

## Managing Health & Safety in Refurbishment Projects involving Demolition and Structural Instability

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### Abstract

*There is consensus among practitioners and academics that refurbishment projects are among the most complex, risky, dangerous and uncertain to manage. This situation is heightened where the works involve elements of demolition activities and where tenants are in occupation. As a percentage of total construction output, refurbishment works in its many disguises have increased substantially in the last 30 years. In many developed economies, it now accounts for over 50% of output. However, the growth in refurbishment works has not been paralleled by empirical research, especially in the management of health and safety. This paper attempts to improve our understanding and knowledge of health & safety in this very important area of construction work. The paper is based on an on-going study funded by the UK Health & Safety Executive (HSE). It investigates, inter-alia, the main risk factors and implications associated with the relatively high level of hazard and poor health & safety incident in refurbishment works involving demolition activities and structural instability. It also considers the health & safety management strategies in current usage, with the view of documenting best practices for the benefit of the industry. The study involves a comparative assessment of the situation in the UK with that of Italy, where there are many historic buildings with refurbishment works involving partial demolition. It employs a combination of research methods, including semi-structured interviews, review of archive documents and site visits to selected refurbishment sites in the UK and Italy. In this paper, it is shown that a variety of factors, which combine in complex ways, are associated with the high level of health and safety incidents in refurbishment. These factors include demolition design, planning & execution. Other factors are knowledge of site and structure, workforce supervision, selection and use of appropriate plant & equipment, selection of subcontractors, communication, and requisite safety information and training. It is also highlighted that existing health and safety management strategies for refurbishment in construction organisations range from many that are alarmingly poor to few enviable practices. It is therefore recommended that there is an urgent need to improve health & safety management practices for refurbishment, with targeted education and training and effective dissemination of best practices seen as vital in this regard. It is also suggested that there is ample scope for further empirical research in this very important area of construction activity.*

**Keywords:** Demolition, Health & Safety, Refurbishment, Structural instability

## Introduction

In the last 30 years there has been a significant increase in refurbishment works both in the UK and in the Italian construction industries. A variety of factors has given impetus to this, such as the increase in redundant and ageing buildings; shortage of available areas for new construction developments; social and technological factors making old buildings inadequate and obsolete; development of building standards and regulations - increasing the need for construction refurbishment to comply with new requirements. Italy also has a huge historical and architectural heritage, which is in need of continual refurbishment and restoration.

The refurbishment sector, in its many forms, accounts for more than 40% of the total UK construction output. Although in the UK, no official statistics on the actual value of refurbishment output exist, this sector has increased in the past 30 years from around 22% to 43% of total construction output. In Italy more detailed statistics are available. Existing data shows the increase in refurbishment work in the past 10 years. According to the statistics provided by CRESME (Research Centre on the Construction market) and ISTAT (Italian Statistics Central Institute) in 1995 refurbishment accounted for the 57.5% of total construction output, this percentage being composed of 30% of ordinary maintenance works. In Italy, in 1999, the refurbishment sector registered a 3% increase and the latest data available shows an 11% increase in the year 2000. The total volume of refurbishment output is composed of 60% private housing works and 40% public works.

The increase in refurbishment activity in the last three decades is, however, not paralleled by comparable empirical research, especially in the management of health & safety.

Although neither the UK nor Italy differentiates between new construction and refurbishment accident data, statistics suggest that refurbishment, in its different interpretations, accounts for a substantial amount of injuries and fatal accidents [HSE, 1988; CIRIA, 1994]. There appears to be little or no empirical and generally agreed data currently available. There, however, exist some anecdotal evidence. The Italian Accident Statistics Body (INAIL) is currently developing a new data collection system in order to separate accidents that occur on new construction sites from those that occur during refurbishment works. This can only be possible through the link between the accident reported to local authorities, Building Regulations and the planning permission of the site where the accident happened. This authorisation has, in fact, to show the nature of the construction site and the type of work performed (new construction or refurbishment).

