Recycling Demolition Arisings at Barts and The London Hospital

By working together, more than 97% of the demolition arisings were recycled both on site and locally contributing to this PFI project’s sustainability target.
Front cover photograph: Ongoing demolition works by Keltbray at Barts Hospital in central London using the top down methodology to progressively deconstruct and recycle the Victorian buildings.

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Executive summary

The Barts and The London NHS Trust commissioned Skanska Innisfree to manage and redevelop the St Bartholomew’s Hospital and The Royal London Hospital. Keltbray was appointed as the demolition and recycling contractor for the works. This is the largest PFI healthcare scheme in the UK estimated at a value of £1 billion. The programme involves the design, demolition, construction and refurbishment of two sites to make way for a new hospital complex covering an area of 270,000m2 in central London.

The demolition of the Victorian buildings was carried out by soft stripping, using the traditional removal of all hazardous materials and non-recyclables first, followed salvage of materials, and structural demolition using the top-down methodology of the building from the top in a floor by floor sequence using small machines with demolition attachments such as breakers and hammers.

Soft stripping allowed the materials to be segregated and sold for recycling and played a key role in achieving high recycling rates and maintaining quality source segregation. Furthermore, soft stripping exposed the structural inert materials and facilitated the recycling of concrete, steel reinforcement and brick. Crushing and sorting were primarily carried out off site at a Materials Recovery Facility (MRF).

An actual recycling rate of 97.1% for the works surpassed both the Client's original 60% target and the extended 85% demolition recycling target.

The attainment of this high recycling rate was driven by the Client’s Environmental Policy, good working relationships, partnership and trust, early contractor involvement to develop common goals between project partners, contractual agreements, agreed sustainability objectives and technical experience.
# Contents

1.0 Introduction ............................................................................................................................. 1
2.0 KEY FACTS: Skanska’s Barts and The London ........................................................................ 1
3.0 Project Details ......................................................................................................................... 1
4.0 Contractual arrangements ....................................................................................................... 2
5.0 Project Planning ....................................................................................................................... 2
  5.1 Early Contractor Involvement ...............................................................................................2
  5.2 Achievable Recycling Targets ............................................................................................2
  5.3 Site Waste Management Plans ............................................................................................3
6.0 Demolition works .................................................................................................................... 3
7.0 Reuse and Recycling Activities .............................................................................................. 3
  7.1 Salvage ..................................................................................................................................4
  7.2 Soft stripping .......................................................................................................................4
  7.3 Demolition and Recycling of Inert Materials .......................................................................5
  7.4 Materials Recovery ..............................................................................................................5
8.0 Recycling Rates ...................................................................................................................... 5
9.0 Quality of Recycled Materials ................................................................................................. 7
10.0 Drivers and Barriers to Recycling ......................................................................................... 7
11.0 Environmental and Social Considerations .......................................................................... 8
  11.1 Transportation ..................................................................................................................9
  11.2 Climate Change Considerations ......................................................................................9
  11.3 Socio-Economic Considerations ......................................................................................9
  11.4 Health and Safety ............................................................................................................9
12.0 Project successes and future improvements ......................................................................... 9
13.0 Further Information .............................................................................................................. 10
1.0 Introduction

Skanska Innisfree (Skanska) were employed by The Barts and The London NHS Trust to manage and redevelop the St Bartholomew’s Hospital (Barts) in the City of London, and The Royal London Hospital (The London) in Whitechapel. This is the largest PFI healthcare scheme ever to be signed in the UK with an estimated value of £1 billion to include the design, demolition, construction and some refurbishment of the two sites covering a total area of 270,000m².

The demolition works are being phased over two periods. The timing of this case study was carried out towards the end of Phase 1 of the demolition works. The demolition at the time of the site visit was largely finished with only the basement slab at Barts to be completed and some partial demolition remaining at The London.

