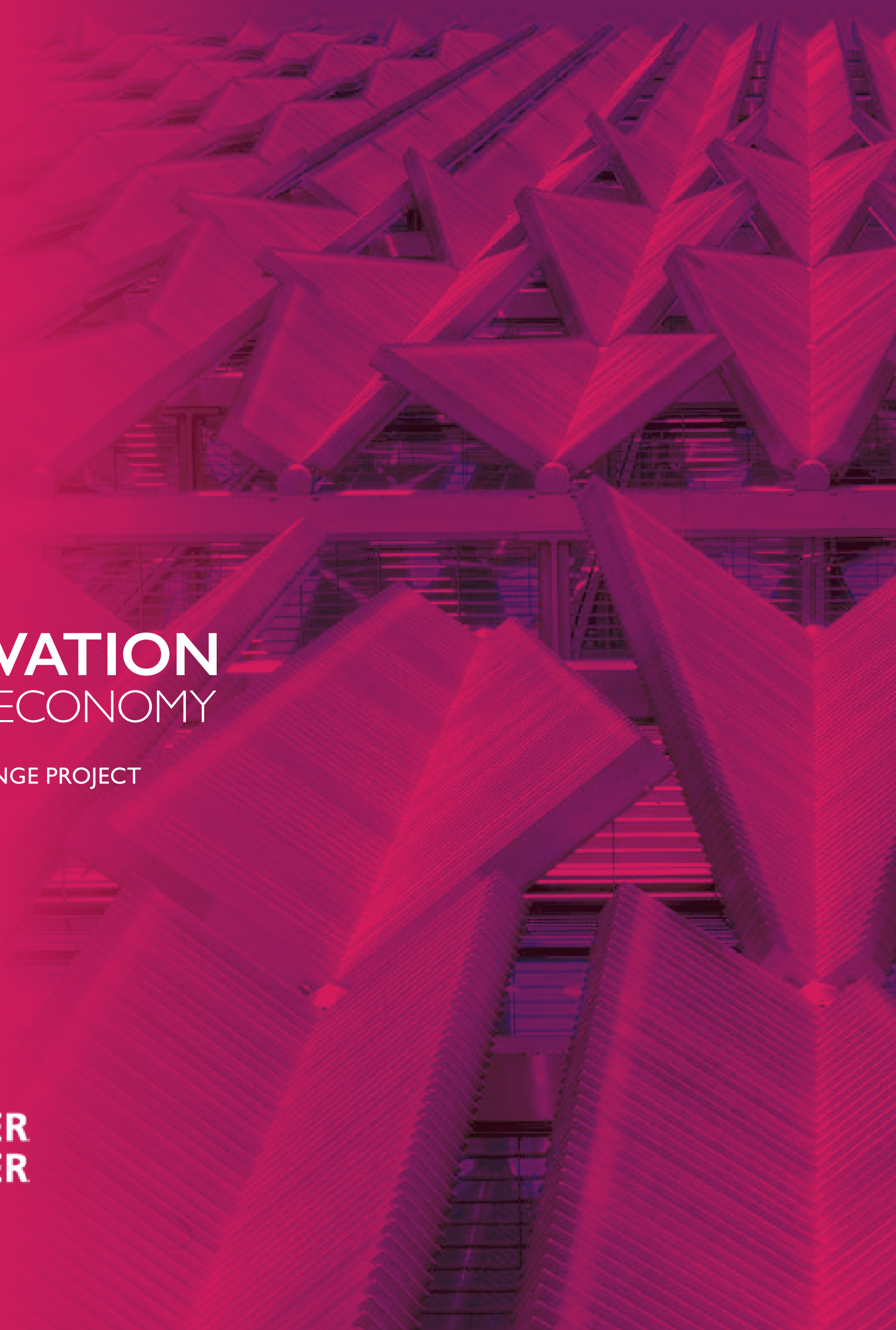
Knowledge Transfer Network



DESIGN INNOVATION
FOR THE CIRCULAR ECONOMY

THE MATERIALS AND DESIGN EXCHANGE PROJECT
FOR END-OF-LIFE BUILDING FAÇADES

Supported by:

ARUP

FRENER REIFER

Contents

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1 Setting the scene

This KTN project has examined how installed façades could be more effectively recycled during the demolition of buildings at end of life. It was considered that this could be better achieved through improved design and more considered selection of materials and assembly methods. The concept of design for disassembly is now well established in the automotive sector and significant effort has been focussed on making cars easier to take apart at end of life. It was intended to apply and adapt that learning to disassembly of façades. Legislation has led to automotive designers ensuring that 85% of the materials used in their vehicles are able to be recycled. Many car manufacturers have openly advertised their use of recycled materials for various components within their new models.

The first phase of the project involved gathering information on the design and materials used within a typical façade.

The opening event in this phase was an "autopsy" or teardown to disassemble a façade designed in the early 2000s. The teardown was attended by the façade manufacturer, façade component manufacturers, façade designers and specifiers, and relevant material and recycling specialists.

