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Evaluating re-use potential: Material profiles and vision for project workflow

Introduction

Material reuse

Our world is facing an environmental emergency. Precious resources are being consumed at an unsustainable rate and our climate is warming. The built environment is a major contributor to these challenges, so it must also be part of the solution.

With the built environment responsible for almost 40% of energy-related carbon emissions globally, we must find new ways to design and construct our cities. It is untenable that the lifespan of many modern commercial structures is often closer to 20 years than 100.

Use of reclaimed materials in construction has the potential to reduce the embodied carbon of construction, minimising the need for virgin material extraction and production. Re-use of materials is not yet common practice and is not without challenges. It is our belief that these challenges can be overcome.

In this document you can find two resources:

- Material profiles: these material profiles begin to explore the challenges and opportunities associated with re-using different materials.
- Our vision for a project workflow to ensure the successful integration of materials for re-use.

Material profiles

These material profiles begin to explore the challenges and opportunities associated with re-using different materials.

Steel

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Steel

Re-use potential: Material profile

Summary

Reusing steel sections reclaimed from buildings into new structures, if done appropriately, can make a valuable contribution to reducing carbon emissions by eliminating energy intensive processes involved in recycling – essentially by avoiding having to re-melt the steel – or in manufacturing of virgin steel. A project need not use 100% reclaimed steel, but a proportion should be targeted.

Introduction

Typically, there are three types of ‘reclaimed’ structural steel available:

1. Second-hand steel removed from previous applications.
2. Stock rusted steel; this is new steel that is either end of line, or steel that has rusted.
3. Overstock

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Re-use potential: Material profile

Current practices

Reuse of reclaimed steel sections is currently a relatively small part of the construction steel market, around 5%-10%[1]. Case studies indicate that this is because there is usually an additional cost of around 10% in incorporating reclaimed steel sections compared to procuring new steel, assuming this can be done with the same steel weight.

The current practice in demolition of buildings is to chop up steel sections into short lengths as this is a requirement if they are to be sent for scrap recycling.

Recovery for reuse

- Structural steel is typically dismantled.
- Bolted sections can be disassembled or cut close to the connections to retain length.
- Beams and columns can be cut.
- Where grade and properties are unknown, testing will be required. This is routine and does not present a major hurdle.

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Re-use potential: Material profile

Challenges with disassembly/reuse:

- Though acquiring the stock of reclaimed steel can deliver a cost saving, other parts of the process can affect the timeline, scale and cost of projects that use reclaimed steel.
- Coatings from previous uses (e.g. intumescent paint or corrosion protection) can affect the ability for the material to meet the British Standards for the new application and removal will increase the cost of the steel.
- Structural steel deconstruction attracts potential health and safety issues and cost factors that need to be considered.
- From the perspective of the structural engineer the use of reclaimed steel in a project represents additional work of a nature similar to work with existing buildings to manage risks and maximise opportunities. This can be mainly in the design stage, but there are also impacts during procurement in monitoring the additional testing requirements. There may be a need to assess substituted sizes and existing features such as holes, welds etc.
- Inefficient use of scrap steel resources in a project reduces scrap availability generally in the industry and this can lead to an increase in global primary steel production, so care is needed to avoid any unintended adverse impact on GWP.

Steel

Re-use potential: Material profile

Recommendations if reuse is pursued:

- Identify elements that could use reclaimed steel sections without an increase in tonnage.
- Construction steel must be CE marked according to the requirements for conformity assessment of structural components BS EN 1090-1. BS EN 1090-2 requires that documentation must be used to declare the relevant material characteristics. Suppliers are mandated to provide this documentation when selling material. If steel is already owned by the developer, it is dismantled and re-used without re-fabrication or is used for temporary works, it does not need to be CE marked.
- There should be more time allotted for inspections and testing of the stock to ensure it meets requirements, including considering any time required for fabrication and cleaning. It is likely that increased time will be required during the design phase to manage risks and maximise opportunities.
- Health and safety implications on workers in deconstructions need to also be assessed.
- Use of overstock may be easier to reuse than post-consumer waste arising from deconstruction due to the known composition and condition of the material.

