INSTITUTE OF DEMOLITION ENGINEERS

Demolition of Tower Blocks

Produced by Perses Group

An objective look at the comparable methods utilised to reduce tower blocks and the hazards inherent to each method.

Table Of Contents

INTRODUCTION

ABOUT PERSES

PERSES was formed in 2013 to provide consultancy services and training courses to the specialist demolition and asbestos removal sectors. It has since provided health and safety advice and training courses to all sectors, including temporary works, safety awareness for construction, occupational health and safety, and demolition work.

PERSES is a demolition consultancy with experienced demolishers working within the business capability and as a company and staff, has significant experience in dealing with demolition types in dealing with tower blocks and other types of structures.

PRINCIPAL AUTHOR

Stephen McCann FIDE, Managing Director, PERSES.

ACKNOWLEDGEMENT – RESEARCH AND DEVELOPMENT

Dr Yazan Osaily PhD, Head of Research & Development, PERSES.

ABOUT THE IDE

The Institute of Demolition Engineers (IDE) exists to promote and foster the science of demolition engineering.

The main objectives include the:

- promotion of the use of more efficient techniques in the industry
- encouragement of safer methods of working
- provision of a qualifying body for the industry

ACKNOWLEDGEMENT – INSTITUTE OF DEMOLITION ENGINEERS PEER REVIEW PANEL

The author would like to thank the president of the IDE, **Mr Richard Dolman** and the IDE committee for agreeing on publishing this piece of work through the institute.

The author would also like to acknowledge the efforts of the panel involved in the peer-review process:

Grant Styles MIDE, Operations Director, Erith Group (IDE Council of Management Member)

Richard Dolman MSc FIDE, Managing Director, AR Demolition (IDE President)

Purpose of this report

To provide an independent comparative report that considers the health, safety, environmental and quality issues that must be addressed to ensure a high-rise tower block's safe, sustainable and effective removals.

The report considers the pros and cons of the various methods and techniques to determine the most appropriate methods and sequence to undertake the work safely and effectively.

Limitation of the report

This document is intended to be used as a report or guide to assist in planning demolition works and is not intended to replace a specific risk assessed method statement for any particular project and does not form a code of practice.

Good practice can only be of value when applied to careful planning and with sufficient attention paid to information, instruction, training and competent supervision to control and monitor the works.

All stakeholders should exercise their knowledge, experience, and judgment when carrying out this type of work.

Costs

This report will not consider the commercial costs required to implement any of the listed controls or compare the listed methods prices as the costs can vary widely from area to area. This report is strictly a comparison of the methods to establish the safest method.

NOTE: as an aside, the comparison of person-hours which is covered as risk analysis, is considerably higher for some methods than others, which, of course, would impact the cost significantly.

Structures

This report is on the various techniques and does not include the removals of asbestos materials or the internal soft strip of the structures but looks at the demolition works actual execution.

This report cannot deal with every eventuality, structural inconsistency or site condition. This report and the recommendations herein are strictly on the methods described in this document based on a generalised stable structure.

There have been successful demolition contracts carried out using piecemeal bottom-up demolition, which will not be covered in this report

Legislation and regulations

While all works mentioned within this report are under current standards and good industry practice, some dates of standards/regulations may not be listed within the document in an attempt to future proof this report; however, some regulation dates must be identified in the interests of accuracy.

Planning

Contract specific methodology prepared in accordance with the requirements of Clause-5.2.3 of British Standard 6187 Code of practice for full and partial demolition, and Regulation-20 of the Construction (Design and Management) Regulation 2015 (C.D.M-15), must be produced and should take cognises of any issues pertaining to each structure as noted in Clause-9 of BS 6187.

Further detailed paperwork such as specific risk assessments (outlining the hazards and control measures) and lifting plans must be completed before and must be specific to the works.

Application of the various methods to different structures

While the findings in this report are based on a like for like structural comparison to ensure that the comparison is correct, i.e. apples for apples, however, I offer the following caveat: each of these methods have their own distinct strengths just as each of the structures have their own attributes.

These methods are irreplaceable in certain environments, i.e. explosives in power stations demolition.

The contractor should conduct a full assessment at the initial stage to determine the best method based on the particular site issues; the most appropriate method should then be selected.

Other factors not considered

Some factors which are of significant importance, i.e. built-up area or inner city, the protection of the general public, have not been taken into consideration for this report as the variables are too wide for a report of this type, but must be considered when carrying out a feasibility study or report for a live project.

For these omissions, I offer the following caveat: While this report seeks to find the safest demolition technique for the demolition of tower blocks, it cannot delve into the minutia and identify all the issues for each and every site as the parameters and variables would be too vast.

It should be considered, too, that in the standalone building used as a test model for this report, the demolition contractor may select a blend of methods such as using top-down piecemeal to reduce the height of the structure down to workable machine height.

Executive summary

This executive summary provides an overview of each demolition method employed to reduce tower blocks on a section-by-section basis.

Further reading of this report's individual sections is required to gain a complete understanding of the issues considered and final recommendations.

Section-1: General hazards and information

This section outlines some of the general hazards which should be considered when planning the demolition of tower blocks and highlights some historical issues.

Section-2: Demolition using high-reach and super high-reach demolition rigs

This section covers the method of reducing high rise structures using high reach demolition rigs.

It covers specific controls required to ensure the safe implementation of this method and outlines the key hazards faced while reducing structures using this method.

These hazards include:

- Exclusion zone;
- Plant interfaces;
- Premature collapse.

Section-3: Piece-meal demolition

This section covers the method of reducing high rise structures using piecemeal.

It covers specific controls required to ensure the safe implementation of this method and outlines the key hazards faced while reducing structures using this method.

These hazards include:

- Manual works;
- Working at height;
- Exposure to weather;
- Premature collapse.

Section-4: Explosive demolition

This section covers the method of reducing high rise structures using explosives.

It covers specific controls required to ensure the safe implementation of this method and outlines the key hazards faced while reducing structures using this method.

These hazards include:

- Manual works;
- Pre-weakening;
- Premature collapse;
- Dealing with the remaining pile;
- Handling explosives.

Section-5: Pros and cons comparison table

This section gives a short visual comparison of the methods with the summarised hazards and controls.

SECTION-6: SUMMARY OF FINDINGS

I conclude that the safest overall method for demolishing this type of structure using a direct comparison is high reach rig using progressive fragmentation.

Of course, in real-world demolition, each structure should be considered on its own merits to decide which method is most suitable considering topography, the height of the structure, the proximity of neighbouring structures, and structural makeup.

Using the correct control measures, this method is by far the safest method as it reduces exposure to dust, vibration, and other health and safety issues while reducing the interfaces with demolition operatives.

SECTION-1: GENERAL HAZARDS AND INFORMATION

LARGE PANEL SYSTEMS AND DISPROPORTIONATE COLLAPSE

This is a significant risk in Large Panel System (L.P.S.) constructed high-rise structures. The Principal Contractor and Principal Designer should take all due care to identify this construction method early to implement proper controls to eliminate this.

The use of large precast concrete walls and floor units were employed in the construction of high-rise buildings during the 1960s and 1970s.

The system was particularly prevalent in high-rise blocks designed for domestic dwelling developments.

This type of construction used reinforcement in the connections and cross walls for framing support. The structures were built on a floor-by-floor basis and assembled using cranes.

Shear loadings were applied via the reinforced in-situ concrete stairs and lift cores.

Structural integrity depended upon the panels being joined and secured by bolted and concrete grout infill connections which, over the years, have been known to be inconsistent in terms of quality and must not be relied upon during deconstruction/demolition.

The process of the `floor-by-floor erection entailed lifting each unit by the inbuilt lifting eyes and bolts, and the propping of wall panels was necessary to stabilise them in position before bolting and infilling with concrete was completed.

The simple multi-box structure was brought under official and professional engineering scrutiny by the collapse of a high-rise block at Ronan Point, London, in 1968[1]. This catastrophe was pivotal in implementing the Mandatory Standard for disproportionate collapse.

Numerous serious accidents occurred during the erection of the structures, of which three hazards, in particular, have been identified. The prime cause of injuries was persons falling from edges where guard rails and toe board protection were non-existent.

The second largest cause was a failure of the propping systems either through insufficient props or the inadequacy of their fixings.

The third-largest cause was a failure of the various components of lifting equipment, including the lifting eyes, which were built into the panels. These issues should be considered at the demolition design stage and must be covered within the method statement and monitored throughout the works.

When carrying out works on L.P.S. structures in a built-up area, a reverse construction method, i.e. demolition using a tower crane to dismantle the structure panel by panel, is more often than not the likeliest method as this method eliminates the risk of potential overload and disproportionate collapse.

SHEAR FAILURE

Many buildings being demolished top down have suffered partial collapse during demolition; this usually results from the building carrying larger loads than originally designed.

The established procedure was to assess the capacity of the existing building by investigation and analysis and then either use plant that could work without overloading the structures without

---

[1] This is a significant risk in panel constructed high-rise structures. All due care should be taken by the Principal Contractor and Principal Designer to identify this construction method early so that correct controls can be implemented to eliminate this

propping or to provide props to distribute the loads. The assumption is that the building is generally in the condition it was constructed.

It has become common practice to load test buildings to establish that larger plant can be used than can be justified by back analysis. However, the nature of testing has generally been to establish mid-span bending moment other than shear capacity and check the shear capacity by calculation.

Shear failures may be a significant risk during top-down demolition of flat slab and hollow pot floors.

A bending failure may leave some residual capacity in a slab; however, a shear failure generally results in a major, uncontrolled collapse which may occur where implied loads during the demolition are inadequately controlled, resulting in overloading.

Note: Where structural failures occur in buildings undergoing alteration or demolition, part of the reason for this may be because of uncertainties with the structure's condition. Factors such as shear or ductile failure should be considered and assessed.

A shear failure, being a brittle failure, can be sudden and lead to catastrophic results. In contrast, ductile failure usually gives a warning; the structure can also accommodate more loading under severe deflection.

There have been concerns that some early examples of flat slabs had weaknesses associated with shear around columns, and potential problems may have been exacerbated by water leakage and general ageing.

A good example of shear failure is to be found in the 1997 Pipers Row Car Park Collapse.