The participants gained for the first time the experience of such a complex exercise and discovered to what extent individual materials could be separated. The team quickly understood how façade design needed to change to reduce complexity and to minimise the number of materials used.

Following the autopsy, several of the team tracked the material recycling streams visiting a demolition site and several different building material recycling facilities to follow the end-of-life path.

The second phase of the project enabled the data and information gathered through this practical evaluation to be assessed by industry and material specialists.

This was accomplished at an Open Innovation Workshop, termed a 'Whitewater', where specifically invited participants gathered to hear the findings of the investigation and through a series of focussed discussions considered what could be done to improve the level of façade reuse and façade material recycling. This led to a series of proposed improvements which the participants prioritised to reveal those ideas that could be considered to be most beneficial and likely to succeed.

2 Autopsy – Façade teardown at Frener & Reifer

2.1 Introduction

Frener & Reifer Srl, a leading designer and manufacturer of building facades based in Brixen/Bressanone, Italy, offered a full-size model façade that the team could disassemble. The objectives were:

- To identify opportunities and issues for component and material re-use or recovery
- To discover how easy it was to disassemble the unit
- To measure how long the disassembly process took

Two Frener & Reifer technicians carefully disassembled the façade under the direction of the team.

Façade Engineers at Arup had identified four distinct elements within the façade model – see Figures 1–3 (Page 6).

- Elements 1 and 4 – Spandrel

The aspects of interest are the range of different materials used (including timber, steel, aluminium and insulation); the design perspective of how they are combined including brackets, the cassettes and use of insulation to provide a thermal barrier.

- Element 2 – Double-glazed unit in frame

Of interest is how easily the various components can be separated and the design aspects of the element, in particular the materials used and the joining methods. The façade used is more representative of a stick-based construction, rather than a unitised (or panellised type).

- Element 3 – Second skin – Weather protection assembly

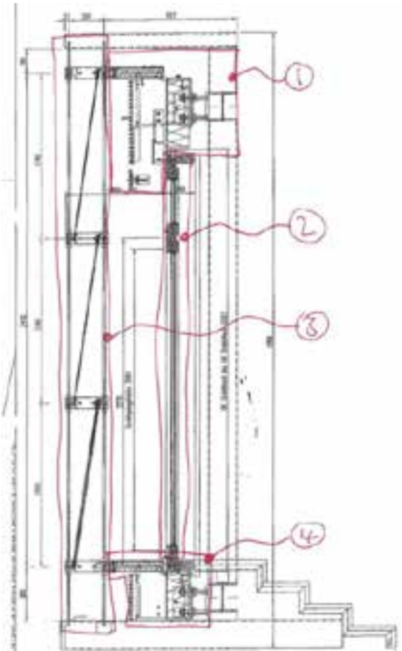
This comprises several panes of glass supported within a metal frame.

1:

Front elevation of façade model at Frener Reifer

2:

Rear elevation of façade model at Frener Reifer



3:

Section of model façade unit at Frener & Reifer showing Elements 1 to 4

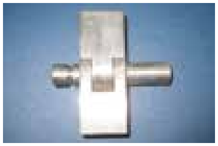
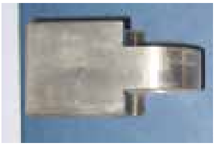
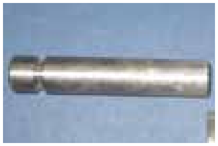
2.2 *Disassembly*

- Element 3 – Second skin – Weather protection assembly

The function of this element is to protect the aluminium slatted blind from wind and rain. This element consisted of four vertical rods to which eight nodes were attached. The eight nodes supported three panes of glass. In the Table below, 'reuse' is the theoretical potential for the part to be reused and 'recycle' is the theoretical potential for the material within the component to be recycled.

Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
Vertical Rod	Rod	-	Stainless steel	Corrosion resistance	Screwed	Yes	Yes
Node assembly	-		-	-	-	-	-
-	Node spine (& node cap & rod fixing)		Aluminium	Corrosion resistance	Screwed	Yes	Yes
-	Node cap (& screw)		Aluminium	Corrosion resistance	Screwed	Yes	Yes
-	Cap head screw		Stainless steel	Corrosion resistance	Screwed	Yes*	Yes

* Only after a scan to confirm there are no micro-cracks created during the previous use. This is currently not practised and recycling the material is more common.

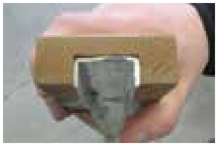
Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
-	Cushion (attached to cap)		EPDM spacer cushion	Weather resistance	Bonded	No, not easily de-bonded	No
Rod connection assembly	-		-	-	-	-	-
-	Screwed block - lower		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Screwed block - upper		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Rotation pin		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Washer		Acetal	Low friction & isolation from aluminium	Trapped	Yes	Yes
Glass	Lower pane	-	Laminated	Operator safety	Trapped	Yes	No
-	Upper panes	-	Tempered	Cost	Trapped	Yes	Yes

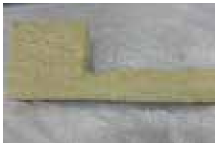
- Elements 1 and 4 – Spandrel

The spandrel units consist of the operating mechanism for controlling the aluminium slatted blinds and the fixings for attaching the façade to the building.

