

# EVIDENCE-BASED SAFETY MANAGEMENT IN BUILDING REFURBISHMENT

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**Abstract:** In response to the long-term need for building asset management, this paper puts forward a new evidence-based safety analysis (ESA) approach to safety management in building refurbishment to prompt the use of evidence-based learning in practice and research in the subject field. This paper initiates a conceptual ESA framework to support the use of evidence-based method in practice-oriented research into safety management for building refurbishment. The ESA approach aims to find an innovative way to facilitate the collection of data and information from accumulated professional knowledge about accidents and failures as well as good practices and innovations, to derive useful lessons to inform improved practice in safety management in building refurbishment. Through the use of such a theoretical framework, this paper demonstrates through a case study how ESA can effectively support learning lessons from previous building refurbishment projects. It is expected that this paper can make a good contribution to the body of knowledge by providing the new ESA approach and a practice-oriented experimental case study on the use of ESA approach to safety management in building refurbishment so as to inform future practice and research at strategic and tactic level.

**Keywords:** buildings, evidence-based learning, refurbishment, safety management

## INTRODUCTION

Building refurbishment is an important appeal for sustainable built environment and has become one of the main proportions in the whole construction market, especially in the developed world. As described by Ala et al. (1996), it is an ideal option for modernising the existing building in terms of the consideration on a number of related issues such as the environment and it helps in retaining the old charm and significance of the existing buildings in a planned manner to adapt to new physical requirements. Under the nature of building refurbishment, it is always an important technical question as Arayici (2008) has highlighted that safety management strategies and procedures are in place to ensure the physical process to add value to the existing building. It is always a target as well as a challenge to pursue zero accident in safety management on building refurbishment, and innovative solutions to continuously improve safety management are therefore in demand.

The technical value of case or evidence based learning has been widely recognised within the learned society in the construction industry. For example, RICS (2014) as a representative from professional bodies has started to publish a series of case studies to guide strategic facilities management, and Liu, et al. (2013) as representative from academics have applied case-based reasoning technique for safety early warning in construction project. Through a preliminary literature review, it has been found that there has been a lack of research into the application of case method for safety management in building refurbishment, and a dedicated research may help to explore a formal procedure with regard to making a good contribution to the body of knowledge in this area.

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This paper describes the structure of and preliminary outcomes from an ongoing research into evidence based learning for safety management in building refurbishment projects. Based on a brief literature review on safety management in building refurbishment and evidence based practice, the aim and objectives of the described research were defined and then achieved through the use of a set of research methods including literature review, system analysis and design, and case study in order to present a new technical framework to facilitate the procedure of evidence based safety analysis (ESA) for safety management in building refurbishment. It is expected that this paper could attract interest in discussion about the research in terms of its usefulness and further research development and collaboration at this ARCOM workshop.

## **BACKGROUND**

The aim and objectives of the research described in this paper were set up through a preliminary literature review in two related areas covering techniques for effective knowledge reuse for safety management in building refurbishment and evidence based learning in relation to safety management. This background review aims to justify whether it is necessary and how to conduct the research into a new ESA approach to safety management in building refurbishment.

### **Knowledge driven safety management**

Safety management in building refurbishment needs to address a similar set of technical issues that building construction needs to deal with in terms of a series of health and safety risks associated with various issues such as Access on site; Welfare; Scaffolds; Ladders; Roof work; Powered access equipment; Traffic, vehicles and plant; Hoists; Cranes; Excavations; Manual handling; Hazardous substances; Noise; Hand-arm vibration; Electricity and other services; Confined spaces; Tools and machinery; Fires and emergencies; and Protecting the public, which have been specified by HSE (2006). For safety management in building refurbishment, there are other specific issues for professionals to deal with. For example, the health and safety risks of demolition and structural instability (Anumba, et al., 2004). Since the Construction (Design and Management) Regulations 2015 (CDM 2015) came into force on 6 April 2015, and the adoption of Building Information Management/Modelling (BIM) in the construction sector, safety management for building refurbishment is in place to incorporate new techniques to well connect stages across the whole lifecycle of building projects. In another words, safety management should be conducted from design through construction into operation in a continuous manner. While it has been always important to adopt a systematic approach (Mills, 2001) to risk management towards the target on zero fatality in construction, new practice on using knowledge through the entire or part project lifecycle has demonstrated the importance of knowledge driven safety management. For example, AstraZeneca (IOSH, 2010) in Manchester, UK has realised additional benefits through using an extended knowledge base during the design phase in a variety of projects. Therefore, it has become more and more important for safety management professionals with duties under the regulations to have new techniques that can support effective use of accumulated professional knowledge such as lessons learnt from past case projects in a BIM pervasive working environment across work stages (Hare, et al., 2006; HSE, 2015; and WBDG Secure/Safe Committee, 2017) such as RIBA (2013) Plan of Work from design through construction/refurbishment into operation.