Planning for the unexpected

Demolition requires contractors to be vigilant during all phases of the works to ensure the following is monitored with suitable hold points, among other things:

- Any additional Asbestos missed during the survey;
- Where the building is constructed differently or reacts differently or as expected;
- Ensure the sections of interest are marked on the method statement withhold points[2] and signatures required to progress the works:
- Ensure permit to works systems[3] are understood and complied with, e.g. hot works, et cetera;
- Ensure monitoring of the works with contingency plans in place which are clearly understood and implemented where necessary;
- Ensure that the contractor is aware of any potential areas of concern and these are acknowledged, planned for, and controlled within the RAMS and during their implementation on-site;
- Encourage good leadership & worker engagement[4].

Floor loading

Overloading the floors resulting in catastrophic failure is a significant cause of collapse in general demolition. Debris should be cleared from the working floor as soon as possible to reduce the likelihood of this occurring.

[2] Hold points are used where areas of significant interest in the method statement require sign off from a supervisor or other competent person before the works are allowed to progress.

[3] As per HSG 250 Guidance on Permit to Work Systems.

[4] As per C.D.M 2015 Reg-14

Suppose there are issues with the floor loading. In that case, it should be mentioned in the Pre-Construction Information and included in the Principal Designer's Designer Key Hazards for implementation into the Construction Phase Plan.

Propping should be carried out correctly to temporary works or structural engineer's designs. Debris should be cleared away as soon as possible to prevent build-up.

Point loading should also be considered where jack legs are involved, as is the case with some remote-controlled machines. All floor loadings should be assessed following a non-destructive floor load test.

The structure should be subject to continuous monitoring during the demolition process to ascertain that load transfer is occurring as designed, vibration from the work has no significant effect on floors below the working floor or neighbouring or adjacent properties, and that props are effective in their role.

Buckling

Where the effective length of a member is increased by the demolition process; for example, in forming openings for access, the capacity of the member can be reduced. Similarly, when asymmetric loading is applied due to changing load paths or partial demolition, members can experience higher bending and reduced axial capacity. There is also a possibility that when a demolition sequence involves removing stability structures, the remaining vertical elements may become framing elements when they have not been designed to work as such.

Fire

Fire is a constant and immediate risk in demolition, especially where hot works are being carried out. Therefore, it is imperative to make sure that the necessary precautions are in place. During demolition or structural alteration, it is vital that the fire plan is kept up to date as the escape routes and fire points may alter. It is vitally important that an effective means of raising the alarm in the event of a fire is available throughout the demolition process. All personnel should be continually updated regarding any amended fire plan.

Dowelled contraction/expansion joints causing lateral floor movement

With floors constructed by this method, one side of the dowels is de-bonded. While the sleeve extends beyond the joint during construction to prevent corrosion, if the joint is not sufficiently tight or if the sealing is inadequate, the dowel can corrode, resulting in a dry joint that may move during the demolition phase. In some cases where different floor slabs on the same level have not been tied together, the movement of compact machines during slewing or turning may cause the floor to shift due to unidentified construction error, which may result in openings appearing.

This may occur with floors constructed with dowelled contraction joints or with starter bars. The Principal Contractor and designer should identify this and ensure that the correct methods for deconstruction are used.

Another issue was the failure during construction to insert the de-bonded dowels during the concrete pour; with no joint shearing, forces cannot be transferred across the joint face.

Details of any previous uses of the building or the site

Specific information to identifying hazards within the structure, including stored energies and structural alterations, must be included in the Pre-Construction Information (PCI) and incorporated in the Principal Designer's Designer Key Hazards for implementation into the Construction Phase Plan as any and all previous demolition and refurbishment work carried out on the buildings may drastically alter load paths and as such this information should be clearly mentioned in the PCI so that the General Principles of Prevention can be met.

It is important to understand the details of the buildings previous use. The crucial details needed are:

- Identify any previous use of the building/site that may indicate any existing hazards, e.g. contamination, underground cellars or voids, and tunnels or underpasses.
- Identify any previous use of the site, which may give rise to a physical or health hazard, influence the demolition method or plant selection, e.g. contamination of land.
- Identify the extent to which the facility has been decommissioned and request a copy of any decommissioning plan, which should itself be checked against the current state of the facility
- Ordnance, where potential ordnance hazards have been identified, sufficient investigations should be undertaken so that tenderers can be suitably informed of the risks.

Construction errors

In the current environment, every structure is expected to be constructed as designed and drawn, as this is demonstrated by signed off inspection checks at every stage. However, very few structures are built precisely as drawn and capturing the changes remains a major challenge in assuring the quality of the recorded information.

It is usually not the main elements that are missing from the information, but rather the smaller details like connection points and additional supports, which is critical

Errors in Construction should always be kept in mind at all stages of the process. It is recommended that investigation into connection points, joints, etc., occur before demolition starts.

Structural survey

Structural survey and design works should be undertaken by a suitably qualified and experienced temporary works engineer and/or an experienced structural engineer.

Temporary propping and shoring

Any temporary propping and shoring should be carried out in line with the Code of Practice for Temporary Works and the Permissible Stress Design of False Work BS5975.

Where propping or shoring is needed, a structural engineer or a temporary works designer will be required to design a temporary propping and shoring system for the building floors and walls. It will be necessary to take account of the following:

- Plant and equipment load on floors, including the weight of any attachments. (actual weight should be ascertained)
- Debris loads on floors or against any wall, including the perimeter wall. Debris should not be allowed to accumulate to such an extent that it imposes loads on the structure above that it has been calculated to carry safely.
- The arrangement of the structure and its safe load capacity.
- Changing structural form, i.e. from original load path design to temporary support.

Dust Control

Provision should be made for an adequate supply of water and/or other appropriate measures to suppress dust arising from the works, particularly where local water pressure is low. Wherever possible, water consumption should be kept low.

Consideration should be given to the monitoring of dust emissions throughout the works.

Noise Control

A section 61 application should be applied for before commencing any work.

Control measures should be implemented to reduce noise pollution, affecting the public and neighbours. These may include appropriate methodology and time limits on the use of plant and equipment.

All site personnel affected by the works must provide the correct personal ear protection following noise assessments. Appropriate signage must be in place to alert personnel of the protection zone.

Consideration should be given to the monitoring of noise emissions throughout the works.

Vibration Control

Demolition Methodology should consider vibration caused by the works, and monitoring may be required.

Risk assessment and personal monitoring is required for any persons exposed to vibration, on or above that recommended with the Control of Vibration at Work Regulations 2005, which could cause Hand Arm Vibration Syndrome.

Asbestos works

Asbestos removal must be undertaken by a qualified specialist[5] and in accordance with Control of Asbestos Regulations 2012.

[5] Specialist training will be required to carry out all the required works and should be in accordance with Regulation 10, and paragraphs 124, 126, 127, and 130 of Control of Asbestos Regulations 2012 (CAR-12), HSE ACoP L143.

SECTION-2: DEMOLITION USING HIGH-REACH AND SUPER HIGH-REACH DEMOLITION RIGS

INTRODUCTION

Picture 1

For the purpose of this section, it should be noted that there is no distinction between high-reach and super-high-reach demolition rigs. This is because while there is a distinct difference in the movement of the rig and the skill of the operator, the fundamental principles remain the same for demolitions over the height of thirty meters (30m).

GUIDANCE NOTES

There is a plethora of information available on this method as the National Federation of Demolition Contractors and the European Demolition Association give guidance on using high-reach demolition rigs. Currently, both of these groups have produced documents that offer differences of opinion on the method used to reduce the structure.

The European Demolition Association[6] (E.D.A.) preferred method of high reach demolition is the strip-down method of demolition which involve reducing the structure back to the shear walls stripping down the floors from the top level to the ground level before moving forward.

The National Federation of Demolition Contractors[7] (NFDC) prefers to step down the building in stages giving maximum stability from the tied in floors and walls during the phases of the works.

After observations of both methods of work, I have concluded that the reduction of a structure by a strip down method offers easier access to the floors to clear the debris, lowering the risk of overloading the floors, maintaining higher structural stability at the initial stages, the final stages will in actuality have an increased issue of structural instability as the last rows will be left with limited lateral support.

The method of stepping down the structure while offering more rigidity also presents an issue of the debris overloading the floors and, if materials fall, giving rise to potential bounce, sending the material closer to the rig.

I posit that both methods be utilised during the demolition of towers acknowledging the requirements of the individual structures identified at the planning stage.

It should also be noted that the subjective preferences of the person operating the rig may influence the method used.

From a risk exposure viewpoint, considering the potential for human exposure to working at height, manual handling, noise, vibration, dust, and premature collapse, the method of reducing the tower remotely effectively eliminates the majority of these on any real scale with the only operative exposed to any issues during the demolition of the structural fabric being the operator of the demolition rig[8].

MACHINE OFFSET

Both sets of notes (E.D.A. and NFDC) offers guidance on the optimal relation between the height of the building and the distance the demolition rig is to be offset. The main difference is the E.D.A.

[6] EDA High Reach Guidelines by the EDA Technical Commission. First published August 2010

[7] High Reach Demolition Rigs DRG 101:2019

[8] This method also observes the standard set within Clause-14.1 of BS 6187: 2011; that whenever practically possible, a remote mechanical process should be used to minimise the risk to workers.

highlights an issue with the distance of structures over 40m but offers no solution. In contrast, the NFDC guidance provides a solution by reducing the distance. A visual aid of this is shown in Appendix 1.

It should be noted that the manufacturer instructions for these specialist demolition rigs vary slightly from the industry guidance. As such, it should be followed as it is specific to the item of plant and not a general note.

This exposure is reduced as far as is reasonably practicable as long as the height to distance ratio as supplied by the manufacturer or found in NFDC guidance note for high reach demolition rig: DRG 101 guidance notes are observed correctly, and sufficient, safe working spaces (often, incorrectly referred to as exclusion zones[9]) are maintained.

SAFE WORKING SPACES AND EXCLUSION ZONES

Sufficient, safe working spaces need to be developed[10] to allow a contractor to safely execute the site-specific demolition method to ensure the safety of the workforce and prevent others from being affected by the works[11].

When considering the approach for achieving the safe demolition, it is vital that this is done in a joined-up way to ensure that the risks are avoided, minimised and controlled and not simply transferred to other areas or factors. When a control measure is implemented, it creates additional hazards or transfers risk to other areas.

An example of where the inappropriate transfer of risk could be avoided would be to carry out the remote mechanical demolition within a city-centre setting by implementing a robust, safe working space with a protective scaffold ensuring that pedestrians using the footpath are properly accommodated and managed. The use of the scaffold as a control measure for structure demolition is covered below.

Safe working spaces, once established, may be altered as the work progresses but should be designed.