4:
Upper spandrel unit

Fig 5:
Lower spandrel unit

Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
Cover	-		Wood and aluminium	Aesthetics and 'green'	Screwed and glued	Yes	Yes
Capping	-		Wood & aluminium	Aesthetics and 'green'	Aluminium bonded to wood. Assembly 'snap fitted' to frame.	Yes	Yes
Cover plate	-		Aluminium	Stiffness-support for the aluminium slatted blind.	Screwed	Yes	Yes
Tread plate			Aluminium	Stiffness, corrosion resistance and support for people accessing the cavity between elements 2 and 3.	Screwed	Yes	Yes
Cover	-		Wood and aluminium	Aesthetics and 'green'	Screwed	Yes	Yes

Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
Fixing bracket	-		Zinc plated steel	Strength and corrosion resistance	Bolted	Yes	Yes
Insulation	-		Mineral fibre	Thermal insulation and fire resistant	Sandwiched between adjacent components	Yes	Yes

- Elements 2 – Double glazed unit in frame

Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
-	Lateral strut		Wood	Green, stiffness and aesthetics	Screwed	Yes	Yes
-	Sealing strip		EPDM rubber and aluminium	Weather and thermal resistance	Compression fit	Yes	Al: yes EPDM: No
Shims	-	-	Nylon	-	Bonded in place with silicone adhesive	If separated	PA: Yes Silicone: No
	Thermal barrier		Forex™ (Foamed uPVC)	Thermal resistance and fire resistant	Screwed	Yes	Yes

Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
Weather gasket	Seal		EPDM	Weather resistance	Compression fit	Yes	No
Double glazed panels	Floor level units		Inner pane: laminated Outer pane: tempered	Safety	Contained within frame	Yes	No
	Upper units		Inner pane: toughened Outer pane: tempered		Contained within frame	Yes	No
	Insulated spacer		Rigid cellular thermoplastic and desiccant material	Structural stiffness, thermal resistance and moisture absorption	Sandwiched between glass panes	No**	No
-	Perimeter seal		Silicone and polyisobutylene	Structural bond and air, weather and thermal resistance	Sandwiched between glass panes	No	No

** The desiccant generally has a 15 year life

- Other elements normally present on a facade

Frener & Reifer explained that as this was a model façade, certain components had been omitted from the model and specifically those concerned with water management.

Component	Material	Reason	Assembly	Reuse	Recycle
Water management membrane	EPDM	Water resistance	Draped	Yes	No

- Time to dis-assemble the model unit

It took two Frener & Reifer technicians with appropriate tools, assembly drawings and an access platform:

- Approximately 45 minutes to disassemble Element 3 – Weather protection assembly
- Approximately 80 minutes to disassemble Element 1 – Spandrel
- Approximately 60 minutes to disassemble Element 4 – Spandrel
- Approximately 50 minutes to disassemble Element 2 – Double-glazed unit in frame

It should be noted that the team regularly interrupted the disassembly process to photograph parts and ask questions. Without these interruptions, the disassembly would probably have taken 100 to 120 minutes.

2.3 *Reuse of components and recycling of materials*

- Reuse of removed components

Almost all of the components encountered in the autopsy could be reused if the design of the new façade is identical, with the exception of the double-glazed glass units. The lifetime of the moisture-absorbing material within a double-glazed unit is typically 15 years. Beyond this period the performance of the unit cannot be guaranteed.

In view of changing customer style requirements, improvements in materials and construction techniques and continued development of building regulations, the likelihood that old façade components could be directly reused is low. Even reusing a component as simple as a standard stainless steel cap head screw requires it to be strength tested to ensure there has been no degradation.

The thriving reclamation market that exists for Victorian building artefacts would need to be extended to include components recovered from more modern buildings. The demand for such components is highly dependent on the fashion cycle. There needs to be a sufficient time interval between the design of the original and its reappearance as a fashionable product. Currently we estimate this interval to be around 80 years.

- Recycling

All of the façade materials, with the exception of the laminated glass*, silicone adhesive, polyisobutylene adhesive, EPDM seals and EPDM water management membranes, could be recycled.

* Although laminated glass can be recycled to an extent, current methods are not particularly efficient. New techniques are being actively researched.