The need for seeking informed decision making support in project management has put knowledge reuse in a demanding place in order to effectively learn lessons from past experience for better performance in new project. For safety management in building refurbishment, the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) (HSE, 2013) have made a formal procedure to accumulate lessons learnt from incidents and accidents from workplaces, and

RIDDOR records have actually become a reliable source of knowledge for professionals in building refurbishment, for example, to learn lessons from past projects. It will effectively support informed decision making if both learning lessons from individual projects and identifying reasons and associated risks through statistics from reports on incidents and accidents on site can be made possible. As described by Anumba, et al. (2006), a decision support system can be applied to avoid structural collapses in building refurbishment; while Kaklauskas, et al. (2008) also described a knowledge-based decision support system for building refurbishment. It is therefore expected that the research into knowledge reuse in safety management can provide sufficient support to decision making in building refurbishment.

### **Evidence based learning**

Evidence-based method as a practical approach to supporting effective professional learning and problem solving has increasingly gained ground in clinical practice in the past more than two decades, and has been applied with good outcomes in many subject fields. According to Sackett et al. (2000), evidence-based practice has been introduced into clinical practice for conscientious, explicit and judicious reliance on current best evidence in making decisions on the care of individual patients by involves integrating individual clinical expertise with the best external clinical evidence available drawn from systematic study, and the general procedure of evidence-based practice includes assessing the patient, asking clinical questions that arise from the case, acquiring evidence, appraising the evidence, integrating the evidence with clinical expertise and evaluating performance. For buildings, evidence-based design has been adopted in numerous projects as mentioned by (Clipson and Johnson, 1987) and it involves the consideration of facts, rational experience, building regulations and guidelines, as well as existing practice in design through a similar procedure. On the other hand, the research into and practice on evidence-based management (Kovner and Rundall, 2006) have further incorporated evidence-based learning in the management world at both strategic and tactical level. It has been found through a preliminary literature review on evidence-based learning that the formal practice adopting evidence-based method with positive outcomes have indicated a potential useful adoption in safety management in terms of many comparable similarities.

The literature review on existing research into knowledge driven safety management relating to building refurbishment and the lack of research into evidence based learning in project management has indicated a new research to bridge the gap between evidence based learning and knowledge driven safety management in building refurbishment, and the evidence-based safety analysis (ESA) approach is therefore proposed for research described in this paper. As a generic method, it is also expected that the ESA could potentially have a wider application on safety management in not only refurbishment projects but also new construction projects.

## **RESEARCH STRATEGY**

The preliminary literature review summarised in the background on safety management in building refurbishment and the need for innovative tools to improve the practice, and this has led a research aiming at a new ESA approach to supporting evidence-informed safety management in building refurbishment. This research has been being conducted through considering the following objectives to achieve the aim:

- A generic theoretical framework called ESA to support the use of evidence-based method in practice-oriented research into safety management for building refurbishment.
- A procedure to implement the framework through the collection of data and information from accidents and failures as well as contemporary good practices and innovations that are

relevant to safety management in building refurbishment in order to eventually derive useful lessons to form improved strategies and processes on safety management in building refurbishment projects.

- A demonstration through a series of case studies on how ESA approach can effectively support learning lessons from previous building refurbishment projects and improving safety management in new refurbishment projects.

The research methodology adopted comprises an extensive literature review to justify the aim and objectives of the study, a system analysis and design to derive the ESA framework based on current techniques for best practice in safety management, a case base to support evidence based learning in safety management in building refurbishment projects, and a series of experimental case studies through the use of ESA and the case base to demonstrate its effectiveness.