In the context of the present study, in which demolition activities and structural instability are being investigated, refurbishment works are seen to involve particular and quite complex works (e.g. site and off-site based works involving specific design works) related to existing buildings. Therefore refurbishment works will involve improvement, adaptation, upgrading, rehabilitation, renovation, restoration and any extraordinary or unplanned maintenance. In this definition, however, ordinary maintenance (e.g. cleaning, painting and decorating), carried out on a regular basis, is not included.

## Aims and objectives of the paper

This paper is based on an on-going one-year scoping study which, *inter-alia*, sets out to:

- Determine the main risk factors and implications associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability;
- Investigate the health & safety management strategies in current usage, for refurbishment work involving demolition activities and elements of structural instability;
- Undertake comparative studies of the situation in the UK with that of Italy;
- Produce checklists of issues to consider in managing Health & Safety incidence on refurbishment projects involving demolition work, and also to identify areas where guidance should be provided;
- Make recommendations for further research in this area and on appropriate education and training provisions relevant to the key stakeholders associated with refurbishment activities involving demolition work.

In this paper, however, only some of our tentative findings will be discussed. These are mainly to do with the main risk factors and implications associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability. The paper will also give cognisance to issues of prevention and control of health and safety incidence on refurbishment projects.

## Methodology

Given the relatively meagre amount of studies that have given attention to this area of study, and the apparent lack of robust and authoritative statistical data, it was important that a combination of research strategies was employed to obtain the needed data set for exploration. These strategies included:

- Industry survey followed by case studies of selected large and small refurbishment projects in the UK involving demolition activities. This involved a root cause analysis to identify the key factors associated with the relatively high level of hazard and health & safety incidence on refurbishment involving demolition works and structural instability;
- Selected semi-structured interviews with general contractors undertaking such works, specialist demolition contractors, health and safety officers from contracting organisations, and representatives from the Health & Safety Executive (HSE);
- Review of archive documentation (reports, case studies) at national and regional levels from HSE;
- Study visits to Italy to undertake appropriate case studies of refurbishment projects involving demolition work;
- Preliminary risk assessment based on key factors identified at the design stage while developing safety plans.

## Refurbishment and demolition

Demolition activities are often related to projects where structural alterations of the existing building are required. These alterations could be very different depending on the size of refurbishment works. They could include:

- total façade alterations;
- total removal of structural elements (columns, beams, slabs, walls);
- partial demolition of the building shell to build extensions;
- construction or enlargement of new openings.

Demolition and de-construction activities are gaining currency in this context, and beginning to be seen as very important activities in their own right. The issues of sustainability, material usage and waste management have brought these activities to the fore, together with unplanned collapses. Demolition works are among the most dangerous operations to be performed on site due to the high level of risk in which the workers are exposed. This paper particularly focuses on partial demolition, which involves carrying out works only on portions of the structure and maintaining structural stability for all the remaining parts during and after execution. Such structural stability can be provided with different methods (e.g. adequate structural analysis, temporary support structures, proper demolition method, schedule and equipment).

Partial demolition also involves other health and safety risks related to site organisation, which has to be properly assessed while planning refurbishment works. Whilst total demolition can be mainly carried out by mechanical equipment, partial demolition works require a larger number of workers employed on site especially for demolition by hand activities. A structural survey studying the interaction between structural elements to be removed and those remaining has to be carefully developed to avoid premature or unplanned collapse.

Unfortunately more accidents and fatalities tend to occur during partial demolition than during total demolition works, especially while carrying out small demolition activities. The appointment of non-specialist contractors and the lack of co-ordination and supervision of all the other activities conducted at the same time are two important culprits.

Given the fact that many accidents, during demolition works are mainly caused by partial or total collapses, this study sought to identify the key contributing factors to structural collapses. It also considered how this might be better addressed.

Some of the tentative findings from the on-going study are presented below.