2.0 KEY FACTS: Skanska’s Barts and The London

- The largest PFI healthcare scheme ever to be signed in the UK.
- £1 billion construction programme involving design, demolition, construction and refurbishment on two sites.
- Victorian buildings to be demolished in central London to make way for a new hospital complex.
- Demolition works were carried out adjacent to a live hospital site.
- Early contractor involvement was key to the success of the project.
- Sustainability targets including recycling rates and waste segregation were integrated into the demolition contract.
- 97.1% of the demolition waste from the site was reused and recycled.

3.0 Project Details

Skanska, a private consortium, was appointed by the Barts and The London NHS Trust to undertake a 42 year contract to manage and run the redevelopment of St Bartholomew’s Hospital and The Royal London Hospital in London. This is the largest PFI healthcare scheme ever to be signed in the UK.

- Client: Barts and The London NHS Trust
- Main Contractor: Skanska
- Demolition Contractor: Keltbray
- Recycling Contractor: Keltbray

The £1 billion construction programme involves the design, demolition, construction and some refurbishment on two sites. Two thirds of the cost of the scheme is expected to be attributed to The London and one third of the cost to Barts. Both sites cover a total area of 270,000m².

The demolition works are being phased over two periods. Phase 1 involved the demolition of twelve 6 storey Victorian buildings, a seven storey building and several low structures. Phase 1 was completed in May 2007 and Phase 2 will commence in 2009.

This case study summarises the recycling activities of the Phase 1 demolition works.

Figure 1: Typical Victorian hospital buildings before demolition, illustrating the proximity to neighbouring buildings and roads
4.0 Contractual arrangements

Key aims of the Barts and The London NHS Trust's Environmental Policy include the need to ‘maximise the efficient use of energy, resources and raw materials in all activities’ and ‘integrate environmental considerations into the procurement process for contracts arranged at Trust level’.

To incorporate this Policy into the PFI project, the Trust engaged in early dialogue with the preferred bidder to discuss sustainability issues at tender stage. The concept of sustainability incorporates economic, social and environmental considerations.

Skanska demonstrated an early commitment to sustainability by establishing Sustainability Champions and holding a series of sustainability awareness workshops in partnership with the ‘Natural Step’ programme, an educational part of Forum for the Future.

Skanska committed to a range of contractual sustainability objectives, including individual objectives, strategies and targets to address:

- reduction of fossil fuel use;
- waste minimisation;
- hazardous waste minimisation;
- reduction of resource depletion; and
- reduction of transport pollution.

Skanska engaged in early dialogue with their demolition contractor Keltbray in order to develop collaborative sustainability commitments throughout the project team.

5.0 Project Planning

5.1 Early Contractor Involvement

Project planning for the demolition works started long before Skanska submitted their PFI tender. Keltbray were involved with the planning, pricing and scoping of the demolition and recycling works several years before the contract was awarded. The PFI project team worked in collaboration to plan and design the demolition works and incorporate optimised recycling opportunities into the overall construction programme.

In practice, recycling activities carried out by sub-contracted demolition companies can be constrained due to programme pressures imposed by the main contractor. The mutual trust between Skanska and Keltbray allowed the two companies to identify and agree challenging but achievable recycling targets.

Early contractor involvement and strong mutual trust were key factors in achieving optimum recycling rates.

Cooperation and coordination continued through the project, and weekly and monthly planning ensured that Keltbray’s demolition works continued to be incorporated into the ongoing construction works.

5.2 Achievable Recycling Targets

The overall recycling target for the whole contract, for both construction and demolition waste was originally 60%. As part of early contract discussions Skanska suggested an increased overall recycling target of 70%, in response to which Keltbray proposed that a higher recycling rate of 85% could be achieved for the demolition work.