## **ESA**

### **Technical analysis**

The evidence-based safety analysis (ESA) being put forward in this paper is generally defined as a technical approach to safety management by incorporating evidence based method into the whole work process of an ongoing project, and a technical framework of ESA has been first developed in the research for building refurbishment projects. The purpose of such a technical framework is to facilitate the adoption of evidence based method in well-regulated work process for safety management in building refurbishment, and the person who will conduct ESA is assumed a CDM Coordinator or Health and Safety Manager for building refurbishment projects. According to the preliminary literature on the background of described research, technical components/processes to be integrated together to form ESA framework include the process of RIDDOR, the process of staged building refurbishment, the process of evidence based method, and the process of decision making on ESA. These technical components need to be well connected to set up an ESA integrated work programme for building refurbishment projects, and the connections across these technical components are procedures which need to be further defined to support the collection, storage, and use of evidence including data and information from past experience on similar projects undertaken by professionals inside and outside the company.

The entire work procedure for implementing an ESA framework in individual building refurbishment projects needs to comply with existing work procedures widely adopted in practice. For this preliminary research, it is ideal to adopt a formal work procedure covering the whole lifecycle of buildings because of the need for incorporating technical review on health and safety management from design through refurbishment into operation for individual refurbishment projects, and the RIBS (2013) Plan of Work is an ideal work procedure to be adapted for a ESA framework for building refurbishment.

The implementation of ESA also needs a case base that has a good amount of evidence in related areas from a rich source of past projects undertaken by both the company that will conduct an ESA in a particular building refurbishment project and other companies in local, regional, national and international scope. Despite of many other sources of evidence relating to health and safety management in building refurbishment, one particular source of evidence, for example, is the set of documentations from RIDDOR, and the structure of each case study needs to be designed with regard to the availability of data and information from RIDDOR. A specified structure of case studies is in need for collecting evidence for case studies in a unified consistent format, and this will facilitate retrieving evidence from the ESA case base.

A conceptual framework of ESA for building refurbishment projects has been developed according to this technical analysis, and presented in Figure 1. Descriptions on processes of this technical framework are given below to explain how ESA can be implemented through a formal procedure.

### **Technical description**

An indicative technical framework of ESA has been developed at the initial stage of the described research. As illustrated in Figure 1, the framework is designed to incorporate activities to implement evidence based learning throughout a generic work procedure for which RIBA Plan of Work was chosen to adapt to the need for use in building refurbishment projects, and these activities include

- Conducting ESA in connection with other supportive activities described below, including collecting technical solutions, collecting evidence (reported case studies, and other data and information from past projects), collecting technical solutions for building refurbishment across work stages, and making judgment on technical solution assessment and execution plan for health and safety management at further work stage. The ESA process will be conducted through several technical steps including
  - Step 1: Preparing evaluation criteria and checkpoints for health and safety review and assessment at individual work stages of building refurbishment in a particular project,
  - Step 2: Acquiring related evidence on internally and externally reported injuries, diseases and dangerous occurrences and other related data and information from past practice in similar projects,
  - Step 3: Assessing the technical solution upon a particular refurbishment project at individual work stages.
- Collecting reported case studies from ESA case base based on data and information in formal documentation under regulations such as the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) in UK. The case base to be developed as part of ESA prototype provides technical evidence accumulated from past projects in a wide scope covering related practice in local, regional, national, and international scale. The process to collect reported case studies is expected to be conducted from internal and external sources of an organisation where ESA is adopted, and the reason for collecting reported case studies is to ensure the reliability of evidence to be used for ESA.
- Collecting other data and information on health and safety management from projects for which internal and external reports on injuries, diseases and dangerous occurrences are eventually collected in a case base for ESA.
- Collecting technical solutions for building refurbishment at each work stage across work stages integrated within the ESA framework. These technical solutions are to be provided by a technical coordinator such as Construction (Design and Management) (CDM) Coordinator or Building Information Modelling (BIM) Coordinator (Shepherd, 2015) at each work stage for specific health and safety review according to related regulations such as the Construction (Design and Management) Regulations 2015 in UK and industry standards.
- Making judgment on the acceptance of the technical solution at each work stage.
- Making an execution plan for safety management at next work stage after a technical solution passes staged assessment.

The ESA framework presented in Figure 1 is developed to incorporate the function of evidence based learning and practice into the current work process such as the RIBA Plan of Work in building refurbishment. All ESA related activities and its technical steps are interconnected to ensure an effective implementation of evidence based learning towards a series of review on staged technical solutions and a series of execution plans for safety management at various work stages.