### **Key factors associated with the relatively high level of health and safety incidence in refurbishment**

Refurbishment projects are likely to be more difficult to manage than new construction works (Egbu, 1994; Marino, 2001). One of the main reasons for this is relatively high level of uncertainty associated with the works. This manifests itself in many ways, including leading to the large number of updates and adjustments (work

methods, schedules, facilities, etc) needed due to the discoveries made while carrying on site works. This can be frequently put down to inappropriate surveys developed at the design phase. Nevertheless, site experience shows that full project information about the building being refurbished, such as structural material conditions can be available only during work execution. This lack of project and planning information influences the whole site organisation with a risk of an under-estimation of important factors such as:

- Site desk study and investigation;
- Contractors and subcontractors pre-qualification and selection;
- Supervision of refurbishment works.

With the increasing number of refurbishment projects being undertaken in the UK and in Italy, these factors, if not properly addressed and checked, could impact on the regular progress of refurbishment projects. This impact on refurbishment works could affect different aspects of the development of the project; most often those related to health and safety issues. The lack of detailed work scheduling, poor site organisation and co-ordination, or inadequate supervision of activities is amongst the main causes of accidents. At the same time the works may not be completed in compliance with project specifications.

The effect of an unplanned collapse impacts on workers' safety as well as the building being refurbished. Greater priority must be given to preventing accidents on site. The effects of an accident can impact upon the client, the contractor and their construction businesses in the following ways:

- Productivity and efficiency of the workforce can be affected as a result of injuries and people leaving work on sick leave;
- Project profitability could decrease due to delays in completing the job or due to structural damages caused by unplanned collapses. At the same time damage caused to adjacent properties need to be compensated by the client or the contractor depending on their responsibility for the damage;
- The impact that refurbishment works involving demolition activities may have on the environment should be assessed as well. Waste treatment, re-use and recycle of debris, hazardous materials disposal should be planned as carefully as demolition sequence. The impact on the environment, when such factors are not properly addressed could be so negative that it may affect the overall benefits achieved from a refurbishment project.

Our study so far suggests that there is a huge variation in health & safety management practices associated with refurbishment work. These range from many that are alarmingly poor to few enviable practices. The tentative finding from our industry survey suggests that the effectiveness and robustness of Health & safety strategies is related to the size of the consultancy/contractor involved. In larger firms it is possible to identify professionals who are specifically appointed to develop safety issues while carrying on their tasks (design activity, work scheduling, site planning etc.). At the same time project documents result to be integrated with construction instruction (e.g. demolition sequence) and safety procedures. In addition, there is some evidence that those consultants and contractors who do not normally bid for

cheap tenders are selected for their best value and their Health & safety strategies can be assumed as an example of good practice.

Health & safety has a great influence in the design and the management of refurbishment projects, especially those involving demolition activities. It can be stated that health & safety is one of the most influential factors in selecting demolition methods to avoid structural instability and prevent structural collapses. Structural collapses have to be identified as events with predictable and unpredictable causes. Unpredictable causes are generally related to natural and catastrophic events such as earthquakes, avalanches and floods. Predictable causes, on the other hand, can be determined, controlled, reduced or removed.

Causes of collapse associated with demolition activities can be identified through the different phases of the building process (i.e. design, construction, use and refurbishment). The building process for a new construction project is quite similar in its scheme to a refurbishment project where a design and an execution phase can be clearly identified. At the same time, the approach to demolition works should be the same as the whole project, with a design phase that needs to be developed and an execution phase that needs to be planned. The demolition phase should therefore be considered as a sub-project where design, planning and execution phases must be carefully studied and assessed. When developing a study of these phases it is possible to determine the main causes of structural instability and therefore able to provide, in such phases, different methods and tools to prevent collapses.

