1. **Introduction**

The Second World War (WWII) may have ended over 60 years ago but Unexploded Bombs and other military ordnance can still be a serious problem to construction projects throughout the UK.

Joanne Kwan (CIRIA), Allen Murray (Worley Parsons) and Lee Gooderham (6 Alpha Associates) outline the process in dealing with Unexploded Ordnance (UXO) during construction projects from a clients’ point of view. With the increased emphasis on brownfield development, which includes many inner city areas that were targeted during WWII and have remained largely untouched since that time, it is unlikely that the risk of encountering UXO during the construction phase of projects will reduce significantly in the near future.

2. **How much guidance do UK construction practitioners currently have?**

There is currently little publicly available guidance to specifically assist construction professionals (particularly clients, developers and ground-works contractors) in assessing the risks associated with encountering UXO during the construction phase of a project.

This lack of previous guidance and of direct legislation regarding the potential risks the construction industry faces from UXO hazards, and the limited knowledge many developers have on the subject, often means that construction professionals depend solely on specialist advice to deal with potential UXO risk at a site. In some cases the potential threat from UXO is not considered at all. In the past this lack of guidance and understanding has resulted in project delays and occasionally forced developers to pay for unnecessary and expensive mitigation measures.
3. **CIRIA - A clients’ guide for assessing UXO risk on construction sites (RP732)**

CIRIA’s research project “A clients’ guide for assessing risk on UXO sites” will produce the first UK good practice guidance to help developers and clients deal with UXO. The guide will enable these professionals to understand the different approaches and how to appoint specialist contractors. The project has been approved by the Health & Safety Executive whose foreword states:

“One unintended outcome from construction activity is that UXO is occasionally discovered. When it is, it usually generates considerable media interest and causes major disruption to the public. Fortunately experience shows that the risk of casualties has been very low.

However, as it is a high consequence but low probability event, appropriate allowance should be made at the design stage for assessing the risk of encountering UXO on-site and for assessing the risk of encountering UXO on site and for mitigating that risk if significant.”

Dr Donald Lamont
HM Principal Specialist Inspector (Construction Engineering)
Health and Safety Executive

4. **Unexploded Ordnance Threat**

During the WWII many defensive establishments, cities and towns throughout UK were subjected to comprehensive bombing campaigns, which resulted in extensive damage to city centres, railway infrastructure, docks, associated industrial areas and military installations. The German Luftwaffe mainly achieved this destruction by deploying High Explosive and Incendiary bombs.

Across London an average of 84 bombs fell on civilian targets and failed to explode every day from 21st September 1940, to 5th July 1941, the bomb failure rate is highlighted further when considering that more than 200 of the 1,500 bombs dropped in East London by the Germans failed to detonate. Most of the unexploded bombs (UXBs) were dealt with by Army Bomb Disposal Services during the war, however a proportion did penetrate the ground unnoticed, only to be encountered many years later.

Government statistics indicate that most unexploded bombs found between October 1940 and May 1941 were either 50kg or 250kg. However UXO can range in size from Small Arms Ammunition to large UXBs weighing more than 2,000 kg, although all items containing high explosives have the potential to cause significant harm to those who encounter them.

In recent decades there have been several incidents in Europe where Allied UXBs have been detonated with at least three incidents causing fatalities. Although no fatal incidents related to UXB has occurred in UK in recent years, data from the Explosive Ordnance Disposal industry show that from 2006 to 2009 approximately 15,000 items of ordnance ranging from aerial delivered bombs to Land Service Ammunition (such as mortar rounds and grenades) have been removed from construction sites. Of that total, it is estimated that about 5% were live and still fully functioning. The number of
items of Small Arms Ammunition recovered during this period possibly runs into tens of thousands.

The legacy of UXO has caused many problems for construction projects throughout the UK, for example:

- In April, 1,000 homes were evacuated in Plymouth when workers on a building site in the Prince Rock area discovered an unexploded bomb weighing 120 kg sticking six inches out of the ground (http://news.bbc.co.uk/1/hi/england/devon/6524353.stm). In the same month, a 200 metre cordon was put up near Oxford Road station in Manchester when workmen found an unexploded mortar shell on a building site.

- Bristol was severely disrupted last June when a suspected World War II bomb was found on Land Securities’ and Hammerson’s, Cabot Circus retail development site, which closed much of the Broadmead area of the city for two days despite the suspicious object turning out to be a piece of reinforced concrete (http://news.bbc.co.uk/1/hi/england/bristol/5065968.stm).

- In June 2008 a 1000kg bomb was found at Bow in East London during construction for the Olympic Games. The Police said it was the largest bomb unexploded found in London in three decades. Service on two nearby subway lines was suspended as a precaution while the bomb was being defused (www.eastlondonadvertiser.co.uk/content/towerhamlets/advertiser/news/story.aspx?brand=ELAOnline&category=news&tBrand=northlondon24&tCategory=newsela&itemid=WeED06%20Jun%202008%2022%3A31%3A52%3A95).