Keltbray made a contractual agreement to meet sustainability targets including the recycling of at least 85% of the demolition waste arisings - some 15% higher than the client’s overall 70% recycling target. The Phase 1 demolition actually achieved a 97.1% recycling rate.
5.3 Site Waste Management Plans

A Site Waste Management Plan (SWMP) was developed for the Phase 1 demolition works by Keltbray. This SWMP was based on the requirements of Skanska’s overarching SWMP but specific to Keltbray’s activities. SWMPs are currently carried out under a Department of Trade and Industry (DTI) Voluntary Code of Practice. However, in 2008 SWMPs will become a statutory requirement for large construction projects under the Clean Neighbourhoods and Environment Act 2005.

SWMPs set out practices and procedures for the handling and management of site waste arisings. They are a tool for improving overall environmental performance, meeting regulatory requirements and optimising the recycling of site waste. SWMPs can also reinforce other policy areas such as health, safety and sustainability.

The demolition phase SWMP was integrated with Skansa’s overarching Environmental Management and Waste Management Plans.

SWMPs are a tool for improving overall environmental performance, meeting regulatory requirements and optimising the recycling of site waste.

6.0 Demolition works

The Phase 1 demolition was carried out in a traditional manner with the removal of all hazardous materials and non-recyclables followed by salvage of materials, recycling of furnishings and inventory, and finally structural demolition.

Keltbray used the top-down methodology which involves the demolition of the building from the top in a floor by floor sequence using small machines with demolition attachments such as breakers and hammers. This ‘floor by floor’ demolition method basically involves the systematic deconstruction of the buildings. It is the preferred method for the City of London Corporation since it allows the process to be controlled and includes the removal of waste. An acceleration package was used on parts of the hospital away from the wards in order to make up for lost time caused by the Government review. The acceleration programme made use of long reach demolition equipment.

This modular method of demolition allows for the safe and controlled demolition of structures, and the effective management of potential environmental nuisances such as dust and noise. It provides an orderly framework for the systematic identification and separation of material for reuse and recycling.

7.0 Reuse and Recycling Activities

According to the guiding principles of the Waste Hierarchy, waste should first be reduced, reused, and then recycled, followed by the recovery of value and then disposal as a final option. Reuse applies to the direct use of retrieved materials or objects, while recycling requires some form of specialist processing before the material can return to the chain of utility.

Soft stripping played a key role in achieving high recycling rates and maintaining quality source segregation.
The demolition programme sought to apply these principles in its hierarchy of activities. Parallel to this, activities were also driven by cost savings, agreed contractual requirements and the Site Waste Management Plan.

The demolition work included the safe and careful removal of items for salvage and reuse, the segregation of materials for recycling, and the treatment of inert structural materials for recycling.

The 3 key activities were:
- salvage of items for reuse;
- soft stripping and segregation for recycling; and
- demolition and recycling of inert structural elements.

7.1 Salvage

A pre-demolition audit was carried out which involved an inspection of the site and buildings to identify what was salvageable, etc; however, volumes of materials were not calculated during the pre-demolition audit.

During the demolition works materials were salvaged either through a list of salvageable objects provided by Skanska or by Kelbray's site inspection. Buyers were identified prior to commencement of the demolition works and materials such as slates and bricks were stored on site prior to being collected by the buyers or delivered to buyer's sites. Potential purchasers of the demolition materials visited the site to assess the value of the materials. This was facilitated by Kelbray and was based on Kelbray's market knowledge and experience. There is a large market for London stock bricks, slates etc. and buyers were either known to Kelbray or Kelbray sought out contacts through organisations such as WRAP and Bio-Regional Development.

Salvage involved the removal of architectural or historical items such as stone engravings, reusable signs, and marketable items such as sinks, ceiling tiles, joists, chimney stacks, bricks, parquet flooring, railings or radiators.

7.2 Soft stripping

Soft stripping, which follows on from the asbestos abatement works, involved the removal of non-structural items from the building interior. It served two purposes: stripping reveals the building structure, which can then be demolished and recycled as inert material with minimal contamination from unwanted materials from the fixtures and fittings. Meanwhile, the stripped materials can be segregated and sold for recycling.