A drawing should be provided as part of the site-specific method statement to illustrate the required zones, highlight any restrictions to the zones, and any specific risk sections. An example of an exclusion zones diagram can be found in Appendix 2.

The safe working zone is in four parts and includes a buffer zone and the area of demolition; sections of this area can be referred to as an exclusion zone[12].

SCAFFOLD PROTECTION

The use of a scaffold tower as a form of protection for this type of work should be avoided as far as possible. Contrary to some assertions, scaffolding is designed to provide a safe working platform to create access to the work face and does not act as a control measure for mechanical demolition unless specifically designed to do so.

The continual use of this method in industry has resulted in the normalisation of bad practise.

It should be self-evident that this is seriously flawed thinking; there are many incidents historically to illustrate this point, such as:

---

[9] As set out in Clause-13 of BS 6187, and NFDC guidance note for exclusion zones: DRG 110. The safe working zone is in four parts and includes a buffer zone and the area of demolition. Sections of this area can be referred to as an exclusion zone.

[10] As per BS 6187; Clause-13 safe working spaces and exclusion zones, and NFDC guidance note for exclusion zones - DRG 110.

[11] As per HASWA-74 Section-3(1), BS 6187; Clause-11: Health and safety of people on or off site, Clause-12: Protection of people and the environment, and HSG 151 Protecting the Public.

[12] In some zones, only trained demolition personnel will be allowed into the exclusion zone, in others, such as drop zones no one is allowed entry. The exclusion zone prevents untrained operatives from entering.

Gerard Street, Reading on the 2nd of August 2019 (Appendix 3);

Abbey Street, Nuneaton on the 7th of August 2019 (Appendix 4);

Smithdown Lane, Liverpool on the 8th of August 2019 (Appendix 5).

Other examples of scaffold collapse, such as at Royal Free Hospital, Pond Street, London, on the 7th of March 2019 (Appendix 6), were the issue was caused by excessive wind loading[13] and not the demolition works.

If the scaffold fails and falls over, which isn't always the case, the frame can fall intact and take more space than a designed exclusion zone would.

There have been cases where scaffold has been used as a control measure for the high reach works, and damage has been caused to the scaffold tubes, which have been highlighted as evidence that the scaffold protection has been effective. I caution against this thinking as damage to scaffold could create hazards when it is to be struck[14] and, in some cases, may require the scaffold to be cut down, adding significant costs to the contract.

This is not to undermine the use of scaffolds while undertaking other methods of demolition such as piecemeal, which will be looked at in section-3; as previously stated in some circumstances, such as the reduction of towers in the City of London, the use of scaffold as protection is not only a viable option but may well be the only possible option.

Environmental considerations

The fuel consumption and CO2 output for the works are considerably less for this method of work on a floor-by-floor basis taking into consideration the delivery of the sections, building of the rig, clearing and processing the arising materials, and the removal of the plant from the site than traditional top-down method.

Additional considerations

Traffic movements

Depending on the size of the demolition rig and the parts it has been broken down into, the moving of the equipment may require a traffic movement order.

Maintenance

Additional issues arise in the safe use and maintenance of the demolition rig, which requires inspections[15] at suitable intervals by the operator and an annual certificate of thorough inspection[16].

Limitation of the plant

There is, of course, a limit to the height of the structure, which can be demolished using this method, as there is a limit to the reach[17] of the rig and the size of the attachment that can be used. The higher the rig reaches up, the smaller the attachment size.

For a demolition rig to reach the height of the structure will in itself pose a problem to which there are the following solutions:

---

[13] The exact cause and root cause of the incident is unclear at this time as there have been no findings or reports on the incident released or shared at this time.

[14] This does not mean the scaffold has been hit, this is the industry terms for reducing the scaffold.

[15] Regulation-6 of the Provision and Use of Work Equipment Regulations 1998.

[16] Regulation-9 of the Lifting Operations and Lifting Equipment Regulations 1998.

[17] The highest reach currently in the U.K is approximately 70-meters which gives an approximate 70% maximum working height.

- Use a different method of demolition to reduce the structure to a height that the demolition rig can reach;
- Build a platform[18] giving the demolition rig additional height to reach the top of the structure.

Of course, both of these options give rise to additional hazards that must be controlled.

It should be noted that the method of using the high reach demolition rig follows the principles in the demolition code of practice, BS 6187; clause 14.1: 'Whenever practically possible, a remote mechanical process should be used to minimise the risk to works'

Financial limitations

The unit cost of an ultra-high reach demolition rig is very high, with a long lead-in time that can extend into years for the complete design and production of the rig.

This will often force the demolition contractor to consider either using a different demolition method or hiring in the correct demolition rig if possible. As these resources are scarce, it can be expensive to hire these rigs, and the most common practice is to hire the ultra-high reach until the structure is low enough for the high reach, which in turn reduces the structure to a point low enough for a standard demolition rig to take over and complete the works.

Pulverising reinforced concrete

There is a known issue of small fragments of concrete and other materials being ejected out with the demolition exclusion zone during progressive fragmentation works; it is, however, very rare for large-sized pieces.

The reasons behind this ejection are still vague, but in my opinion, this is caused by some form of stored energy springing the rebar and acting as a catapult to throw a piece of concrete. This, however, is still my interpretation and requires further research. In recent times, it has become commonplace for contractors to use a screen (usually an old crusher belt) that is lifted into place as a debris shield[19].

Note that similar ejections could result from bending and pulling steel in the process of being cut by a shear.

Summary of key hazards

The key hazards for the high reach demolition include:

- Exclusion zone;
- Plant interfaces;
- Premature collapse.

---

[18] The platform is normally formed of a mixture of materials in a shape of a pile under the machine (particle size of no more than 150mm) as per the high reach demolition rig NFDC guidance DRG101.

[19] There is a guidance on the use of screens which was produced by the NFDC.

SECTION-3: PIECE-MEAL DEMOLITION

INTRODUCTION

The traditional technique of reducing tower blocks has always been piecemeal, which is a process of demolishing the building floor by floor to retrieve materials with minimal damage for reuse and recycling purposes. The reason why it has become a traditional technique may be due to the initial and historical limitations of technology within the demolition industry, the reliance on tried and tested methods, and the industry's resistance to trying new methods; this, of course, is entirely understandable considering the commercial and/or safety impacts if something should go wrong.

In principle, the use of mast climbing work platforms (MCWP), scaffolding, and vertically descending containment caps such as the cap created by Despe of Milan are variations of control measures, with the method of demolition more or less remaining the same.

As this section focuses on the reduction of towers using piecemeal, I will look at these different controls in turn and comment on the specific controls as well as the physical demolition.

GUIDANCE NOTES

The NFDC has produced the only available credible guidance on this particular demolition method[20].

PLANT SELECTION

Remotely controlled machines and robotic devices should be used where appropriate throughout this work method, particularly when hazardous or potentially dangerous situations arise.

These machines effectively allow the operator to position himself out of harm's way while safely tackling the hazardous task.

The use of this plan is described in Clause-17.4 and 17.5 of BS 6187: which states that when compact machines such as mini-demolition rigs and skid-steer loaders are used for demolition on the upper floors of buildings, an assessment of the strength of the floor should be made, taking into account the possibility that the machine and a quantity of debris could eventually be supported on part of the floor before being removed, e.g. to the floor below.

Account should be taken of the weakening effects on the structure by the progressive removal of elements and the extra loading caused by any temporary access ramps.

These machines should be fitted with appropriate capacity hydraulic attachments that can be used, for example, for breaking out and cutting, handling, processing and soft stripping, the weight to which will also have to be allowed for in any calculations.

Precautions should be taken to prevent machines from falling down holes in floors or falling from the edges of buildings, through operator awareness by detailed instruction and where required by the provision of adequate edge protection (e.g. wheel stop block), and/or a suitable restraint system.

REFUELLING PLANT ON THE FLOORS

Unless they are electric, the plant working on the floors will need to be refuelled.

The obvious way of carrying out this process is to lift a fuel bowser to the appropriate floors and refuel the plant.

Fuel bowsers should be included in calculations for the weights of floor loadings as a full bowser can add significant weight if not allowed for.

---

[20] Guidance for deconstruction of tower blocks floor by floor/piecemeal NFDC Guidance Note DRG 102.

Adequate drip trays should be on hand, as should spill kits and the appropriate fire extinguishers.

Environmental considerations

The fuel consumption and CO_2 output for the works are higher for this method of work on a floor-by-floor basis taking into consideration the delivery of the plant types (skid steers, mini diggers, Brokks, and cranes), delivery and installation of the crane, scaffold and other temporary works, clearing and processing the arising materials, and the removal of the plant from the site than the other methods.

Cranes

The use of cranes to assist in removing debris from the working floors and lifting materials up to the working floors is commonplace in this type of demolition.

With each lift and crane movement, there is, of course, an additional issue that comes along with this type of works.

This could also directly affect the program if the works are affected by severe weather and the crane is winded off.

Plant and people interfaces

There will, of course, be significant interfaces during this type of work where people and plant are in direct and continuous contact with each other.

This must be well managed as where there are interfaces. There is a risk of injuries occurring. Where there are increased interfaces, there are increased risks.

Temporary works

Where lift shafts are used for rubble removal, the structural engineer should consider the need to provide additional external support to the shear walls against bulging or fracturing.

A structural engineer's proposed floor loading calculations should consider the loading likely to be imposed by plant equipment and arising demolition debris. It is recommended that back propping is provided as appropriate.

It should also cover the additional load on the floors once a layer of back propping is removed when a floor is completed.

An example propping diagram is attached in Appendix 7

Behavioural safety

While the scaffold provides a control measure for working at height, the physical exposure to noise, vibration, inhalable and respirable dust, premature structural collapse, weather, musculoskeletal fatigue, and vehicle and plant interactions still remains high.

This impact on the human body is significant throughout the works and may run for many months while the structure is slowly reduced. Suppose the structure is much stronger than anticipated. In that case, the prolonged exposures impact greater on the workforce than the original estimate, and as such, the risk of near misses and injuries[21] is increased in line with the work program.