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Re-use potential: Material profile

Resources and references:

1. Leroy, C. et al, Reconciling recycling at production stage and end of life stage in EN 15804: the case of metal construction products, 2019 IOP Conf. Ser.: Earth Environ. Sci., 323, 012049
2. Dunant, C. F., et al, Options to make steel reuse profitable: An analysis of cost and risk distribution across the UK construction value chain, Journal of Cleaner Production 183 (2018) 102e111
3. Carpenter, A., CO2 abatement in the iron and steel industry, CCC/193, IEA Clean Coal Centre, January 2012
4. WRAP's Reclaimed building products guide, link
5. Eurofer 2012 survey (Tata Steel, 2020)
6. Cullen and Drewniok, 2016, link
7. Densley Tinley et al, 2016
8. SCI Publication P427, Structural Steel Reuse

Stockists:

- EMR Ltd, (www.emrltd.com)
- Ainscough Metals, www.ainscoughmetals.co.uk
- Cleveland Steel & Tubes Ltd, (www.cleveland-steel.com)
- Opalis, (https://opalis.co.uk)


Bricks

Bricks

Re-use potential: Material profile

Summary

Whilst brick re-use is technically feasible, either reuse from the existing building, site to site reuse, or from the market, it isn't without challenges. It is unlikely to save significant quantities of carbon (if any), although there may be heritage benefits to re-using bricks from an existing building.

Where bricks are to be re-used, known provenance should be ensured, transport and processing should be minimised, and stocks well managed (careful-handling, storage, security).

Introduction

Clay 'facing' bricks are typically used in building facades and landscaping. Up until the mid-20th century, clay 'common' bricks were typically used in the non-visible structural core of masonry facades and for internal partition walls.

Current practices

A case study included in a report from BioRegional and Salvo from 2008 stated that of the 3 billion bricks arising from building demolitions in 2007, 10% were reclaimed for reuse[1].

Most typically at 'end-of-life', bricks are crushed for reuse as low-grade aggregates. These are commonly used for road base materials.

Bricks

Re-use potential: Material profile

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Recovery for reuse

In some instances, reclaiming of bricks for reuse is carried out, but it can be a labour intensive and costly process.

Face bricks versus common bricks

One of the challenges in recovering and re-using bricks is that not all bricks within a façade will be the same. In the UK, most buildings up to about the 1920s were constructed from load-bearing brickwork masonry (more latterly, grander, taller buildings were constructed with masonry encasing steel frames). Either way, the brickwork was solid, rather than cavity construction. The bricks fell into two categories:

‘Facings’ - facing bricks selected for their appearance and durability (frost resistance etc.), and laid to a high degree of precision as the outer face of the facade, and:

‘Commons’- common bricks used for the non-visible parts of walls, so not selected for appearance and not necessarily durable to frost etc.

Usually, only facings are worth recovering. The commons are uneconomical to recover because their market for use in the non-visible parts of walls has largely been replaced by concrete blocks and steel or timber stud walls.

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Bricks

Re-use potential: Material profile

Challenges with disassembly/reuse:

- Most reclaimed bricks will not have been tested to modern standards (BS EN 771-1) and may not be durable (frost-resistant/resistant to sulfates). Their water absorption and compressive strength may also be variable.
- Recovery from the existing building: Only a proportion of the bricks will be desirable for reuse (facings versus commons) and some will be broken during deconstruction, cleaning, storage and transportation. It is likely that only a small proportion of the bricks will be ultimately re-used.
- It is likely that the bricks will need to be processed somewhere off-site. It is estimated that bricks should not travel more than 250 miles by road; beyond this the transportation may have a greater impact than new material manufactured locally.
- Whilst there are readily available second-hand bricks available on the market, it can be very challenging to determine provenance and technical performance of the bricks.

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Re-use potential: Material profile

Challenges with disassembly/reuse cont.:

- Disassembly of bricks can be time consuming and costly. Older load bearing walls tend to be made of weaker lime mortars which sometimes means the bricks can be carefully dismantled by hand. In the early 20th century, stronger lime mortars and cementitious mortars became more prevalent which makes recovery of bricks more difficult, as the mortar is difficult to remove without breaking the bricks.
- The process of preparing bricks for reuse is laborious and usually involves chipping the mortar away by hand with potential health & safety issues. Immediately the cost of doing this exceeds the cost of making new bricks, so is only economically viable where the bricks have heritage value and/or a characterful appearance that cannot be replicated with modern brickmaking techniques.