2.4 Points of discussion during the autopsy – factors affecting façade reuse or recycling

- The age of a building before demolition can vary from three to more than 40 years. Re-use of components may be limited by changes in building regulations and advances in building techniques and materials.
- Building systems – buildings can be constructed on site or manufactured in a factory and delivered to site (stick system). The stick system uses more material but construction is more rapid. It also results in the use of more protective transit packaging, most of which can be recycled (the main exception being expanded polystyrene). Potentially the façades from stick buildings should be easier to remove and then recycle, possibly remote from the demolition site.
- The façades of heritage buildings generally cannot be demolished, but in some circumstances may have a secondary skin (often glass) built over them.
- The simple and rapid recovery of components from a 40-year-old building may be hampered by the non-availability of the original design drawings and the inability to precisely identify each of the materials removed.
- Double-glazed (DG) units generally have a design life of 15 years determined by the efficiency of the seal and desiccant. Current DG units now incorporate various glass coatings to improve thermal efficiency and reduce solar transmission, so old recovered DG units have little commercial value or use. Some new units may now be specified to include solar photovoltaic electricity generation, which would further complicate recovery and/or reuse.
- Composite materials are difficult and/or labour intensive to reuse. Recovery of the intrinsic energy by granulation and then thermal degradation is probably the only current economic option.

- In certain circumstances a building may be refurbished and designated for an alternative use which prolongs its life. Examples include Centre Point in London, which is being converted from commercial to residential use. Other examples include 19th century warehouses in various parts of the UK converted to flats, offices or light industrial use.
- Government regulation, particularly the continued increase in Landfill Tax, has significantly increased the use of recycling of materials resulting from building demolition.
- Certain materials (asbestos, plasterboard, most rubbers and laminated glass in particular) currently do not have any technically and commercially economic recycling or separation method. Further research and development of markets is needed.
- Buildings are designed for the particular climatic zone in which they are to be constructed. With climate change and the accompanying increase in frequency of so-called 'exceptional climatic events', buildings may need to be redesigned to cope with higher wind loading and greater extremes in temperature. This may result in façades recovered from a building not being suitable for reuse in that climatic zone.
- Future proofing of buildings by design is difficult. Prediction of future legislation change and client choice complicates the potential for reuse.
- Making façades more energy efficient and functional will tend to make reuse and possibly recycling more difficult.
- It is not easy to identify the exact coating (thermal infrared, reflective, emissivity, etc) on glass. There would need to be an industry standard or government-promoted marking scheme to uniquely identify coatings to aid their precise makeup and their reuse or recycling.

3 Tracking façade material at end of life

3.1 Visit to a demolition site

With the assisstance of the National Federation of Demolition Contractors the MaDE team were invited to view the Oriana demolition site on the corner of Oxford Street and Hanway Street in London.

The buildings to be demolished are a mixture of architectural styles, varying from a 19th Century bay window four-storey building with an original butterfly roof, to a building constructed in the 1960s.

Within the proposed work some façades are being retained including one built in 1923 with a tripartite stone façade in Portland Stone. A second late 19th century building has a four-storey mansard attic with red stone, projecting central bay and a secondary rendered and painted façade with round beaded windows. On the same site a seven-story early 20th century grade II listed building with a stone front and slate pitched roof will have the front and the sides retained but the rear demolished.

Due to the need to retain some of the façades and the limited access to the site, the majority of the demolition is being conducted by hand from the top of the building. This is a labour-intensive process but it is the only way to ensure the safety of the old façade.

The first demolition stage involves a soft strip – doors, light-fittings, cabling, pipes, radiators etc are all removed by hand. The better the soft strip, the less contamination occurs during the structural demolition.

The stripped materials are separated on site and placed into different skips, which are routed to different material-specific recyclers. On some very small sites with limited access, the materials are separated off site. More valuable stripped components – interesting doors for example – are sold intact.

Contractors aim to do as much sorting as possible. Steel reinforcing bars (rebars) are extracted from concrete beams using small impact jack hammers so that the rebar can be sold separately. Large steel girders are cut to skip size on site using a propane flame cutter. Plastic covered power cables are removed and are sold for plastic stripping. For health and safety reasons, glass panes are not usually extracted as a single pane. Glazed units are usually smashed and included in building rubble. In some cases where a building contains a lot of glass or the glass has architectural or historical importance, it may be preserved as sheets and reused. Reuse of flat glass and double-glazed units is currently limited due to issues involving quality standards, low demand and the limited processing capacity for glass recycling. There are two driving forces for this approach to building demolition:

› The Land Fill tax at £82/T encourages contractors to sort and re-sell as much material as possible

› The revenue gained from selling material enables the contractor to offset contract costs.

Currently 95-96% of demolition waste is recovered and recycled or reused. Only plasterboard, asbestos and to some extent glass are not effectively recycled or reused.

3.2 Visit to a concrete recycling site

The Day Group is a long-established supplier of aggregates and other materials to the construction industry from their quarries in the south-east of England. They have progressively invested in the processing of waste building materials from demolition sites to the point where recycling accounts for about 25% of their business. The MaDE team visited their site in North Greenwich, London, to better understand the recovery of concrete from building waste material. The Day Group recycles over one million tonnes of building waste material (concrete, asphalt and glass) each year across their sites in London and the south-east. Generally, buildings in London have a 20-30 year life before they are rebuilt. Due to the low margins, transport represents a high proportion of the total cost and recycling centres need to be close to demolition sites. To ensure high quality, Day establish a relationship with demolition contractors and use their own transport to collect building materials from demolition sites. Strict quality control of the demolition waste is applied so that contamination of the final product is minimised. The two main materials they process are concrete (~80%) and asphalt (~20%).