Looking at this method from a human behavioural view then the reliance on temporary works to provide the safe working platform (scaffold), the floor loading support (propping), and panel integrity give an additional issue of human error failures as each of the temporary works requires continual

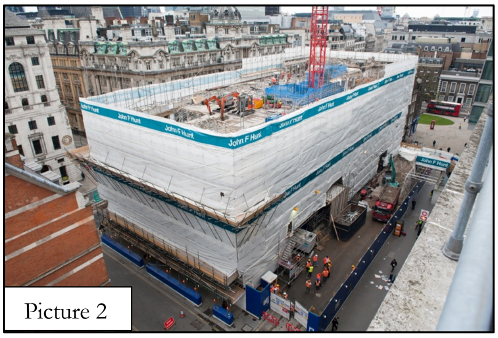
[21] As suggested by Heinrich's/Bird's triangle.

physical inspection by a competent person. This in the initial stages is okay, but the longer the contract takes, the more the opportunities for human error due to complacency begin to creep in.

This is best explained by the four stages of competence model developed by Noel Burch (see Appendix 8).

As each of the floors of the structure may react differently, the required checks to ensure the stability of the floors, structural ties and scaffold checks must remain at all times.

Edge protection using scaffolding



Picture 2

Using the traditional method of wrapping the structure in a demolition specification scaffold[22] to provide a safe working platform from which the operatives can work offers a nuisance factor reduction screen, helping to contain the effect of noise and dust. This method often entails using a tower crane (as in the photograph opposite) to allow the safe lifting of plant from one-floor level to the other and assist in removing some of the arising debris down to ground level.

It is well known that the introduction of a control measure introduces additional hazards and is not the end of the problem. If we think to the finish, we can establish that the introduction of the crane itself offers a risk of failure of the lifting equipment and accessories and other standard crane-related issues such as rescue plans for the operator and the erecting of the unit.

Scaffolding

While the working platform controls the risk of falling from height if the scaffold is correctly designed to the required standard[23], it should be noted that the scaffold ties and platform must be inspected every seven-days[24]; the tower crane and crane base require their own set of checks.

A scaffold tower will be a requirement to ensure safe access in many places. As a control measure for dust, noise and other arising concerns and in some places, such as major built-up cities such as the City of London, it may be the only realistic option.

It should be noted that the scaffold will have a significant cost to the project and is one of the driving factors in costs comparison analysis, which is not covered here, as explained in the introduction section of this report.

Scaffolding and protection are a critical part of the deconstruction of multi-storey buildings using the piecemeal method. As such, all scaffolds should be designed by qualified scaffold designers who will provide scaffold drawings and calculations. A well-designed and constructed scaffold (See appendix 6) may help eliminate other issues and provide a safe working platform.

A positive for using scaffold as protection is that it can be designed to incorporate a protection measure to the public and edge protection and a general nuisance screen. A design such as this may

---

[22] Service Class 4 - 3.00 kN/m2.

[23] It is a requirement of the Work at Height Regulations 2005 that unless a scaffold is assembled to a generally recognised standard configuration, eg NASC Technical Guidance TG20-21 for tube and fitting scaffolds or similar guidance from manufacturers of system scaffolds, the scaffold should be designed by bespoke calculation, by a competent person, to ensure it will have adequate strength, rigidity and stability while it is erected, used and dismantled. This will also require compliance with BS EN 12811-1:2003 Temporary works equipment. Scaffolds. Performance requirements and general design, and BS 5975:2019 code of practice for temporary works procedures and the permissible stress design of falseworks.

[24] And other instances such as after alterations, after inclement weather, et cetera as per the Work at Height Regulations 2005 (amended 2007).

include fully boarded lifts, cantilevered protection fans at various levels, safe pedestrian tunnels/walkways etc., where local authorities will not allow long term closure of footpaths or roads.

Scaffold construction and design should follow BS EN 12811-1:2003 Code of Practice for Temporary Works Equipment and comply with C.D.M. 2015 under the duties of a designer[25], where it is classified as a temporary works structure placing the designer under strict conditions.

This type of work would be expected to see a full design, including the required amount of pull ties and boxing around the columns where pull ties are not sufficient to ensure the system remained in place considering the type of works being undertaken.

While there are many examples of scaffolds failing during demolition works, these are statistically low; in general, they are usually where the scaffold is not used as just a working platform. Examples where the scaffold being used solely as a working platform (as noted in appendix 7) and was discovered to have failed due to wind loading,[26] are rare.

Edge protection using mast climbing work platforms (MCWP)


Picture 3

The substitution of the traditional scaffolding wrapping around the structure with that of a mast climbing work platform is, while controversial, very interesting as it is considerably faster to install than scaffold and, as such, maybe more desirable from a commercial viewpoint.

This method also eliminated the reliance on a tower crane to lift small plant items to the working levels by having one of the mast climber sections rated to take the additional weight of the skid steer, brocks and mini- diggers.

This meant that the plant items being used could be moved from level to level much more cost-effectively, reducing the potential for winding off issues.

However, since the section loaded for the plant has to be disconnected from the rest of the platform, this gives rise to potential issues as the edge protection is removed during these operations and relies on additional controls being implemented.

The lowering of the platform also gives rise to potential issues as the sections need to be disconnected and lowered independently, and as always, each of these movements increases the potential for issues arising.

The location of the mast climber supports is a concern and needs to be correctly planned, so it is clear of plant interfaces such as the internal drop zone within the structure where the arising debris is being cleared.

Additionally, this method is less efficient at containing dust and noise than the others in this category.

As the scaffold section above outlined, there is an inherent issue of temporary works checks with this method as the mast climber requires to be in the temporary works register and should have regular inspections, and as the works progress, this may become less and less thorough.

While the mast climber is only on one level, there is a lower level of wind loading on the working platform, which affects the scaffold, making it a safer option; from that respect, the mast climber is affected by high winds and can be winded off. This control can be manually overridden or missed and requires planning in long-range weather forecasts and vigilance for wind speed changes.

---

[25] C.D.M-15 Guidance Note: L 153, paragraph 72.

[26] the root cause is unknown to the author at this point as no investigation reports for findings has been resealed.

The mast climber can also be lowered and raised at will by the team and, as such, may be misused. The distance from the working platform to the structure's gable ends may vary with the construction and need to be taken up by an inner board which again needs to be regularly inspected and maintained due to wear and tear and other impacts imposed on it.

The human factored impacts remain the same as the method stated in the scaffold outlined above.

It should also be noted that once the mast climber is in motion during specific points in the demolition sequence, there is the potential to have the edge protection removed.

The actual demolition is still carried out mechanically on a floor-by-floor basis and, as such, has very much the same risks associated with the demolition works as the other piecemeal. However, there may be a degree of unnecessary risk transferer when considering this method. There are factors such as falling objects that will fall to the ground unhindered, which would not be the same if using a well-designed scaffold.

EDGE PROTECTION USING VERTICAL DESCENDING CAP

Picture 4

The use of a vertical descending cap as a safety innovation is remarkable, and the version, Top-Down Way™ developed by Despe[27], is capable of covering three floors, so nuisance factors such as dust are contained within the frame and do not escape.

This method offers a tight fixing around the gables as the unit has a hydraulically variable inner board. Top-Down Way™ is reliant on the structure supporting the cap and not on the structural ties as is the case with both the mast climber platform and the scaffold and as such eliminates some of the reliance on human checks, further reducing the risk factor; however, the floors are still supported by the use of propping which requires the temporary works checks to be carried out on each floor.

As seen in the photograph above, this method also uses a tower crane to lift the plant and equipment from level to level and remove some of the arising debris.

The actual demolition is still carried out mechanically on a floor-by-floor basis and, as such, has very much the same risks associated with the demolition works as the other methods as there are few differences in the actual method as with the scaffold and mast climbers. Still, due to the reduction of human factor checks on the scaffolding during the demolition, it appears to be a safer method from this perspective; however, this is offset against other introduced hazards while carrying out these works.

However, as above with the mast climber system, there may be a degree of unnecessary risk transferer when considering this method as there are factors such as falling materials - be it tools or dust - which will fall to the ground unhindered, which would not be the same if using a well-designed scaffold.

Plus, there is still a requirement to routinely check the integrity of the cap and the props, which are likely to be significant and, on all floors, due to the increased loading put on the structure by the cap and the point loading presented by the jacks which are used to control the descent of the platform.

Further, this method is limited in its application as it can only work on standalone structures in its current form. If the structure is attached to another, it will render this system impractical. Further, the cap is limited in height, with the works being suspended at the 5th floor to allow for the dismantling

[27] http://www.despe.com

of the cap. This then requires the remaining structure to be demolished using a high-reach demolition rig.

This method also relies on the structural integrity of the load-bearing walls to support the large jacks, which lower and raise the containment cap.

If the structure is unable to carry this safely, as may be the case when looking to apply this method to a panel build structure, then it would need to be financially assessed whether the use of temporary push-pull props and their installation made it viable or if another method is then more practical.

The key hazards for piecemeal demolition include:

- Manual works;
- Working at height;
- Exposure to weather;
- Premature collapse.

SECTION-4: EXPLOSIVE DEMOLITION


Picture 5

The reduction of towers using explosives is very much a show that draws large numbers of spectators and requires the neighbouring residents to be decanted.

While this may be enjoyable, it is, however, from a safety viewpoint, far from ideal and commercially very expensive.

There is very little information on this method from any of the governing bodies of trade federations.

STORAGE OF EXPLOSIVES

The storage of the explosives will need to be considered, where the explosives are being stored on the site. This will include security.

Where the explosives are not permitted to be stored in an on-site battery, there will still be a requirement to have security in place in the run-up to the blast date as the explosives will be in place with the final connections being made just before the detonation time.

PUBLIC LIAISON AND DECANTING

The actual demolition event is very controlled and safe as no persons are permitted into the safe working space during the explosives event.

PRE-WEAKENING

During the structure's engineering preparation (pre-weakening), the workforce is exposed to extremely high amounts of noise and vibration, dust, fumes, manual handling, and the danger of premature collapse. The most physically impacting part of this work is the engineered preparation, as this exposes the operatives to the risks continuously for the entire time frame of the works.

Considering the amount of physical work required to prepare a concrete structure successfully, this could create a legacy issue for those involved in the works, such as musculoskeletal disorders.

The method of the soft strip for this would also be slightly different as all timber and steel need to be removed entirely to a stricter degree than in other methods, as a deeper strip can be completed while undertaking the demolition work itself.

EXPLOSIVES

While placing the explosives, many factors require careful planning from a health and safety perspective; these include: handling explosives which should only be carried out by persons with specialist training or who can demonstrate they have sufficient skills, knowledge and experience[28], and security and storage of the explosives.

The planning and placement of the explosives should be carried out by an engineer with a structural engineering qualification and a sound understanding of both explosives and the demolition process.