Soft stripping would normally be carried out at the contractor's discretion, driven by financial incentives and market forces. However, Kelbray made a contractual agreement to soft strip before structural demolition. This played a key role in achieving high recycling rates and maintaining quality source segregation.
7.3 Demolition and Recycling of Inert Materials

After soft stripping, the structural elements were demolished and inert materials were segregated and treated for recycling. Key material streams were concrete, steel reinforcement and brick. Due to site constraints, treatment such as crushing and sorting were primarily carried out off site. Some of the recycled inert material was used on site for The London site piling mat. Recycled materials were also exported off site and sold to external markets.

A key advantage of early contractor involvement was that it enabled Keltbray to plan for and identify suitable markets for recycled materials. Keltbray used their experience and market knowledge to identify suitable outlets through other project work and contracts, existing clients and contacts.

7.4 Materials Recovery

Due to health and safety constraints and the need to maintain cost effectiveness, some soft stripped materials became mixed with other materials during the demolition process. A key factor in maintaining the high recycling rates was the onward processing of these mixed materials at a Materials Recovery Facility (MRF), which provided off site sorting and bulking for recycling. 50% of mixed strippings sent to the MRF were recycled by the facility operator.

Materials that were not recycled included, asbestos (a hazardous waste), window glass and other mixed waste. Window glass often contains metal frames, plastic covering, adhesives etc. As a result window glass was not recycled due to health and safety reasons and difficulties in separating the various materials from glass.

8.0 Recycling Rates

Keltbray provided monthly recycling reports to Skanska based on Waste Transfer Note records, indicating the types, quantities and destinations of waste materials. Recycling rates were calculated using information on the tonnages sent to particular facilities or markets.

Monthly recycling rates varied depending on the programme and building elements being demolished. The overall recycling rate was 97.1%. Materials arising from the demolition are detailed in Figures 5 and 6 below and include the following: a mixture of concrete, bricks, tiles and ceramics; mixed construction and demolition wastes; soil and stones; bricks; mixed metals; wood; gypsum based construction materials; and tiles and ceramics.
7.1 % Mixed construction & demolition waste

5.5% Soil and stones

2.9% Bricks

2.6% Mixed metals

0.1% Wood

<0.1% Gypsum based construction materials

<0.1% Tiles & ceramics

81.9 % Mixture of concrete, bricks, tiles, & ceramics

Figure 5: Waste produced between January and April 2007 for The London

3.8% Mixed metals

9.0% Soil and stones

0.6% Mixed construction & demolition wastes

86%

Mixture of concrete, bricks, tiles, & ceramics (6,022 tonnes)

Soil and stones (627 tonnes)

Mixed metals (265.5 tonnes)

Mixed construction & demolition wastes (38.5 tonnes)

Figure 6: Waste produced between January and April 2007 for Barts

The following wastes were not recycled due to the given reasons:

- asbestos – this material is not recyclable;
- window glass – this often consists of a metal frame, plastic coverings, adhesives and other materials that are difficult to remove from the glass. Difficulties in removing these materials from glass would lead to on-site health and safety problems; and
- other mixed construction and demolition waste – this materials is removed in a highly mixed state (e.g. contaminated with general waste) and therefore difficult to separate other than at a MRF. Recycling at the
MRF is only considered to achieve a conservative recycling rate of 50%, although MRF figures are recycling rates of up to 75%.

It is important to note that within typical demolition works, the normal recycling rates achieved would usually be in the order of 60-70%. However, within this scheme the significantly higher rates were achieved primarily as a result of the following:

- early demolition contractor involvement at the project planning stage allowing for Keltbray to identify materials for reuse and recycling, and thus identify markets/end users for each type of material;
- the contractual requirement for soft stripping was included for the works thus ensuring this precursor to achieving high recycling rates was acted upon;
- the use of a MRF for mixed soft strippings and the recording of these quantities into the overall rates; and,
- good site discipline and quality control, reinforced by the SWMP and clear communications.