5. **Who is responsible and what are the implications?**

*Employers responsibilities under health and safety legislation* - All employers have a responsibility under the Health and Safety at Work Act 1974 and the Management of Health and Safety at Work Regulations 1999 to ensure, so far as is reasonably practicable, the health and safety of their employees and that of other persons who are affected by their work activities. Construction professionals have further specific duties under the Construction (Design and Management) Regulations 2007 (CDM). Under CDM, the client has the legal responsibility for the way that a construction project is managed and run and they are accountable for the health and safety of those working on or affected by the project.

*Financial Implications* - Although the likelihood of an inadvertent detonation of an item of UXO is low, the presence of an item of UXO at a site can still have significant implications. If sites with potential UXO risks are not managed efficiently, it can lead to programme delays and an associated increase in project costs.

6. **How can such risk be managed?**

CIRIA has designed a robust 4-stage risk management process to help construction professionals to deal with UXO hazards. These are depicted in flow chart form at Figure 1 and further described below:

**Stage 1 - Preliminary Risk Assessment.**
The purpose of the preliminary risk assessment is to enable the non-UXO specialist to crudely risk-rate a site having specific regard to the potential risks that might be posed by UXO in order to identify whether more detailed assessment might be required. The assessment is based on data obtained from a desktop review of historical information regarding site location, previous site development, wartime bombing records etc.

It is anticipated that the majority of sites in UK will be identified as having a NIL or low probability of containing a UXO hazard and would be excluded from further consideration following the completion of the preliminary risk assessment. However this is considered an important initial step to help construction professionals to assess sites with potential UXO risk.

**Stage 2 - Detailed Risk Assessment.**

If a potential UXO risk is identified at the Preliminary Risk Assessment stage, it is important that a UXO specialist is commissioned by the client. This should take place during the initial stages of the project planning and ideally before the start of any detailed design work. This early involvement may also enable the project team to identify appropriate techniques to cut or reduce potential risks through considered design, without the need for UXO specific mitigation methods.

Detailed Risk Assessment enables an estimate to be made of the likelihood of encountering a UXO hazard present on a site, giving due consideration to the development type and construction methods to be employed.

For aerial delivered ordnance, this will involve using the estimated bombing density, failure rate, likelihood of detection, site ground conditions etc, to carry out an aerial delivered UXO risk assessment.

In addition to aerial delivered UXO, there may be a risk posed by discarded or forgotten military ordnance resulting from both wartime and peacetime military usage of the site.

Former military sites are usually subject to so called “clearance” before they are returned to civilian usage, primarily using indigenous organisations from within the MoD. However, UXO is sometimes discovered after the MoD clearance has been undertaken. For this reason it is considered that any site having a previous military use and/or involving the potential use of military ordnance, should be considered as being potentially contaminated with UXO (even if a MoD “clearance” certificate has been offered).

Due to the site-specific nature of the various UXO that may be encountered in such circumstances, a specific methodology for the assessment of military ordnance is not included in CIRIA’s report. As a result it has been left to the professional judgement of the UXO specialist to assess the potential for a military UXO hazard. In carrying out such an assessment, the specialist should use expert knowledge and undertake a sufficiently detailed review of the history of the site in order to determine:

- The likely type(s) of ordnance stored and used, including their age, condition and sensitivity;
• The potential for UXO to exist, i.e. whether ordnance could have been employed and failed (e.g. on a range), or simply discarded, either deliberately or accidentally;
• The likely distribution of UXO across the site, i.e. whether there are areas of higher and lower risk.

In order to assess the risk posed by UXO to the construction activity in question, the specialist should consider:

• The depth, location and extent of intrusive work in relation to the potential areas of UXO contamination;
• The likelihood of initiating UXO with the proposed intrusive methods;
• The consequences of initiating UXO.

Stage 3 - Risk Mitigation.

The purpose of Risk Mitigation is to eliminate risk or reduce it to an acceptable level. The Risk Mitigation process provides a framework that identifies appropriate mitigation methods for the various risk scenarios that may be identified by the Detailed Risk Assessment. Identified options are then assessed to ensure that an efficient and cost effective risk mitigation programme is selected.

Stage 4 - Implementation.

The final phase of the Risk Management process is to ensure that the selected Risk Mitigation plan is implemented correctly and efficiently during the construction phase of the development works and that the works are verified as having been completed to the required level.
Figure 1 – UXO Risk Management Framework
For sites where there is a possibility of encountering UXO, there should be an emergency response plan in place that provides clear and unequivocal guidance on what to do should an item of UXO be encountered, and/or initiated as part of the site works, with accompanying emergency management team roles and responsibilities. This should be included in the Health and Safety Plan for the proposed works and should be communicated to the work force at the operational level, typically as part of a Tool Box Brief.

7. Conclusions

The legacy of UXO has continued to cause many problems for construction projects throughout the UK. Invariably these problems have led to very expensive delays, especially during the site investigation and groundwork phases of construction. In many cases these problems could have been avoided if an appropriate risk management procedure had been implemented at the initial stages of the project design process.

Clients have a legal duty under CDM2007 to provide designers and contractors with the project-specific health and safety information needed to identify hazards and risks associated with the design and construction work. The possibility of UXO being encountered on a site falls within the category of a potentially significant risk and is therefore, a matter that should be addressed as early as possible in the lifecycle of a project.

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