The charge weights of the explosives must be proven to create the desired effect. This is proven by the undertaking of test blasting, which is carried out by the shot firer and should be witnessed by the explosives engineer and explosives supervisor (where they are different people).

[28] As per Regulation-15 of the Construction (Design and Management) Regulation 2015.

Exclusion zone

During the explosives event, the contractor must put into place a suitable exclusion zone[29]. With this in place, the exposure to the operative during the actual demolition (as long as the hazardous materials are removed from the structural shell) is insignificant, with the main issue arising from the dust cloud.

Dust

Once the structure has been felled, there can be a significant amount of dust that is a health concern. This dust cloud may contain respirable crystalline silica[30], which is classified as a human lung carcinogen, asbestos, and other potential contaminants.

The control of dust takes considerable planning and consideration, which include long-range weather reports and dust suppression to ensure the suppression is in the correct position at the time of the blast.

Vibration

The ground vibration impacts as the structure drops to the ground needs to be controlled as excessive ground vibration and blast overpressure could have an impact on surrounding structures and infrastructure.

Emergency planning

If the explosives event has failed to reduce the tower, the tower's stability needs to be assessed, and the time frames set out in BS 5607 Code of practice for safe use of explosives in the construction industry are strictly observed. The contingency committee responsible for planning the safe reduction of the structure should consider this carefully and select a demolition method while remaining as far away as possible to ensure no one is harmed if the structure fails later.

A crisis management plan should be in place and within the contractor's blast manual to ensure that the issues arising from a failure of an explosives event are considered as far as is reasonably practicable and planned form in advance.

Remaining structure

The actual demolition event is very controlled and safe as no persons are permitted into the safe working space during the explosives event.

Once the structure has been successfully felled, the final phase of the works begins in the processing of the debris piles.

Depending on the height of the structure, the debris pile may be of a significant height which may require the use of a high reach to process, which in turn reverts back to the method discussed in the first section of this report: demolition using high-reach demolition rigs and all the hazards pertaining to that particular method plus further hazards such as the debris pile collapsing.

As the structure collapses during the demolition process, voids may be present, which can affect the stability of the pile, resulting in collapses of varying degrees. Further, with the removal of the debris

---

[29] As set out in the Health & Safety Executive Construction Information Sheet; CIS 45 Exclusion zones for explosive demolition, Clause-13 BS 6187, and BS 5607 Code of practice for safe use of explosives in the construction industry, and NFDC guidance note for exclusion zones: DRG 110.

[30] Silica is present in large amounts in most rocks, sand and clay, and in products such as bricks, concrete and mortar. Some of the dust created by demolition activities is fine enough to be breathed deeply into the lungs; this is called respirable crystalline silica (RCS). Exposure to RCS over many years or in extremely high doses can lead to serious lung diseases, including fibrosis, silicosis, COPD and lung cancer. These diseases cause permanent disability and early death: it is estimated that over 500 construction workers die every year from exposure to silica dust.

pile, additional plant will be required during the processing, which increases the plant interface, which therefore increases the risks exponentially.

Environmental considerations

The fuel consumption and CO2 output for the works are higher than the demolition by high reach for this method of work on a floor-by-floor basis, taking into consideration the delivery of the plant types (skid steers, mini diggers, Brokks), delivery and installation of the scaffold and other temporary works, clearing and processing the arising materials, and the removal of the plant from the site than the other methods.

The key hazards for explosives demolition include:

- Manual works;
- Pre-weakening;
- Dealing with the remaining pile;
- Handling explosives.

SECTION-5: PROS AND CONS OF THE COMPARATIVE METHODS

Note: This structure is a fictitious high-rise building, so there is no visual representation of what we are comparing the methods against.

METHOD	DESCRIPTION	PROS	CONS
Progressive Fragmentation	• Remote mechanical demolition using high reach demolition rigs fitted with pulverisers for the majority of the building • Once the structure is reduced to a workable height, the high reach will be removed, and the demolition works will be completed using a standard demolition rig.	• It follows the principles of removing persons from the risks. • Generally faster than the other methods.	• Expensive item of plant. • Not always possible to site the demolition rig in city centres
Top-down piecemeal demolition with a fully scaffolded structure (the most common type)	• Demolition carried out using mini/small-sized demolition rigs (mini diggers: 5t/small rigs: 13t) and pedestrian operated demolition rigs (Brokk) fitted with percussive and non-percussive attachments. • A mobile/static crane may be required for plant access and support. Once the structure is reduced to a workable height, the demolition works will be completed using a standard demolition rig.	• A proven method for city-centre sites and sites with a tight footprint. • Smaller machines reduce the loading on the structure. • Works are screened behind sheeted scaffold reducing the public nuisance factor.	• Generally slower to demolish than the other methods. • Increased exposure for the scaffolding and demolition operatives to work at height, manual handling, weather and elements, dust, noise and vibration.
Explosive Demolition	• Once the structure is reduced, a high reach will be required to deal with the debris pile.	• Potential for good publicity. • The structural demolition is carried out in a single event.	• Not all cities allow explosive event demolition. • Significant occupational health impacts on the demolition operatives. • Failure to fell the structure or issues arising from the demolition can cause significant problems. • Issues arising dealing with the debris pile.

SECTION-6: SUMMARY OF FINDINGS

Picture 6

It has long been known that the significant risk of an accident occurring is increased by the introduction of the man into the workplace, and based on my research, I concur, and due to this, it is of my opinion that the safest method of reducing tower blocks is remote demolition using high-reach demolition rig, this is because risk exposure is massively reduced when compared to the other methods of demolition.

Suppose the contractor fully observes the industry-specific guidance on using high-reach demolition rigs and the correct exclusion zone is planned and implemented. In that case, the demolition operator will be out of the danger zone at all times.

The main risk involved in this method is the interface between the machinery and the operatives, and as such, monitoring the exclusion zone is critical.

As stated in the specific section above, from a risk viewpoint, considering the potential for human exposure to working at height, manual handling, noise, vibration, dust, and premature collapse, the method of reducing the tower remotely effectively eliminates the majority of these on any real scale.

The second safest option would be the reduction of the tower using explosives. The human exposure to working at height, manual handling, dust, vibration, noise, et cetera is extremely high and may be in line, in part with the piecemeal method, as piecemeal relies on small plant over human resources; however, during the actual demolition works the exposure is low as long as the exclusion zone is maintained.

By its very nature, this is a high-profile method, the success of which can - and will - be immediately judged by those not involved in the project. Public confidence in the technique (and therefore confidence that public money can rightly be spent on it) may be low. That issue can be successfully managed by (externally) citing lessons learned from failed explosive event demolitions and (internally) stringent project management that negates the possibility of future limited successes.

Third, the reduction of the tower by piecemeal as throughout the entire reduction, the operatives have continual exposure to all the listed health hazards even where the possible risks are managed and controlled, hazard exposure is still omnipresent of the three piecemeal systems covered in the report. I should offer the caveat that, as I have noted within the document, this is likely to be the only real option for a safe and successful demolition in built-up areas. This is not to put any inference in any way that this method is not safe; it is simply the least favoured option if there is sufficient room on all sides to facilitate all possibilities, which is seldom the case in city centre demolition.

Mast-Climber-Work-Platform; while this method offers a perimeter working at height controls, there are still too many factors to consider. I feel that the mast climber technology is not sufficiently developed to be a viable option on many structures, especially where the area is built up. This would require considerable research and design to become a viable alternative to scaffold towers.

Top-Down-Way™; offers better risk controls than the mast climber system; however, it is my findings that there are limitations to the use of this system, such as building type and proximity of neighbouring structures.

SECTION-7: CONCLUSIONS

I reiterate the limitations outlined in the initial Purpose of the Report that each of these methods has its distinct strengths, just as each of the structures has its attributes, and while this report seeks to find the safest demolition technique for the demolition of tower blocks, it cannot delve into the minutia of details.

Every project needs to be assessed individually and the safest method adopted for the live project.

Taking into consideration all of the information contained within this document, as outlined in sections one through four, my conclusion is that the safest overall method for the demolition of this type of structure using a direct comparison is high reach rig using progressive fragmentation.

This is because the demolition team faces fewer bn hazards, and fewer team members are exposed to the hazards; ergo, the likelihood of an issue arising is considerably reduced.

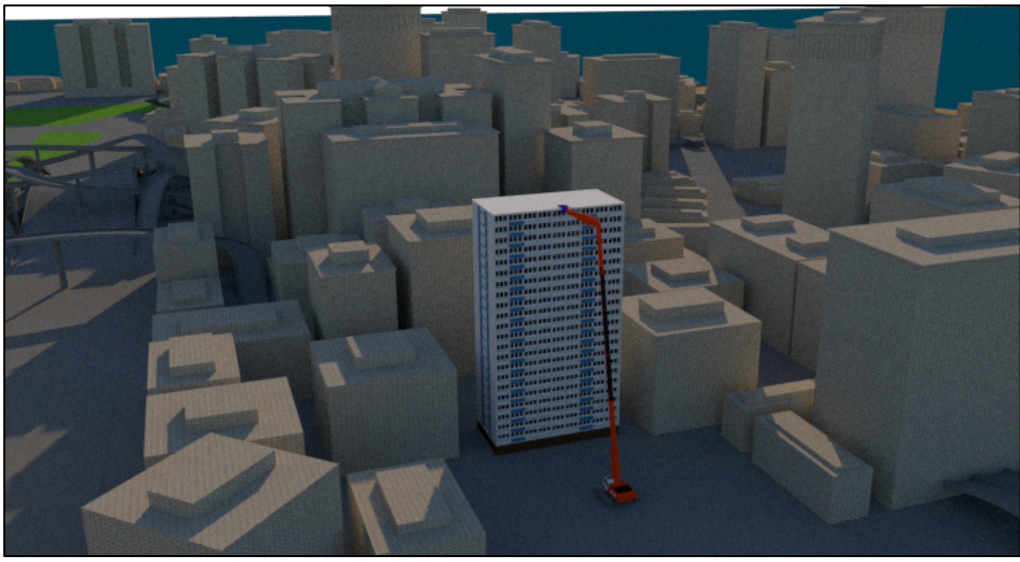
In city centre demolition top-down piecemeal method is likely to be the only implementable method as it is difficult to put into place controls such as footpath or road closures to use a high reach due to stakeholder pressures and reluctance from local authorities. These parties often either directly[31] or indirectly influence the selection of the demolition method, which can often, as outlined in this study, have a significant impact on the works in the way of inappropriate risk transfer, planning, and outcome.