### **Demolition design**

Prior to carrying out any refurbishment works involving structural alterations a detailed and complete structural survey needs to be prepared. To develop this survey the following information needs to be available:

- Original structural design documents (e.g. drawings, structural calculations);
- Report of all structural alterations carried out on the construction in the past;
- Material samples taken from the construction site to test real structural conditions;

Upgrade of buildings and change of use may increase the loads on the ground where the structure is based. This can lead to subsidence of the foundations thereby compromising the stability of the whole building. An appropriate geotechnical survey is therefore required to identify whether geotechnical processes are needed or not (underpinning, pile foundations). The purpose of this survey is to determine the condition of the framing, floors and walls as well as weak structural elements so that measures can be taken to prevent the premature collapse of any portion of the structure. The interruption of a load path, the effect of gravity and the inability of the remaining structure to support any force redistribution may cause structural instability and therefore lead to an unplanned collapse. Any adjacent structure(s) or improvements should be similarly checked. The survey should indicate if the structure to be demolished has been damaged by fire, flood, explosion or some other causes. This can normally be determined after removing pavements and finishings from the structure.

When all the information about the structure is available, demolition techniques can be assessed and schedules developed accordingly. The sequence of demolition phases will be determined in order to maintain the structural stability of all remaining parts at all times. Key structural elements of the remaining parts do not have to be demolished or damaged by demolition activities. If the layout of the refurbishment project requires the demolition of any key structural elements (e.g. before reconstruction of a new part of the structure), temporary support systems should be investigated, designed and used.

When designing demolition activities it has to be recognised that collapses may be caused by activities induced during the execution of demolition works and not only by the removal of key structural elements. Therefore appropriate plant and equipment have to be selected to avoid excessive loads on the remaining parts of the construction (e.g. air compressor for pneumatic hammer on weak floors or mini-excavator on a weak structure).

### **Demolition planning**

As already mentioned unplanned collapses are not only determined by an unsafe sequence of demolition activities. Other factors may contribute to structural collapses in a refurbishment work, many of them being related to site organisation. The British Standard code of practice for demolition (BS 6187:2000) in clause 7 gives clear advice about the importance of the “knowledge of the site”. This information can be obtained either from a desk study or from a site survey. A desk study will provide some information about site conditions that may affect structural integrity during demolition activities such as:

- ground conditions (e.g. water table, ground type, sink holes);
- location and type of services, above and below ground;
- traffic condition and site access;
- extent of buried features or above ground structures.

The investigation on site should extend the knowledge gained during the desk study and provide a more accurate understanding of the existing conditions of the construction compared to what is identified in drawings and documents. Such survey will point out any differences and alterations that may have taken place and if these changes have been reported within the building files. Site investigation plays an important role in the development of a structural design survey, as well as in the planning of all demolition activities.

After the selection of methods and plant for demolition, a work schedule has to be developed taking into account site-specific conditions. The noise level should be assessed as well. Noise assessment should take into consideration if people are occupying the facility being refurbished or any adjacent buildings. Noise levels should be checked for the health of site workers too. Such assessments may give cause for the work schedule to be modified in order to avoid the concentration of demolition activities or to avoid their execution during certain hours of the day. This can cause an extension in the duration of refurbishment activities and therefore must be taken into account while managing the whole project.

## Demolition execution

Provided all the structural and site surveys have been properly developed, the demolition methods have to be correctly implemented. To control demolition, method execution supervision needs to be provided and managed. Prior to setting up a supervision activity through inspectors and safety professionals, the client must select contractors and subcontractors for demolition activities. The client should limit the number of subcontractors working on site to allow for easier control over subcontractors employed on site at any time. At the same time the client should be able to pre-qualify and therefore select contractors and subcontractors on their competencies and experience in demolition works.

On the other hand, contractors have to respect demolition methods assessment and the site-specific demolition health and safety plan procedures. A continual workforce control activity must be carried out by contractors' demolition supervisor to avoid workers deliberately executing unplanned activities. Workers should be informed of the risk arising from non-compliance with safety instructions. This may be carried out through training courses and toolbox.

The analysis of the case studies, the industry survey and the interviews conducted point to the need for contractors to employ specifically trained site supervisor for activities involving higher levels of risk. One of the most important roles is the "temporary works co-ordinator", who is in charge of the supervision of the execution of temporary works on site (e.g. façade retention structures, scaffolding). One of his duties is to verify the compliance of the construction with temporary works design as well as safety procedures, he has also to check the structural stability of temporary and permanent structures during the refurbishment and demolition works.