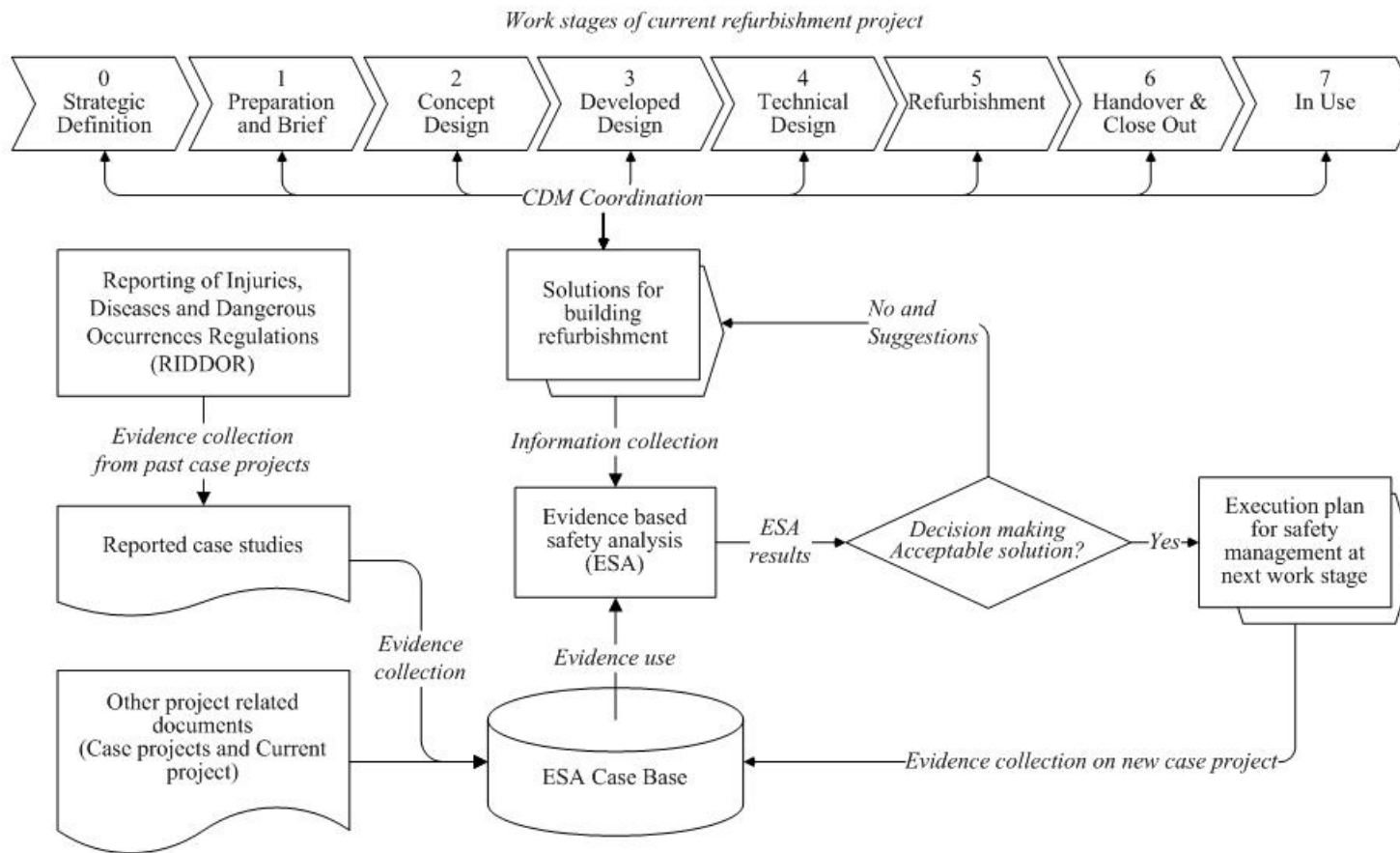


Figure 1: ESA framework

## DISCUSSION

It is necessary to demonstrate the effectiveness of ESA in real projects after the technical framework is developed. As it is an on-going research into ESA framework and its toolkit including the ESA case base and ESA evaluation criteria and checkpoints, this paper just provides a brief discussion on the use of ESA on a scenario base in one building refurbishment project in London.