### 9.0 Quality of Recycled Materials

Source segregation, storage and contamination can all affect material quality and market price. The SWMP played an important role in promoting the good site discipline needed to maintain material quality. The SWMP was focussed on the handling and management of the demolished materials.

Salvaged materials were cleaned and stored in protected, designated areas and palletised for onward sale. Soft stripping prior to structural demolition was a contractual requirement and minimised the contamination of inert materials with non-inert fixtures and fittings. Performance based specifications were used for some recycled materials which allowed their use as recycled aggregates (RA). For example, masonry was crushed to the Highways Agency 6F2 specification, for use as a capping layer in road construction.

### 10.0 Drivers and Barriers to Recycling

The underlying drivers for recycling are:

- the Client's Environmental Policy and commitment to incorporating sustainability objectives into the project contract;
- early contractor and subcontractor commitment to the client's sustainability objectives; and
- the financial value of recycled and reclaimed material resources.

The technical know-how and early involvement of the demolition contractor, and the collaborative approach adopted by the project partners played a key role in unlocking the recycling potential of the project.

The potential barriers to the recycling initiatives are programme and space. The programme did not require the use of the recycled materials until much further into the programme; furthermore, limited space and the tight...
time schedule hindered crushing of the materials on-site. Programme issues were addressed at the early planning stage, and through close partnership and collaborative working the Keltbray demolition works were integrated into the overall construction programme.

The day to day function of the adjacent operational hospital buildings and infrastructure was a priority and imposed significant spatial constraints on the demolition work. Materials had to be mainly stored and treated off site, and mixed waste sorting and segregation had to be carried out at a specialist MRF.

Occasionally site constraints restricted the choice of options for particular waste streams, and the waste hierarchy was used as a guiding principle to identify the next preferable option. For example, the salvage and reuse of Portland façade stones at the Barts site was unfeasible due to storage restrictions, programme constraints and the risk of damage through manhandling. According to the hierarchy of reduce, reuse, recycle, façade stones that could not be reused were crushed and recycled.

The cost-benefits of recycling were assessed at the planning stage by Skanska and Keltbray. Keltbray provided significant market knowledge, and the viability of recycling was primarily driven by market forces and contractual targets.

Technical know-how and early contractor involvement played a key role in unlocking the recycling potential of the project.

The 97.1% recycling rate represented an optimum recycling achievement. The cost of further increasing the recycling rate would have outweighed the value of the recycled materials, undermining the economic and practical viability of the initiative.

11.0 Environmental and Social Considerations

Skanska and Keltbray carried out standard risk assessments for the demolition works to identify risks to human health and the environment and develop effective mitigation measures to reduce risks to an acceptable level.

A key challenge for the Barts and The London project was to carry out the demolition while allowing normal activities to continue in the adjacent hospital buildings. The very young, elderly and infirm are particularly vulnerable ‘receptors’, and care had to be taken to control risks and manage the demolition without harm to human health and the environment.

A continuous real time monitoring system was set up by Skanska to provide online information on variables such as dust and noise. Threshold values were programmed to trigger an SMS text message to alert Skanska staff, which would then deploy emergency procedures to reduce the readings to acceptable levels. Dust PM10 monitoring which is facilitated by Bureau Veritas is implemented on site. Skanska are the only construction site in the country implementing this. Furthermore, Skanska co-ordinate the noise and vibration monitoring at the site.

In particular, the system monitored aspergillus, an airborne pathogen which can come from degrading material such as rotten wood, causing a condition known as farmer’s lung and aggravating existing conditions such as asthma. The real time trigger-alert system together with close communication with the NHS Trust Infection Control officers enabled Skanska to monitor and control risks.
11.1 Transportation

A detailed travel and logistics plan was developed for the whole project, covering movements associated with the demolition activities. This was developed and policed by Skanska in order to avoid particular roads and put up signage around the sites. Any vehicles not complying with these routes are turned away from the site.