The concrete demolition material is processed by crushing using a jaw type crusher, followed by removal of ferrous metals with an electromagnet. The resulting pieces are sorted by size with a screen deck, then plastic, wood, bricks and other contaminants are removed by hand. Further hammer crushing gives angular pieces of less than 40-50mm and any further ferrous material is removed by a second electromagnet. Air separation removes any small pieces of wood before another screen deck sorts the material to less than 40mm.

EU legislation dictates that there must be less than 1% of contaminant in type 1 aggregate for use in concrete. Several years ago this was not the case and this recycling limited the use for aggregate.

The Day group also manufactures a secondary aggregate containing a percentage of incinerator bottom ash (IBA). IBA is the residue from incineration of household waste in ‘Energy from waste’ plants. It comprises concrete, ceramics, glass, brick, clinker, some metals and fused material particles. IBAs can be added to aggregates to form incinerator bottom ash aggregates. In certain circumstances these can be used in pavement or road construction.

Another recycled product from building and household waste is glass sand and this is used for bedding block paving and concrete slabs. This is produced by crushing glass waste in a special process that does not give any sharp edges. The coarse nature of the glass sand gives excellent drainage.

3.3 *Visit to a metal recycling site*

At their site in Canning Town, London, European Metal Recycling (EMR) receive building waste from demolition sites in central and east London. Contracts with demolition or refurbishment companies are established to qualify what type and more importantly, what quality of building waste they will receive. The site is equipped with shears to reduce the size of steel bars extracted from reinforced concrete beams or steel girders to a manageable size. Lighter material can also be densified or baled to minimise the volume.

Incoming material includes pipes, ductwork, heat exchangers, cables, reinforcing bars, beams, pipe fittings, lighting units, aluminium window frames, machining swarf and stainless steel catering furniture.

Demolition materials processed at the site include steel, stainless steel, aluminium, lead, brass, various grades of copper and many types of cable including pyrotechnic cable used in fire detection and alarm systems. Cable may be stripped at a sister EMR site in Burnopfield or sold with the insulation material left on.

Most material is exported through either Tilbury or East Tilbury docks, depending on the material and its recycling destination.

As with concrete waste, transport costs are a significant concern for cost-effective recycling. As a rule of thumb, it is only sensible to collect metal waste and deliver sorted material within a six-mile radius. Due to the recent extensive redevelopment activity in central and east London, the site has been ideally placed to process metallic building waste.

3.4 *Visit to a glass recycling site*

The Berryman site at Knottingley, West Yorkshire, receives four categories of used glass.

Post-consumer mixed colour glass bottles collected from kerbside or commercial contractors are processed on a continuous crushing line. Material is sorted on a finger screen and any metallic caps, paper labels, foil wrapping or other material contamination is progressively removed using a variety of techniques. The resulting glass is dried and further screened to obtain a uniform size mixed colour material. This is then separated into the three principal colours – flint, green and brown, using a series of fully automated sorting machines. This material is then sold to an adjacent glass bottle making company where it is added to the glass melt.

The colour quality of the resulting separated glass is better than 99%.

The material contamination level for remelt has to be lower than 5g in 1000 kg (< 5 ppm).

This plant is currently the most advanced of its type in the EU. Further planned investment in the colour separation process will enable smaller fragments of glass to be separated and reused.

Accredited plate glass is received from local glass manufacturers. As the history and composition of the material is known and it is uncontaminated, it is relatively easy to recycle to a form where it can be reused by the original manufacturer.

Unaccredited plate glass may contain a proportion of wired and heat resistant glass. In this case, as its history and exact material composition is not so reliably known and it is likely to be contaminated with other materials, it is processed to a suitable form to be accepted by the fibre glass insulation market.

Mixed glass includes construction waste, vehicle windscreens and mirrored glass. It is difficult to achieve the material quality requirements for it to be used as remelt. The techniques for removal of the PVB layer within laminated glass are not particularly sophisticated, resulting in a low yield of glass. The poorer separation limits the amount of this type of material that can be used in remelt as the level of organic contamination in remelt needs to be below 500g per 1000kg (500ppm). PVB separation technology is currently not as advanced as, for example, the separation of mixed coloured glass.

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4 Open Innovation Workshop ‘Whitewater event’

The Open Innovation Workshop attracted a wide range of individuals representing the complete spectrum of façade design, construction, use, demolition and recycling together with material specialists and trade bodies representing particular façade construction materials.

The workshop opened with presentations from the various contributors to the information-gathering phase of the project. These included façade designers, manufacturers, architects and recyclers.