Language barriers can be a serious problem especially in the construction industry where almost all the instructions, as well as emergency advice, are given verbally. Language problem also extends to the fact that refurbishment works seem to attract many nationals who move in and out of refurbishment and jobbing works because of its relatively short duration. This exacerbates the language challenges. Such barriers can be partially overcome through the use of illustrated safety instruction and signals.

After the analysis of demolition phases, from design to execution stage, the key factors reported in the flow chart in Figure 1 should be assessed and implemented prior to carrying out any demolition work.



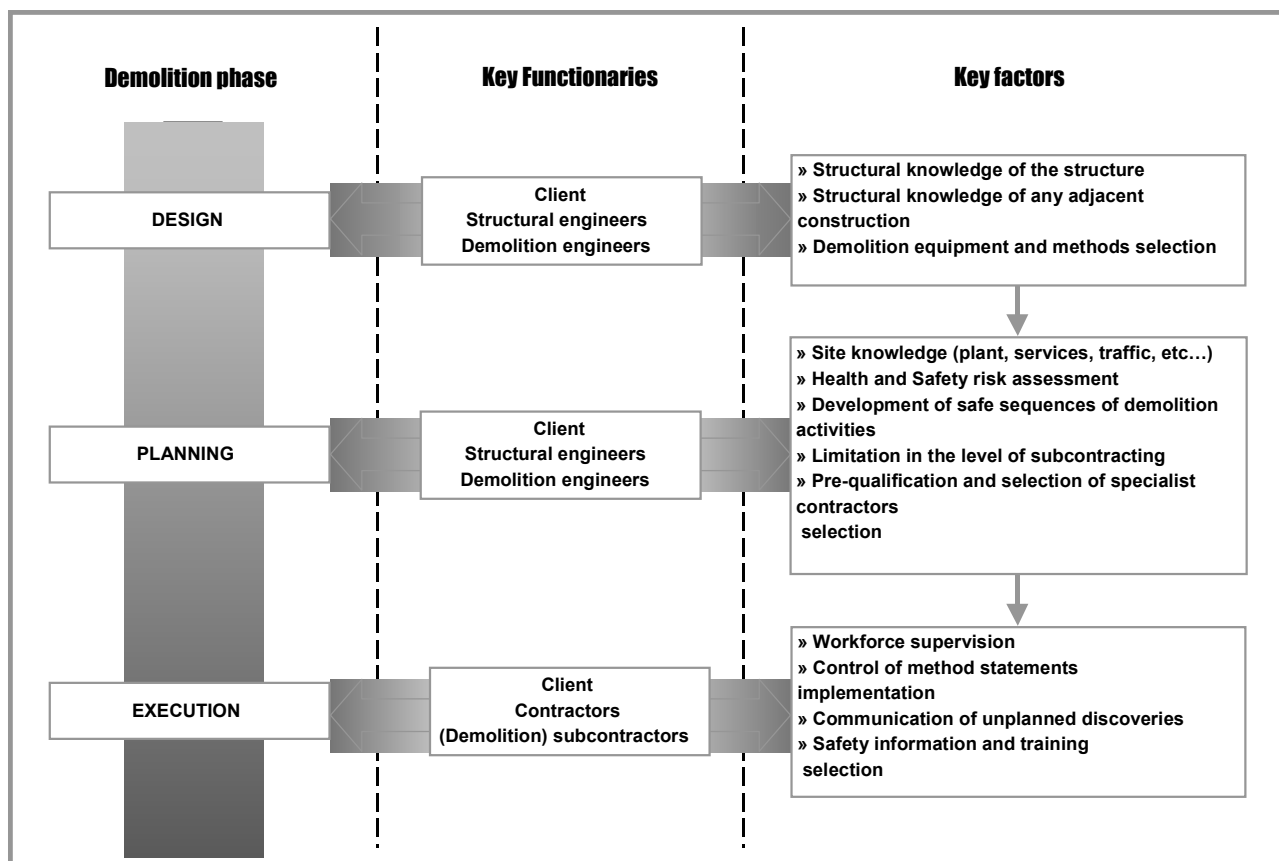


Figure 1: key factors to be assessed and implemented prior to carrying out any demolition works