Bricks

Re-use potential: Material profile

Recommendations if reuse is pursued:

Bricks recovered from existing building:

In evaluating the feasibility for recovery of bricks, a careful dismantling trial should be carried out by a specialist. This should consider an estimation of the percentage of salvageable brick based on: how difficult it is to remove the mortar from the bricks, and an allowance for further bricks being broken during transportation, storage and delivery.

Bricks should be processed as locally as possible to ensure transportation impacts do not negate carbon saving benefits of reuse. 70% of new bricks used in the UK are manufactured in the UK[1] (mainly England), the remainder mainly imported from northern Europe (the Netherlands, Belgium, Germany and Denmark). Whilst bricks can come from anywhere, transport distances from factory to site average 70 miles[1] in the UK and so a brick sourced from a modern, energy efficient brickworks in southern England may in fact have a lower embodied energy when compared to a brick which has been dismantled on a site in London, taken by lorry some way outside of London for processing and returned to site, potentially doubling the transport movements.

Bricks

Re-use potential: Material profile

Recommendations if reuse is pursued:

Bricks procured from the market:

Reputable sources (reclamation merchants) should be sought. Provenance of the bricks should be identified and testing should be carried out to determine durability and strength, although bricks will vary hugely so testing is only ever indicative.

Reclaimed bricks should be sourced as locally as possible. Design consideration should be given to using local brick types. For example, the ‘London Yellow Stock’ bricks commonly seen on pre-railway era London buildings were made in Kent or Essex and just across the Channel in the Netherlands (where they were made for the London market and imported as ship’s ballast). Such bricks are rarely seen outside of London and so reclaimed London bricks are unlikely to have travelled far.

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Re-use potential: Material profile

Stockists:

- London Reclaimed Brick Merchants (https://www.lrbm.com/)
- Windsor Reclamation (https://www.reclaimed-brick.co.uk/)
- Cawarden (https://cawardenreclaim.co.uk/)

Resources and references:

1. Pushing Reuse: Towards a low-carbon construction industry, 2009, Salvo Llp and BioRegional, Link
2. WRAP's Reclaimed building products guide
3. BDA comment on the use of Reclaimed Clay Bricks, Brick Development Association (BDA), January 2014, link

Timber

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Timber

Re-use potential: Material profile

Summary

Using reclaimed timber can have very variable cost implications, from cost savings of up to 80% through to cost premiums up 200%, depending on the application and quality of the reclaimed timber. Typically, where there is a cost premium there is aesthetic or historic value in the material.

According to the BedZED Materials Report, reclaimed timber can offer 83% reduction in environmental impact.

Introduction

The following use cases were explored:

- Beams: Structural beams, non-structural cladding of rolled steel joints.
- Joists: Suspended floors, purlins, other structural applications.
- Studwork: Structural and non-structural applications.
- Timber floorboards, parquet flooring
- Timber street furniture

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Timber

Re-use potential: Material profile

Current practices

- A survey conducted by Salvo in 1998 indicated that annual sales of reclaimed timber beams, joists, trusses, planks, sleepers and baulks totalled £42m (51% softwood, 38% native hardwood and 11% tropical hardwoods). The total tonnage and the total number of businesses trading these materials has since risen.
- The classification of 'salvaged timber' in this survey included softwood studding, modern staircases, mouldings, scrap timber and cheap modern furniture. Approximately 30% of wood available was salvaged.

Recovery for reuse

Timber joists and studwork can be salvaged without requiring specialist labour and are more widely available than beams, doors and floorboards.

Timber

Re-use potential: Material profile

Challenges with disassembly/reuse:

- The processes required to source or deconstruct, test, inspect or post fabricate the material will often increase the lead time and labour required, leading to higher costs and extended project schedule. However, the cost and carbon savings could offset this.
- Reclaimed timber flooring may require more skill to lay to avoid trip hazards as the old boards will typically have some warping.
- Reclaimed beams are often better-quality timber however they are typically available at a cost premium.
- Reclamation outlets generally hold large stocks of beams to meet most small to medium sized orders immediately, however, very large orders would take time to source the beams and could extend the project schedule depending on availability.
- Oak will typically be sourced from France which increases the embodied CO_2 of the reclaimed material due to the long haulage distance.