[31] There is of course an argument that anyone who specifies the use of a particular method of work would therefore classify as a designer under the CDM Regulations; this could include instance where commercial clients become actively involved in designing the safe systems of work in relation to their project.

Appendix 1: Machine off set calculation example

The information here is guidance only, and each demolition rig operator, company, rig manufacturer, and trade federation may supply information that differs from the information here.

None of the potentially conflicting information is either correct or incorrect as there are no confirmed and agreed with standards for this.



QUICK REFERENCE TABLE

UP	OUT
20m	10m
25m	12.5m
30m	15m
35m	17.5m
40m	20m
45m	21.25m
50m	22.25m
55m	23.75m
60m	25m
65m	26.25m
70m	275m
75m	28.75m
80m	30m
85m	31.25m
90m	32.5m
95m	33.75m
100m	35m

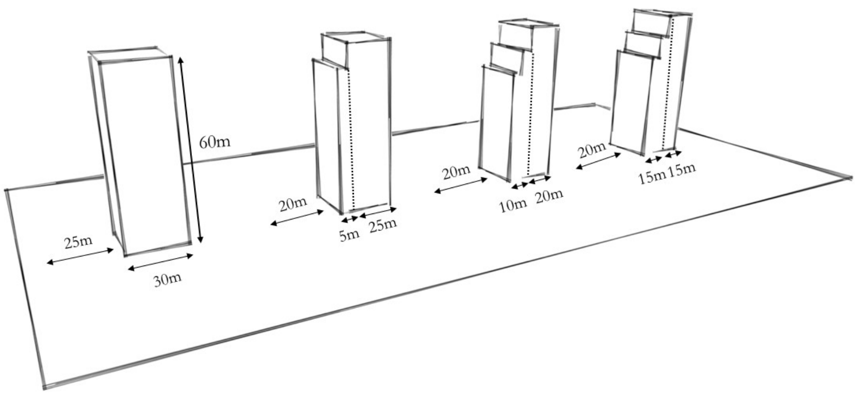
Stepdown method

This method is stepping the levels down to expose the working floor and the upper floors to give the operator good visual lines across each floor so it can be reduced and safely cleared.

This offset distance should be set on the closest face of the works at all times as any falling debris will be at this nearest face, and therefore the safety factor must remain in place.

As the works advance, the demolition rig should remain at the same set off distance as the working face does not alter.

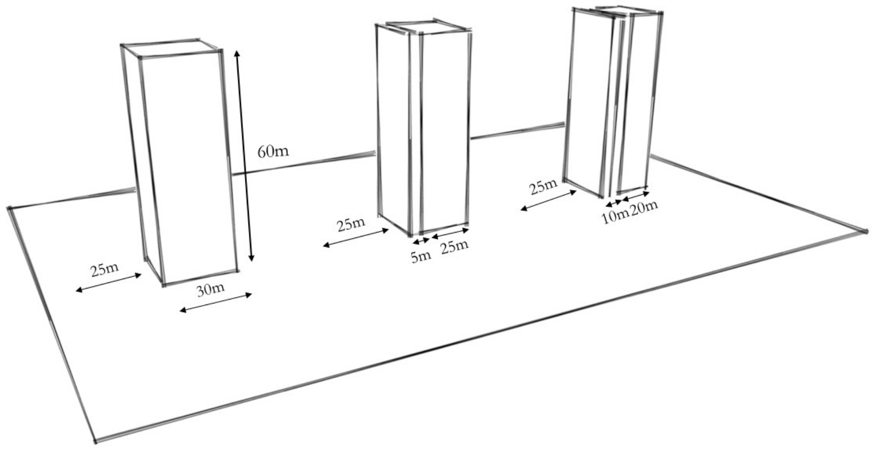
60 metres = 40 at 2:1 = 20m
= 20 at 1:0.25 = 5m
25m



Strip down method

Calculating the offset distance using this method is simple as the working face remains the same until the stripped-down section is completed, after which the demolition rig can edge forward if needed.

60 metres = 40 at 2:1 = 20m
= 20 at 1:0.25 = 5m
25m



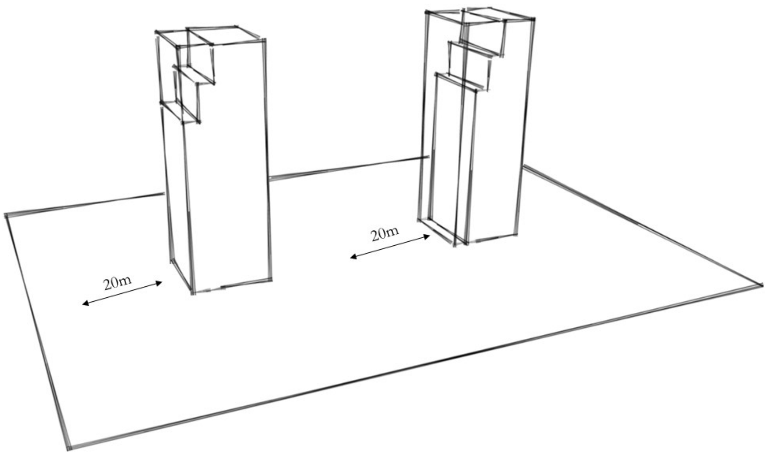
Strip and step method

The step and strip method is a combination method that again applies the setback distance to the closest working face.

As the stripped-down section is completed, the demolition rig may track forward to a closer point to continue the method as per the standard strip method.

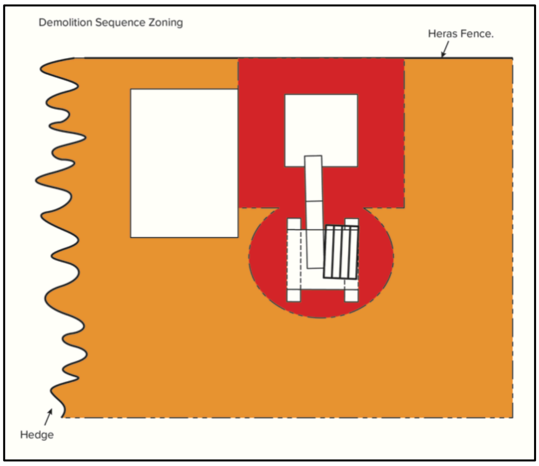
It should be noted that using this method, the height of the tower is reduced as the strip down advances and as such, repositioning of the rig may not be required or may be less frequent than the other methods.

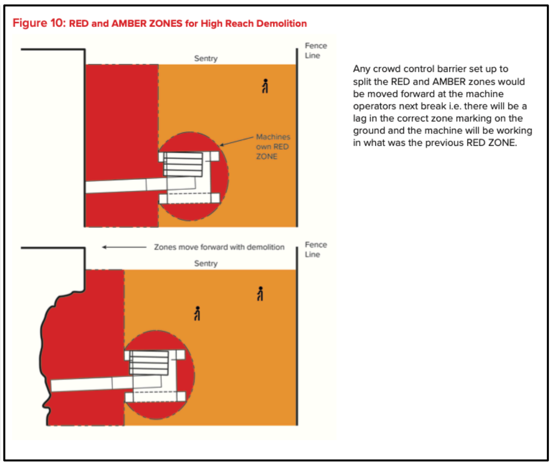
60 metres = 40 at 2:1 = 20m
= 20 at 1:0.25 = 5m
25m



APPENDIX 2: EXCLUSION ZONE DIAGRAM EXAMPLE.

The following examples are extracts from the current NFDC guidance note:

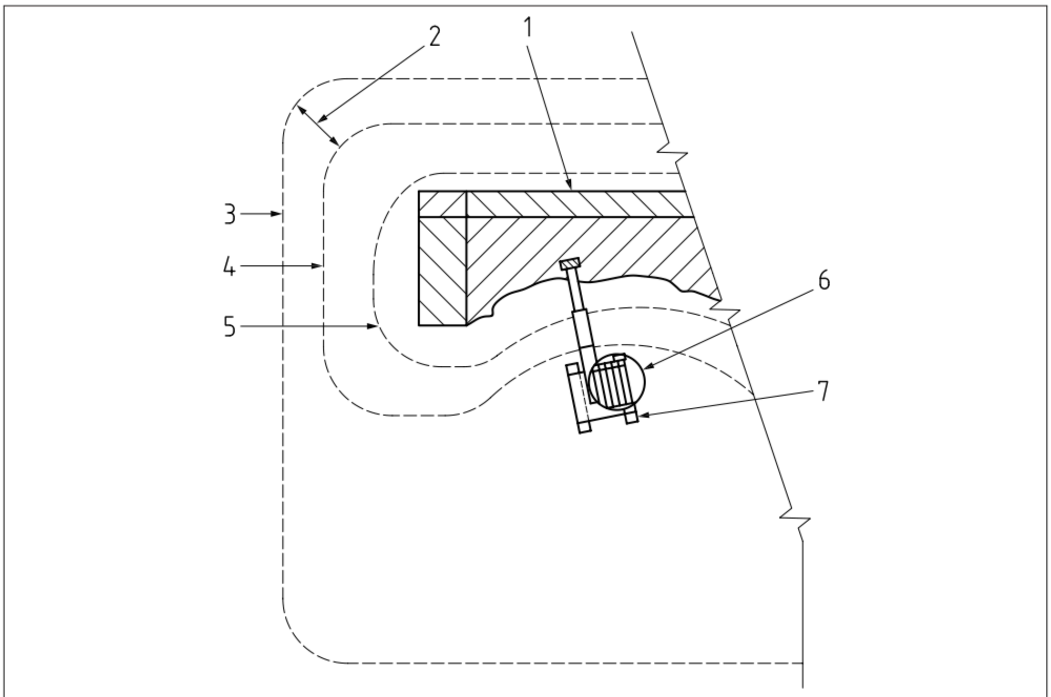




The following example is an extract from the BS 6187:

BRITISH STANDARD **BS 6187:2011**

Figure 16 **Example of safe working space within an exclusion zone (typical for mechanical reduction or top-down demolition employing mechanical plant, etc.)**



Key

1 Structure being demolished
2 Buffer area
3 Exclusion zone boundary
4 Limit of predicted debris area
5 Limit of designed drop area
6 Safe working space for operator in protected cab
7 Demolition machine

NOTE 1 The safe working space is in a protected area within the buffer area and is therefore beyond the limit of predicted debris.