Delegates considered the recycling or reuse opportunities of a wide range of materials commonly used in current facades. This demonstrated the scale of the problem in view of the wide range of structural and insulation materials available to designers

Delegates were also invited to estimate the cumulative value of one tonne of ten different materials recovered from buildings, ranging from lead and copper pipe to power cables and aggregate derived from concrete. The resulting estimates suggested a value between £3,000 and £21,000 which ably demonstrated the lack of real knowledge concerning material value. The correct market value at this time was considered to be £13,000.

In the final session, the four groups discussed and then proposed solutions to the following questions.

› What performance and architectural objectives, and subsequent design choices, lead to challenges in closing the materials loop in building façades? How can they be overcome?

› Do current business/commercial models support façade design for end of life? What changes might lead to better recycling rates at end-of-life?

› What fabricating strategies are utilised and how do they limit recyclability?

› Are there any quick wins or constraints in the supply chain that affect or can improve building façade recycling at end of life?

Q1

What performance and architectural objectives, and subsequent design choices, lead to challenges in closing the materials loop in building façades? How can they be overcome?

1.1 Inform and educate clients and architects that their brief on 'shape' is a complicating factor for reuse or recycling

1.2 Use an ownership model where the architect and constructor have liability for reuse and recycling

1.3 Create a disassembly model in virtual space

1.4 Avoid mixing materials

1.5 Use one supplier for each material for leasing and the subsequent return of the material to the manufacturer at end of life

1.6 Improve education regarding materials recyclability

1.7 Change the belief that the required properties of a façade (style, airtightness, durability, etc) must lead to the use of composite materials and adhesives

1.8 Develop a 'magic adhesive' that permits easy disassembly at end of life

1.9 Introduce incentives to consider reuse or recycling at the design stage

1.10 Provide more information so that 'cannot find (or will not look for) relevant information on recycling' behaviour is overcome

1.11 Provide relevant information about new materials on their recyclability and long-term environmental impact

1.12 Promote client demand for reuse or recycling

1.13 Introduce a feedback loop to building designers and architects from building users regarding building performance and end of life issues

1.14 Establish a trading standards body for design teams

1.15 Reduce complexity – 'The more you add to a material (films, coatings, etc), the more difficult it is to remove and recycle'

1.16 Make the metallic component easy to separate and recover – metals are the valuable materials

1.17 Use adhesives and fasteners that enable easy disassembly

Q2 *Do current business/commercial models support façade design for end of life? What changes might lead to better recycling rates at end of life?*

2.1 Introduction of legislation would assist (cf landfill) without limiting individuality or innovation.

2.2 Ensure that the landowner has end of life responsibility

2.3 Inform and educate that choice of materials has a landowner legacy

2.4 Permit more time to dismantle buildings to avoid making mixed rubble

2.5 Change the mindset of ‘always wanting new’. It creates the build/demolish cycle.

2.6 Overcome the ‘business as usual’ mentality that leads to little account for end of life in design

2.7 Encourage and actively publicise more green building rating schemes

2.8 Adopt a life cycle approach, eg Environmental Product Declaration (EPD)

2.9 Introduction of incentives from government (avoid perverse incentives)

2.10 Introduction of legislation from government

2.11 Proactively examine other business sectors for ideas

2.12 Introduce a demolition tax (on an escalator) levied during construction, based on recyclability. The client would need to pay more if the material could not be easily reused or recycled

2.13 Provide more information – product information tags to be public

2.14 Make reuse and recycling part of BREEAM* regulations

2.15 The business model must ensure that it is commercially interesting at each stage

* BREEAM = Building Research Establishment Environmental Assessment Method for buildings and large scale developments

Q3 *What fabricating strategies are utilised and how do they limit recyclability?*

3.1 Recognise that for composite assemblies each material has a different value to different parties – logistics, storage, waste, ease of separation

3.2 Improve clarity of information on separation and disassembly – labels and information

3.3 More education is needed about how reuse and recycling is easier to consider when there are fewer material types

3.4 Introduce requirements for recycled or reused material content in new parts – x% recycled content, y% reused content, etc

3.5 Encourage the attitude of 'building for self' rather than others

3.6 The trend to prefabrication, which has led to fewer 'wet' trades on site and fewer bolts and mechanical fixings, makes recycling more difficult.

3.7 Prefabrication has led to the use of more composites and the adhesive bonding of materials makes disassembly and recycling more difficult

3.8 Need more information through building information modelling (BIM) and operation and maintenance manuals

3.9 Develop a material tagging system that is not seen as costly

3.10 Ensure that there are disassembly plans

3.11 Recognise that innovation in new products can reduce recyclability

3.12 Drivers towards better efficiency can have unintentional negative effects on recyclability

Q4 *Are there any quick wins or constraints in the supply chain that affect or can improve building façade recycling at end of life?*

4.1 Logistics will influence economic environment

4.2 Develop local sites that sell on to larger recovery sites

4.3 Encourage resale of material for its material or aesthetic value

4.4 Problem in contamination or breakage of parts

4.5 Problem in space needed for storage of parts awaiting sale

4.6 Improve demand for purchase of demolition materials

4.7 Recognise this is a material-specific issue eg well-established recycling of metals – develop recycling methods for more difficult to recycle materials

4.8 Create reverse logistics – vehicles that deliver new components (eg glass panels) to a site should also remove the recovered glass panels

4.9 Improve awareness and education about recycling technologies

4.10 Make reuse/recycling more convenient

4.11 Award 'extra points' for reuse over recycling

4.12 Develop BS or ISO standards for reuse and recovery

4.13 Introduce a tax on products and materials that do not meet the standards above

4.14 Tax would drive recycling industry as recyclable products become more attractive

4.15 Use industry federations to set targets

After the workshop, the delegates were asked to rank all of the ideas in terms of their viability. The top five highest scoring solutions for each question are shown below.

