems for the contractor in dealing with archaeological encounters. Current practices seem, to some extent, address the problems but other factors can overburden the contractor. A review of past problems so that strategies can be developed and applied to improve future projects is necessary. It is clear that the initial review of literature has highlighted major potential factors. Preliminary research is focusing on:

- Preconstruction Project Planning
- Failure Mode and Effect Analysis (FMEA) and other problem solving methods
- Site Pre-investigation Techniques

Although the research is in its early phase, it is clear that combining these factors to form a composite strategy must start at the very early stages of project development and ensued in a proactive approach rather than trying to solve the problem in a reactive manner. This action will not reduce preconstruction project costs to the owner, but it will improve the probability of reduced legal, redesign and production costs.

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