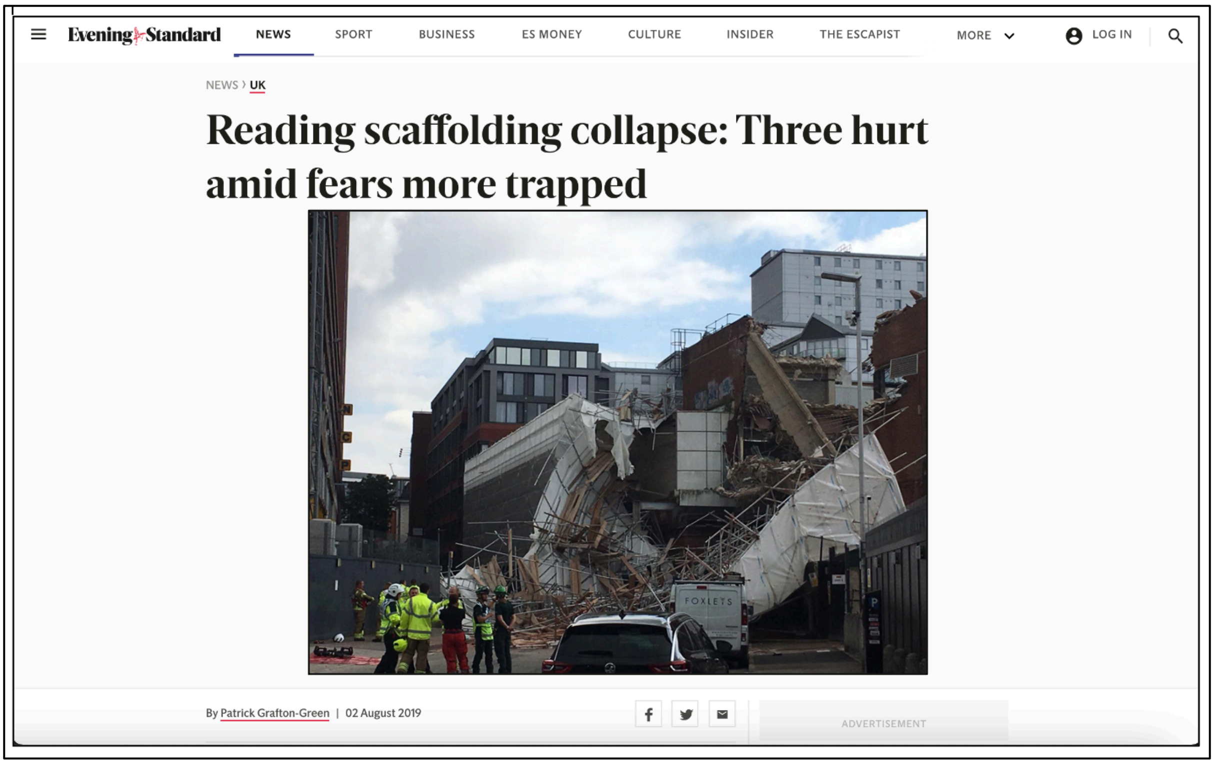
NOTE 2 See also Figures 17, 18 and 19, which demonstrate aspects of machine work.

Appendix 3: Gerard Street, Reading

In the cases shown in the following appendixes, safe working spaces were developed to allow a contractor to execute the site-specific demolition method safely; however, in these and many other similar cases, the extent of the area had been compromised as it was taken up by and the scaffold which meant that the zones would not be able to do its job and act as a control measure if there was any type of collapse. In some circumstances, the scaffold platforms have remained complete and fallen over as a frame

The screenshot is taken from the Evening Standard news website.

https://www.standard.co.uk/news/uk/two-hurt-and-fears-more-are-trapped-after-scaffolding-collapse-in-reading-a4203356.html


Evening Standard NEWS SPORT BUSINESS ES MONEY CULTURE INSIDER THE ESCAPIST MORE LOG IN

NEWS › UK

Reading scaffolding collapse: Three hurt amid fears more trapped

By Patrick Grafton-Green | 02 August 2019

ADVERTISEMENT

APPENDIX 4: ABBEY STREET, NUNEATON

The screenshot is taken from the ITV news website.

https://www.itv.com/news/central/2019-08-07/emergency-services-called-in-after-building-collapses-warwickshire-abbey-street-nuneaton-co-op-police/

ITV REPORT 7 August 2019 at 2:33pm

Emergency services called in after building collapses

Credit: BPM Media

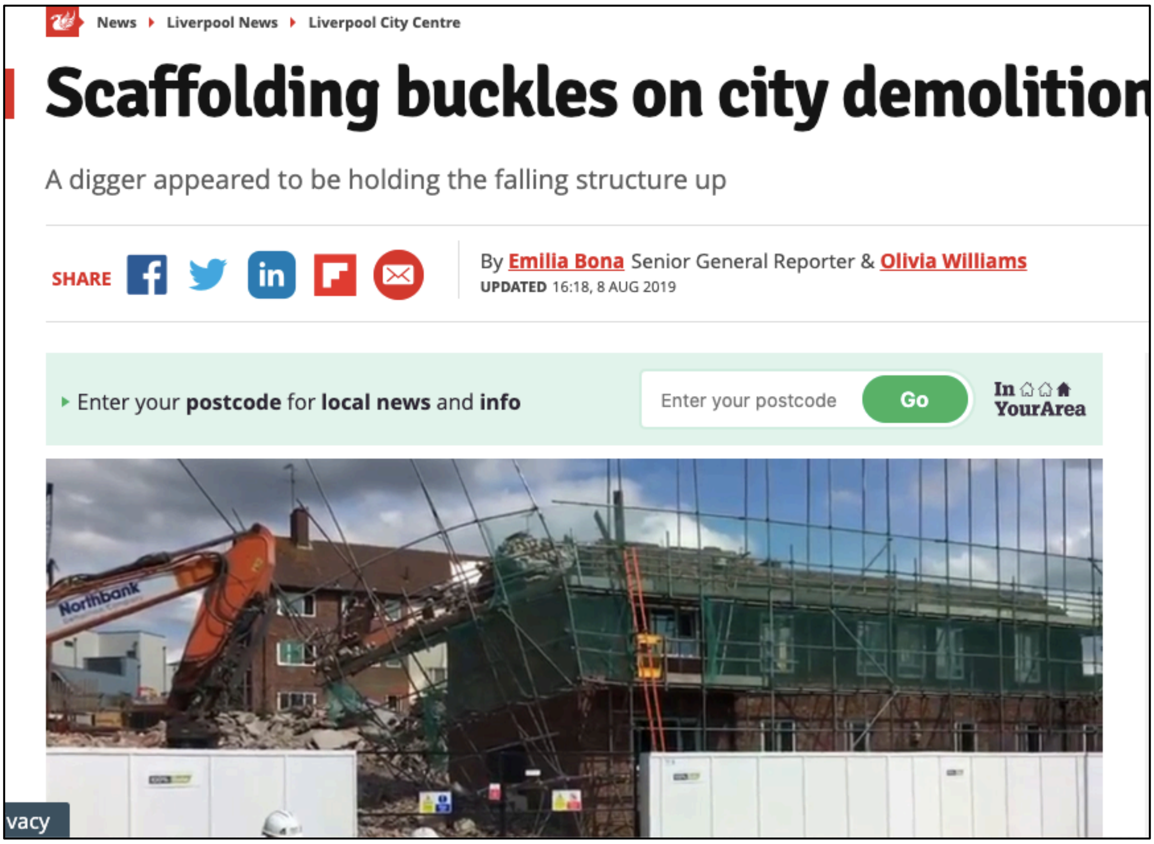
Emergency services have been called in after a building partially collapsed in a shopping street.

Warwickshire Police were called to Abbey Street in Nuneaton to reports of a building collapse at about 10.52am on Wednesday 7 August.

Appendix 5: Smithdown Lane, Liverpool

The screenshot is taken from the Liverpool Echo website.

https://www.liverpoolecho.co.uk/news/liverpool-news/live-updates-scaffolding-buckles-city-16722415



News ▸ Liverpool News ▸ Liverpool City Centre

Scaffolding buckles on city demolition

A digger appeared to be holding the falling structure up

SHARE

By **Emilia Bona** Senior General Reporter & **Olivia Williams**
UPDATED 16:18, 8 AUG 2019

▸ Enter your **postcode** for **local news** and **info**

Enter your postcode Go

In YourArea

Appendix 6: Scaffold Design

A well planned and designed scaffold can offer more than just a working platform.

Courtesy of Erith

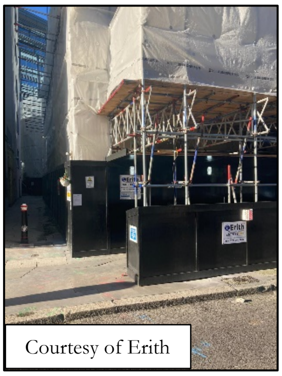
In major built-up areas and city centres, the scaffold can offer a form of protection such as heavy-duty beamed pedestrian impact tunnels erected at pavement level, as can be seen in the picture to the left.

This can also be used to house welfare facilities, essentially removing them from the ground level, eliminating a potential problem created by a tight working space, and reducing the overall laydown area requirement.

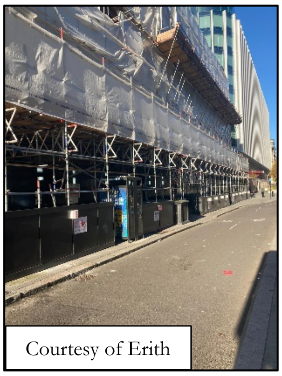
Further, the scaffold tower should be designed to the [illegible][32] and have cantilevered/spurred double-boarded protection fans erected at various levels giving added public protection from falling objects. This can be seen in the photographs below.

This offers a better control measure against falling debris and dust. Nets should not be used on a demolition contract as any falling debris will not be stopped.

Courtesy of Erith

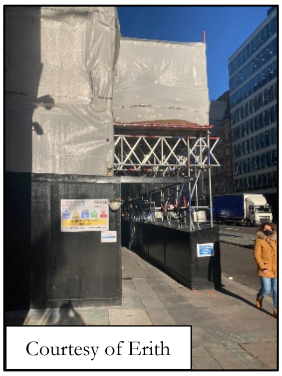


Courtesy of Erith



Courtesy of Erith

Courtesy of Erith



Courtesy of Erith

Scaffold for demolition works should be fully wrapped where possible to give additional protection from falling debris.