Q1

What performance and architectural objectives, and subsequent design choices, lead to challenges in closing the materials loop in building façades? How can they be overcome?

Rank	Points	Idea
1	82	Use adhesives and fasteners that enable easy disassembly
2	79	Introduce incentives to consider reuse or recycling at the design stage
3	77	Improve education regarding materials recyclability
4	76	Make the metallic component easy to separate and recover – metals are the valuable materials.
5	71	Provide relevant information on new materials on their recyclability and long-term environmental impact

Q2

Do current business/commercial models support façade design for end of life? What changes might lead to better recycling rates at end of life?

Rank	Points	Idea
1	86	The business model must ensure that it is commercially interesting at each stage
2	81	Make reuse and recycling part of BREEAM regulations *
3	78	Introduction of incentives from government (avoid perverse incentives)
4	70	Proactively examine other business sectors for ideas
5	70	Adopt a life cycle approach, eg Environmental Product Declaration (EPD)
6	70	Overcome the 'business as usual' mentality that leads to little account for end of life in design

* see page 26

Q3

What fabricating strategies are utilised and how do they limit recyclability?

Rank	Points	Idea
1	83	Ensure that there are disassembly plans
2	79	Improve clarity of information on separation and disassembly - labels and information
3	74	More education is needed about how reuse and recycling are easier to consider when there are fewer material types
4	74	Recognise that innovation in new products can reduce recyclability
5	72	Need more information through Building information modelling (BIM) and pperation and maintenance manuals

Q4

Are there any quick wins or constraints in the supply chain that affect or can improve building façade recycling at end of life?

Rank	Points	Idea
1	79	Improve demand for purchase of demolition materials
2	76	Make reuse/recycling more convenient
3	75	Recognise this is a material-specific issue, eg well-established recycling of metals – develop recycling methods for more difficult to recycle materials
4	75	Develop local sites that sell on to larger recovery sites
5	71	Improve awareness and education about recycling technologies

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5 Consideration for next steps

The project has demonstrated that in terms of reuse, there seems to be little prospect that façades or even components of façades can be reused, unless the façade is part of a heritage building.

For recycling, metals appear to have a good closed-loop process, albeit not one that particularly benefits the UK economy. Concrete similarly can be recycled but usually into lower-grade and lower-value products. The material with the least successful recycling path is glass. The well-established routes for recycling domestic glass bottles do not translate well to architectural plate glass due to the optical and structural quality requirements. This is even more the case for laminated glass. The output from the innovation workshop highlights a number of themes:

- Incentives are required to encourage reuse/recycling in new demolition and new construction projects. This should increase the UK demand for recycled materials
- Improved education and training about material recycling are required for the design and architectural community as well as the demolition and recycling industry
- Regulating reuse and recycling should part of BREEAM
- Recycling is a material-specific issue and its successful application can be affected by material considerations
- Developing an easily de-bondable adhesive would be particularly valuable to increase the speed and ease of façade disassembly
- Innovative business models and logistics are fundamental to cost-effective recycling

Recycling legislation with very specific targets kick-started the automotive industry into taking recycling seriously; the landfill tax may have achieved the same objective with the construction and demolition industries (maybe unintentionally).

Next steps (continued)