11.2 Climate Change Considerations

Whilst this project did not measure overall CO₂ consumption, the principles of energy efficiency were incorporated in the agreed sustainability objectives and the principles set out in the SWMP and the waste hierarchy.

Skanska monitor site electricity consumption and fuel use, and are committed to using low sulphur fuel. This monitoring is being undertaken at present to generate benchmark figures against which future targets may be set. Local markets for recycling materials indirectly reduce CO₂ emissions by substituting the use and transportation of non-local virgin materials.

11.3 Socio-Economic Considerations

Adjacent hospital activities, local businesses and residents also needed to be protected from potential adverse impacts of the demolition work. Skanska developed a Communications Plan which provided information on pending activities, and sought to develop good working relationships with the Corporation of London. The communications plan involved a large number of local stakeholders from neighbours, community groups, local business partnerships, local strategic partnerships, faith groups, and public patient involvement forums etc. Skanska programmed site operations to make optimum use of hospital ‘slow’ times.

A continuous real time monitoring system was set up to provide online information on variables such as dust and noise.

11.4 Health and Safety

Significant efforts have been made in recent years to improve health and safety performance within the construction sector. Demolition contractors, like any construction industry contractors must comply with stringent health and safety legislation and practice, and the health and safety of both site operatives and the public are a priority.

Keltbray are members of the National Federation of Demolition Contractors (NFDC), who contributed to the development of BS6187 Code of Practice for Demolition, the HSE Guidance Notes GS29 ‘Health and Safety in Demolition Work’ and the Certification of Competence Scheme for Demolition Operatives.

Health and safety risk assessments were carried out as for all construction activities, and no serious incidents occurred during the demolition.

12.0 Project successes and future improvements

As part of the Environmental Management System and company policy, Skanska and Keltbray are committed to continual improvement in services and environmental performance.

Keltbray incorporate recycling as part of their standard operations, however, early contractor involvement and contractual agreements provided a successful mechanism for incorporating extended recycling targets and agreed sustainability objectives into the project delivery process.

Good working relationships and early contractor involvement allowed the project partners to identify and realise high recycling targets, with the actual recycling rate of 97.1% surpassing both the Client’s original 60% target and the extended 85% demolition recycling target.

Due to site constraints, some high quality materials could not be stored for reuse, and had to be transported off site for processing and recycling. Future projects should aim to push site waste management further up the waste hierarchy by placing more emphasis on waste minimisation and incorporating where possible more reuse,
followed by recycling and then recovery, and finally disposal. It may in the future be possible to adopt a ‘zero direct to landfill’ policy, depending on the nature of treatment facilities available to the contractor.

The secondary resource economy for construction and demolition waste materials is growing. While market prices will continue to fluctuate, like any material commodity, improved source segregation techniques and recycling infrastructure together with growing site awareness and new Codes of Practice such as Site Waste Management Plans are all helping to increase the economic viability and incentives for the reuse and recycling of construction and demolition waste.

Contractual agreements can be an effective way of developing common goals between project partners. Early contractor involvement is essential if demolition recycling is to take place efficiently within the project programme.

In the future, more consideration could be given to the carbon footprint of waste management options. Alternatively, options could be assessed using a method of sustainability appraisal, whereby economic, social and environmental advantages and disadvantages are identified and assessed to assist in option selection and prioritisation.

This project demonstrates that early contractor involvement, partnership and trust, reinforced with contractual targets, agreed sustainability objectives and technical experience can overcome perceived barriers associated with cost and programme. Economically viable high recycling rates can be achieved - and can extend far beyond client aspirations.

13.0 Further Information

WRAP has developed a step-by-step guide to the efficient use of materials in regeneration projects which integrates the ICE Demolition Protocol, SWMP and WRAP recycled content approached.