Where Monarflex containment sheeting is used, it should be overlapped to create a seal to stop debris. The upper sheet should overlap inside to push debris back into the scaffold.

[32] National Access and Scaffold Confederation (NASC) SG34 Guidance on Protection of the Public.

APPENDIX 7: ROYAL FREE HOSPITAL, POND STREET, LONDON

The screenshot is taken from the B.B.C. news website.

https://www.bbc.co.uk/news/uk-england-london-47487290

Scaffolding collapses near Royal Free Hospital in Hampstead

7 March 2019 Share

The scaffolding collapsed on to the road shortly before 14:50 GMT

A wall of scaffolding has collapsed on to a street in north west London.

The mass of metal and timber, which was attached to a block of flats opposite the Royal Free Hospital, fell during high winds.

Appendix 8: Propping diagram example

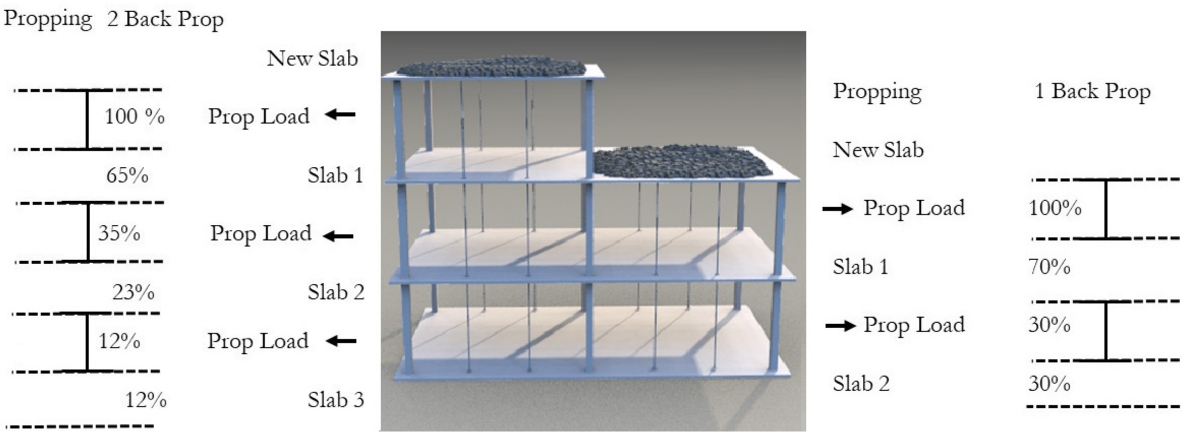
There is uncertainty regarding the structural integrity of the floor and walls immediately below the operational level. It is recommended that at least two or more floor levels be propped.

During the breaking out of the upper floor level, edge protection for the prevention of falls will need to be considered. The work should be planned in such a manner that no free walls are left standing.

Where this is not practical or possible, additional propping should be provided to ensure stability for prolonged periods or overnight.

The diagram below shows that the imposed load on the third prop is only 12% of the overall load. When the floor is removed, and loads such as debris and small plant are on the floors, the load through the bottom prop will then increase to 30%.

Therefore, it is important to ensure that an additional level of props is in place on demolition sites at all times to account for the reduced props and increased load.



Appendix 9: Four stages of competence model

Glossary of demolition terms and definitions (as per BS:6187)

For this report, the following terms and definitions are given:

Adjoining owners: freeholders, owners, lessees, tenants and/or occupiers of a property adjoining the site of work

NOTE: *The term "adjoining owners" has a specific meaning under the Party Wall etc. Act 1996 [1].*

Attachment: assembly of components forming the working tool that can be mounted onto the base machine or (optional) equipment for specific use

Base machine: machine without equipment and attachment that includes the mountings necessary to secure equipment, as required

Building owner: person or organisation having the right to refurbish, demolish or partly demolish a building, including plant or other structure, by virtue of legal ownership or other legal authority

NOTE: *The term "building owner" has a specific meaning under the Party Wall etc. Act 1996 [1].*

Client: initiator of the works for demolition or partial demolition for structural refurbishment

NOTE 1: *The client is usually the structure owner, but could also be, for example, a main contractor.*

NOTE 2: *The term "client" can have a particular meaning in contractual relationships and has a specific meaning under the Construction (Design and Management) Regulations 2015*

Cold cutting: method of cutting that generates no incendiary sparks and little or no heat

Competent person: person with sufficient knowledge of the specific tasks to be undertaken and the risks which the work will entail, and with sufficient training, experience and ability to enable them to carry out their duties in relation to the project, to recognise their limitations, and to take appropriate action to prevent harm to those carrying out or affected by the work

Complex structure: structure with unusual or complicated load paths and/or internal forces, which might not be obvious, that requires the planning of safe modes of failure during demolition activities following appropriate structural assessments and analysis

Contaminated site: site which harbours residual health hazards resulting from the presence of physical, biological, ionising or chemical entities

Decommissioning: process whereby an area is brought from its fully operational status to one where all live or charged systems are rendered dead or inert and reduced to the lowest possible hazard level

NOTE: *Decommissioning includes decontamination, where appropriate. Some industries, e.g. the nuclear industry, have specific meanings for this term which include dismantling. In practice different hazard levels will apply. For the purposes of this British Standard, decommissioning does not include demolition or dismantling.*

Deliberate collapse: controlled removal or weakening of key structural members causing collapse in a planned way of the whole or part of the building or structure being demolished or partially demolished

Deliberate removal: controlled removal of selected members of the structure by dismantling or deconstruction

Equipment: set of components mounted onto the base machine to fulfil the primary design function when an attachment is fitted

Exclusion zone: designated three-dimensional space from which all persons, including the public, are excluded during demolition activities

NOTE 1: *One exemption is where an operator in a protected position is authorised to be within the zone to effect a particular demolition activity, such as initiating explosives.*

NOTE 2: *In certain circumstances, key personnel may remain within the zone for a specific task provided they are adequately protected.*

Facade retention: method of maintaining the stability of the outer wall of a building or structure in its original position during and following nearby demolition activities using auxiliary or temporary structures

Fan: temporary platform at height used solely to contain any debris or other materials unintentionally dropped in the demolition process and prevent this from being a danger to persons or property below

NOTE 1: *A fan is usually formed in scaffolding projecting from a building or structure at an inclined angle.*

NOTE 2: *Fans are not intended to be used for access, storage of materials, accumulation of demolition debris or as working platforms.*

Gantry: designed temporary structure providing a covered way that protects people from unplanned falls of materials and/or a structure that protrudes from the building facade to facilitate the removal of debris and materials

Hand-held equipment: powered portable equipment or manual tools held in and operated by hand

High-pressure water jetting: cutting, removal or cleaning of material using high-pressure water

Hot cutting: method of cutting where heat is applied (e.g. by flame) or is generated

NOTE: *With this method there is potential for producing incendiary sparks.*

Materials recycling: action of reprocessing materials which have previously been processed for inclusion in a product

NOTE: *For example, concrete and bricks recovered through a reprocessing activity can be crushed, screened and sold as an aggregate.*

Mobile demolition machine: self-propelled machine made, or adapted for use, for demolition activities, which comprises a base machine, equipment, optional equipment, and attachments, as appropriate.

Mothballing: process of decommissioning and then preserving buildings, plant or structures in such a way that they can be readily brought back into service if required

Optional equipment: optional items of equipment mounted onto the base machine to increase, for example, capacity, flexibility, comfort and/or safety

Permit to work procedure: procedure which sets out the agreed work to be undertaken on identified equipment, or in an identified area, and the precautions to be taken and to be managed as part of a safe system of work

NOTE: This is an additional level of management control provided specifically to ensure that risks arising during high-hazard activities are appropriately controlled.

Prestressing: process whereby compressive stresses are built into the parent material by, for example, tensioning wires or bars to give added strength prior to working loads being imposed

Post-tensioned prestressed element: structural element in which the wires or bars are, for example, tensioned after the material to be compressed (e.g. concrete) is in place and has reached a suitable strength

Pretensioned prestressed element: structural element in which the wires or bars are tensioned prior to the placing of the material to be compressed (e.g. before concrete is poured) and then released after the material has reached a suitable strength

Pre-treatment: process of changing the physical, chemical or biological properties of material to facilitate its handling, recovery and disposal

NOTE: Pre-treatment can include sorting and segregation, provided this involves an element of recycling. All wastes are required to be pre-treated prior to disposal.

Pre-weakening: deliberate weakening of part of a structure as part of an efficient controlled design collapse mechanism to be effected a short time afterwards, while ensuring sufficient residual stability until deliberate collapse is initiated

Product reuse: repeated use of products taken from buildings or infrastructure, in their original form, for the same or a similar application

Progressive demolition: controlled removal of parts of a structure whilst maintaining the stability of the remainder as demolition activities progress through the facility

Recovery: operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy

(Waste Framework Directive [3])

Shoring (including propping): system of auxiliary supports which provide a load path to maintain stability during temporary states of the structure

Site waste management plan (SWMP): systematic identification of expected and actual waste arisings together with an appraisal and implementation of management options in line with environmental legislation and the principles of the waste hierarchy

NOTE 1: *There are financial threshold values above which the Site Waste Management Plans Regulations 2008 [4] require an SWMP to be prepared.*

NOTE 2: *There are statutory variations in some parts of the U.K. There is guidance particular to different areas.*

Structural refurbishment: alteration to an existing retained building or structure that involves removal or modification of structural elements or members, which might or might not cause instability

NOTE: *This includes removal or addition of structural elements, dismantling and partial demolition of the existing structure.*

Weakening: deliberate removal of parts of a structure that can reduce its ability to resist loadings, including imposed loadings and its own self weight

NOTE: *Weakening may be undertaken to create openings (e.g. in walls and floors) for removal of materials, for example, but excludes deliberate structural pre-weakening.*

Waste: substance or object which the holder discards or intends to discard or is required to discard

(Waste Framework Directive [3])

NOTE: *Any material no longer required by the original owner and, in the case of demolition, any material that leaves the site boundary, is legally classified as" controlled waste" and is subject to the provisions of the Environmental Protection Act 1990 [5]. Under case law [*R *(Save Britain's Heritage) v. SSCLG 2010], any material no longer required by the original owner is classified as waste, regardless of whether it is sent for recycling or recovery, whether it has a commercial value and an end market, and whether or not it poses an environmental threat. This is important because demolition materials left on site for a period of time might need a permit to remain on site until a market is found. As a general rule, further use needs to be a certainty, not a possibility.*

TABLE OF PICTURES