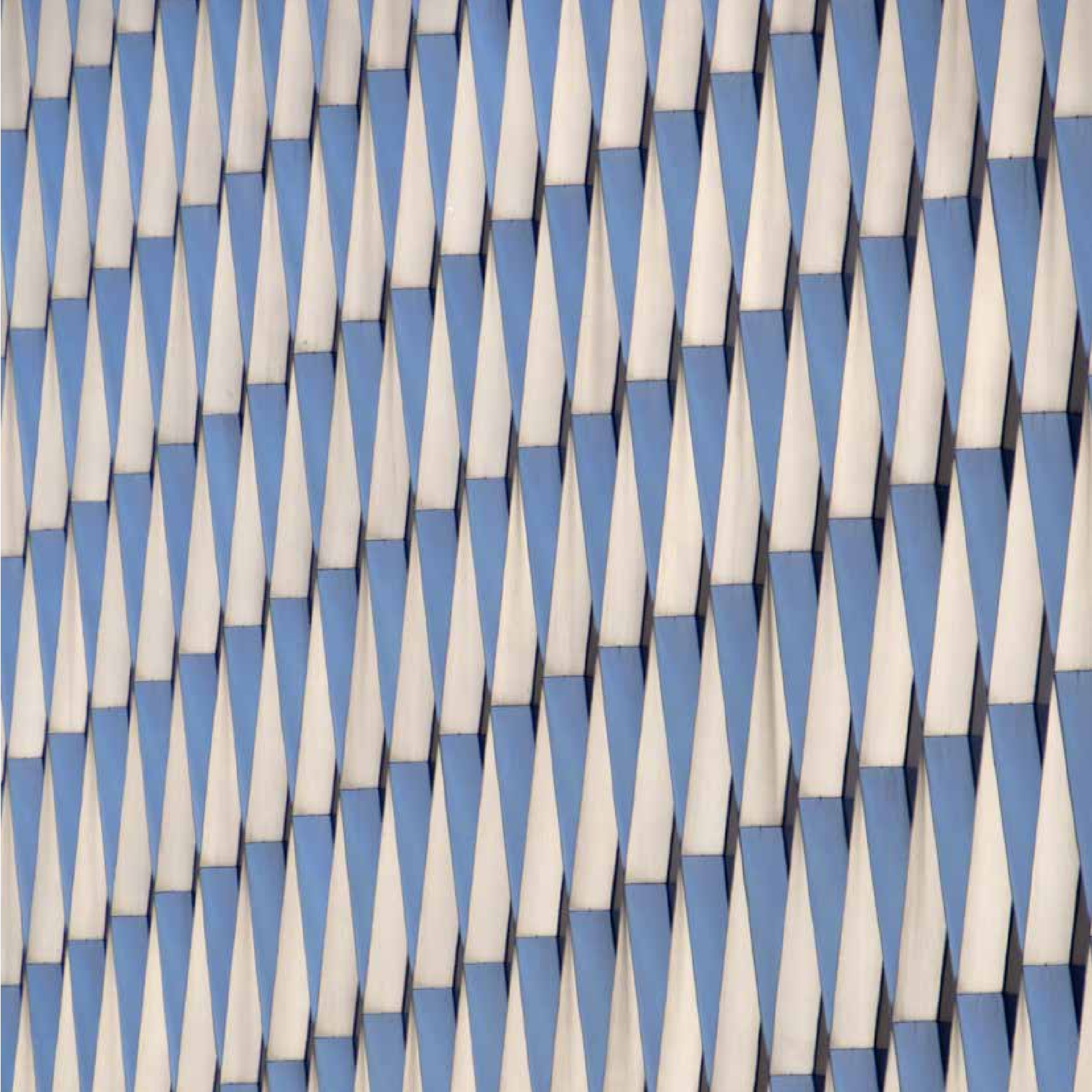
The façade material that seems to require the most development is glass. Considered difficult and dangerous to remove whole and considered very risky if added as remelt due to its unknown history, the opportunities for reuse of façade glazing need to be actively researched.

› We would propose a workshop specifically focusing on the issue of recycling and the reuse of architectural glass. This should involve glass manufacturers, glass trade bodies, glass material specialists, glass standard and specification writers, and glass recycling companies, to understand what effort is needed to improve architectural glass recycling or reuse.

As several of the participants at the innovation workshop remarked during the day:

> *"It is the first time I have ever been in a room with representatives from all parts of the building design, construction, demolition and recycling chain."*

This project, having achieved a notable first, must find a way to continue to exploit the economic benefits of recycling of building materials and in particular glass. With the current fashion for high-rise commercial buildings with double-glazed façades, which have limited life due to desiccant exhaustion, the effective recovery and recycling of glass is pressing.



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Teardown – 'autopsy'

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Mr Chris Hube	Arup	Dr Bernd Kroll	Kuraray Trosifol
Mr Paul Cunningham	Delaminating Resources	Mr Stuart Preston	IOM3
Fr Irene Bachmann	Frener & Reifer	Dr Keith Watkinson	IOM3

Demolition site

Our thanks go to Howard Button, Chief Executive of the National Federation of Demolition Contractors, and Richard Turner of Erith for allowing us to visit the Oriana demolition site.

Fr Sabine Kleining	Arup	Mr Stuart Preston	IOM3
Ms Emma Griffiths	IOM3	Dr Keith Watkinson	IOM3

Concrete recycling site

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Ms Emma Griffiths	IOM3	Dr Keith Watkinson	IOM3

Metal recycling site

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Dr Keith Watkinson IOM3

Glass recycling site

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Ms Emma Griffiths	IOM3	Dr Keith Watkinson	IOM3

Whitewater workshop – delegates

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Mr Chris Hube	ARUP
Dr Kristian Steele	ARUP
Mrs Linda Barron	Barron Gould Associates
Mr John Edwards	Berryman
Mrs Vallishree Murthy	British Glass
Mr Martin Jarrett	Constellium
Dr Justin Furness	Council for Aluminium in Buildings
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