## Demolition methods and techniques

While investigating partial demolition in refurbishment projects; demolition methods, techniques and equipment must be identified and assessed. Depending on the structural elements to be removed or demolished and applying the principles of structural demolition as reported in BS 6187 “Code of practice for demolition” structural demolition methods can be identified as follows:

1. Progressive demolition;
2. Deliberate collapse mechanism;
3. Deliberate removal of elements.

Progressive demolition should be considered to be “the controlled removal of sections of the structure, whilst retaining the stability of the remaining part and avoiding collapse of the whole part of the building to be demolished” (BS 6187:2000). Therefore the key structural elements of the construction should be clearly identified as well as demolition sequence. The Italian safety legislation requires that the contractor develop a site-specific demolition schedule prior to the opening of the site. As reported in the code of practice, progressive demolition is the most commonly used type of structural demolition. This method seems to be particularly useful in confined and restricted areas.

Deliberate collapse mechanism should be considered to be the “removal of key structural members to cause complete collapse of the whole or part of the building or structure” (BS 6187:2000). When used in total demolition this technique should be employed on “detached, isolated, reasonably level sites”. This requires sufficient space in order to move and place equipment and personnel at a safe distance. Before carrying out any partial demolition works, a structural survey needs to be undertaken to ensure that no structural instability will arise during demolition. This should avoid any unplanned collapse of the structure in areas where workers are present. In fact amongst the most common causes of structural collapses, it is possible to identify such culprits as activity induced, load induced (e.g. debris localised overloading), spontaneous collapse, remote activity and machinery impact.

The deliberate removal of elements is a demolition method used to remove selected parts of the structure by dismantling or deconstruction. Prior to the removal of any parts of the structure any potential instability or collapses must be assessed.

Focusing on partial demolition the health and safety risk assessment will be developed through the analysis of:

- Demolition method and techniques;
- Structural elements to be removed and their constituent materials;
- Equipment and tools.

While studying partial demolition in the refurbishment of old buildings, it was noted that structural elements are more likely to be composed of timber, concrete and bricks. Depending on the size, the type and materials of structural elements and on the extent of demolition works, proper equipment and tools have to be selected. When demolishing structural elements, such as beams, slabs or walls, vibrations induced by mechanical equipment could be dangerous for the integrity of the whole structure and of adjacent construction. If the structural survey assesses that the structure may show instability or damage after being exposed to vibrations, demolition by “hand method” is strongly recommended. Use of manual tools as well as electrical or pneumatic hammers is recommended in confined spaces and for internal demolition works due to the lack of space and of safe areas.

Demolition techniques such as demolition ball, demolition by explosives, blasting and bursting are mainly related to total demolition, therefore not discussed in this paper.

Earthwork machines with hydraulic attachments are frequently used when required by the size of demolition works and when permitted by structural conditions of the remaining parts of the structure. Excavators of different sizes and skid-steer loaders are among the most commonly used type of demolition machines. They are generally used in the demolition of steel, concrete and masonry buildings.

Hydraulic attachments have to be selected dependent on the materials that are required to be demolished. The most common hydraulic attachments are:

- Pusher arm;
- Impact hammer: pneumatically or hydraulically operated;
- Hydraulic shears;
- Pulverizer;
- Demolition pole;

- Grapple.

Through the study of demolition methods it is possible to develop a preliminary risk assessment that will identify those general risks involved in demolition operations. This general risk assessment will need to be further developed on the site-specific context to allow an effective development of safety procedures.

Most of the health and safety risks in demolition activities are related to an unplanned collapse of the structure; at the same time the incorrect use of a demolition tool can cause injuries as well as an unsafe site. Through the analysis of accident statistics it is possible to notice that a reported accident such as “*trapped by something collapsing or overturning*” can be related to the collapse of structural parts or uncontrolled discharge of debris. Using demolition machines involves risks such as being struck by moving vehicle or objects (e.g. excavator’s attachments) as well as contact with moving machinery or material being machined.