The scenario based case study is a façade replacement project for one office building alongside a busy street in central London. As shown in Photo 1, which was taken on site on 20 July 2016, a team of workers were dismantling a scaffold system in front of the building after it had been well equipped with a brand new façade system. However two risks relating to potential falling objects were spotted at that moment when the photo was taken, and these include

- The handle of one piece of steel scaffold board on the top of scaffolding, and
- Several large pieces of reinforced polyethylene scaffold sheeting flapping on the scaffolding without control.



*Photo 1: Risk of falling objects*

By using ESA for this scaffold dismantling process, which was part of the entire façade replacement project, the three technical steps given in the Technical Description section above need to be conducted, and a brief discussion is given below:

- Step 1: A general set of evaluation criteria and checkpoints for safety review and assessment on a scaffold dismantling plan needs to be set up, and it needs to focus on risks in connection with falling objects and structural stability of the scaffold system. In this case study, it was obvious that the risks of falling objects were still high during scaffold dismantling, and evidence associated with falling objects need to be further added in Step 2 in this ESA.
- Step 2: In the review and assessment of a scaffold dismantling plan prior to operation on site, lessons need to be learned and/or revisited from similar projects focusing on scaffold dismantling. As this case study is for demonstration only, evidence were therefore first collected in terms of accidents that had happened in connection to falling objects from scaffolding in building refurbishment projects in London. The following accidents were found identical from reported accidents in the City of London in recent years with regard to the risks of falling objects spotted in this project:
  - Al-Othman, 31 May 2016: A pedestrian was rushed to hospital with serious head injuries after she was hit by a piece of falling scaffolding in Rathbone Place.
  - Rucki, 5 May 2015: A pedestrian was treated for serious injuries in hospital after she was hit on the head by scaffolding which fell from a building site in Manor Park Road.
  - Blundy and Mann, 20 January 2015: Two women, both aged in their 50s, were taken to hospital with serious head injuries after being hit by falling debris in Eldon Street; while witnesses described their horror at seeing the women hit by a metal pole, which catapulted to the floor towards the opposite side of the street.
  - Morgan, 23 October 2014: A young child on his scooter escaped death “by inches” after scaffold workers dropped a 2kg metal clip onto the pavement below on a side street just off Oxford Street in front of dozens of shoppers. The terrified child froze in horror and then vomited in front of his shocked father after a metal clip used to secure the rigging fell and clipped the rear wheel of his micro-scooter. Scaffolders working on site were dismantling the scaffolding when the clip broke free.
- Step 3: A scaffold dismantling plan and its process as shown in Photo 1 is then reviewed and assessed. Based on evaluation criteria and lessons learned from partially collected evidence, conclusion from technical review and assessment on the technical solution including techniques and processes for scaffold dismantling was therefore made to amend the plan in order to reduce risks of falling objects.

This scenario based case study aims to demonstrate the procedure of ESA in technical review and assessment for reliable safety management planning on scaffold dismantling process. Although the two spotted risks of falling objects might not have led to any serious accident or injury on site, the photo taken from a site visit had revealed defects in that scaffold dismantling process, and the adoption of ESA prior to dismantling the scaffold system can ensure a safer plan of work so as to eliminate risks of accidents. In addition to ESA review and assessment, an improved scaffold dismantling plan will need to show a comprehensive consideration on directly related issues including the protection of the public and scaffolders working at height, and the entire stability of scaffold system in the dismantling process; and include a safety management procedure to cover monitoring, supervision as well as training; and these will form a safety management plan prior to scaffold dismantling.



## CONCLUSIONS

The described research in this paper has achieved preliminary outcomes on a conceptual framework of ESA and technical descriptions on the use of ESA as an integrated technical process for safety management in building refurbishment projects. The ESA process requires collaborations between safety management and CDM coordination throughout a chain of individual work stages to make effective and efficient review and assessment on a technical solution coming from one work stage and to make safety management plan for the next work stage if the technical solution can pass ESA review and assessment. The ESA process can therefore reinforce safety management in design through refurbishment into operation with regard to eliminating risks of accidents. Under the ESA framework presented in this paper, further research is under consideration to focus on several key technical components including an ESA case base and a set of evaluation criteria and checkpoints for ESA review and assessment.

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