Structures partially demolished should be bounded and danger signals should be provided to prevent workers from getting into dangerous areas. Falling from height (e.g. falling from a floor partially demolished) is among the most frequent kind of accident encountered (HSE, 1988). Risks related to explosions should be assessed when plants and services are still in use and therefore a temporary suspension of gas and/or electricity supply should be required during the execution of demolition activities. Even if the number of risks related to demolition activities seems to be relatively small, there are many factors that when not properly addressed may cause a serious injury or fatality.

### **Prevention and control of health and safety incidence on refurbishment projects – Some key issues**

The relatively high level of health and safety incidence on refurbishment sites involving partial demolition activities can be attributed to some key factors as previously discussed. These key factors are related to the design phase of refurbishment projects as well as to the execution phase, and they involve key functionaries in the refurbishment and demolition processes, such as the client and the contractor. It is normally the case that the client is more involved in the design phase, therefore his supervision is very important to ensure that the key health and safety factors are properly addressed and assessed.

Some of the important activities of the client could be expressed in the following actions:

- to appoint a competent engineer to develop detailed structural survey on the construction to be refurbished;
- to appoint a competent planning supervisor for the control and supervision of all the safety aspects on site;
- to provide sufficient time in the project development to get all the necessary information for the structural survey, desk study and site investigations;
- to assess a reasonable time schedule to complete refurbishment works in order to ensure that the activities are performed in safe conditions;

- to pre-qualify and select specialist contractors with good experience and competence in refurbishment works;
- to ensure that project documentation is updated and/or modified following discoveries that may be made while working on the structure.

When contractors are selected to carry out demolition works they should obtain from the client all the information developed during the design and planning phase. For example the structural survey, the demolition method and sequence. The contractor's experience will be useful in integrating any safety procedures to the project safety documentation developed by structural and safety engineers.

During the execution phase contractors and subcontractors will have to contribute to effective safety management ensuring the following activities:

- providing appropriate information and training related to health and safety hazards during demolition works;
- using appropriate demolition machines and tools as indicated in demolition method statements;
- following demolition sequence and method as provided by demolition/structural engineers;
- to maintaining the site in a safe condition and in compliance with health and safety plan requirements;
- providing workers with all the appropriate PPE related to health and safety risks they are exposed to;
- appointing a supervisor to be on site during the execution of all the demolition activities; great attention must be paid to supervision in order to prevent the workforce from taking any initiatives which may lead to the execution of unplanned activities;
- communicating as work progresses to the client any modifications or structural diversities from what was found in the structural survey;
- providing illustrated statements and safety instructions when the workforce is composed of workers speaking different languages;
- removing waste and debris to avoid localised overloading of the structure.

## **Conclusion and recommendations**

Refurbishment activities in the UK and in Italy have increased in the last three decades and now command a substantial amount of total construction output. Refurbishment activities are also perceived to be dangerous, with a high level of poor health and safety incident. The situation is heightened when such works involve demolition and structural instability.

This paper has addressed some important factors, which combine in complex ways to contribute to the relatively high level of health and safety incidents on refurbishment projects involving partial demolition and structural instability. These factors include demolition design, planning & execution. Other factors are knowledge

of site and structure, workforce supervision, selection and use of appropriate plant & equipment, selection of subcontractors, communication, and requisite safety information and training.

The paper points to the fact that existing health and safety management strategies for refurbishment in construction organisations range from many that are alarmingly poor to few enviable practices. There is therefore an urgent need, especially for small-sized contractors, to improve health & safety management practices for refurbishment, based on best practices. Any meaningful Health and Safety management strategy should be robustly developed and should give due cognisance to the factors identified above. Targeted education and training and effective dissemination of best practices are vital in this regard. There is also ample scope for further empirical studies in this area for the benefit of the refurbishment sector and the construction industry.

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