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Recommendations if reuse is pursued:

- Design teams are encouraged to be flexible in terms of the size and species of timber specified.
- Savings can be achieved by specifying timber studwork in place of aluminium studwork.
- Timber windows, although typically cheaper, attract a higher maintenance cost.
- Designers should establish the optimum length for supply of studwork and ensure that the floor to ceiling height is designed around this length. Reclamation outlets typically prefer to supply 2.4 - 2.8m lengths, rather than 4m lengths as the shorter lengths are easier to source.
- Studwork is typically supplied de-nailed from reclamation outlets.
- Strength grading requires a specialist. Engineers on the project team can undertake a stress graders' training course in order to do the assessment.
  - Visual strength grading can be done to establish grade, disease, infestation, paint and bitumen contamination and straightness.
  - Moisture content of studwork is important for use inside buildings, this can be measured during the strength grading process.

Timber

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Re-use potential: Material profile

Recommendations if reuse is pursued:

- Strip flooring needs to be taken up with care to avoid damage to tongue and grooves. Specialist timber reclaimers will work faster and produce less wastage.
- Block flooring can be labour intensive to clean, hence it is not as widely traded as timber floorboards.

Resources and references:

1. WRAP's Reclaimed building products guide, link
2. Beddington Zero (Fossil) Energy Development, Construction Materials Report, link

Stockists:

- Reclaimed Timber, (www.reclaimed.uk.com)
- Oak Beam UK (https://www.oakbeamuk.com)
- Lower cost oak beams are available from material exchange websites such as www.salvomie.co.uk.
- National Community Wood Recycling Project,(www.communitywoodrecycling.org.uk)
- LASSCO, (www.lassco.co.uk)
- Opalis, (https://opalis.co.uk)

Plasterboard

Plasterboard

Re-use potential: Material profile

Summary

Reuse of plasterboard is currently not wide spread and we have not identified any suppliers of reclaimed plasterboard to date. As such, it is anticipated that the greatest opportunity for reuse of plasterboard may be recovery from the existing building or from other construction sites.

Introduction

Plasterboard is most commonly used in partitions, wall lining and ceilings.

Plasterboard is traditionally formed from a gypsum plaster core with a paper facing. In Europe, over 1,600 million metres of plasterboard is used in building interiors per year (EU 2016). The gypsum component of plasterboard can be ‘indefinitely’ (closed-loop) recycled because its chemical composition does not change. Despite this, a large proportion is landfilled and backfilled due to economic factors. Up to 1.3 million tonnes of plasterboard waste is generated within new build construction and refurbishment sectors per year.

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Plasterboard

Re-use potential: Material profile

Current practices

- Currently, approximately 7.5% of all new plaster and plasterboard is wasted before use. Waste arises during installation through design, damaged boards, offcuts and over-ordering.
- Approximately 10-35% of waste occurs on site leading to 300,000 tonnes of waste per year from this source in the UK alone (WRAP).
- Plasterboard that is not contaminated can be recycled into plasterboard products or alternative uses. Most recovery methods for on-site waste plasterboard rely on on-site sorting of components (WRAP).
- Uncontaminated plasterboard can be crushed and used as fertiliser.
- Recycling of plasterboard is mature, however reuse is still nascent.
- Plasterboard is often skimmed with gypsum plaster after installation which cannot be removed, making it unsuitable to re-use.

Plasterboard

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Re-use potential: Material profile

Recovery for reuse

- Reuse is currently not wide spread.
- Some organisations, such as British Gypsum, have developed a cost-effective process to take back and recycle plasterboard waste.
- Closed loop recycling is developing, it involves close collaboration among all stakeholders throughout the value chain.
- Deconstruction will enable greater reuse and recycling to be achieved.

Challenges with disassembly / reuse

- Demolition practices instead of deconstruction contribute to the low reuse rates of plasterboard; plasterboard installation is not design for disassembly. If not nailed, screw heads are covered with plaster making them inaccessible.
- Storage and transportation need to be carefully considered so that stock is not damaged from impact, contamination or moisture. Safe handling is important for keeping plasterboard from waste streams.
- Reliance on on-site sorting can be difficult for smaller construction sites where disposal container spaces may be limited, and the quantities of plasterboard waste may be small thus reducing the cost effectiveness of recovery (WRAP).

Plasterboard

Re-use potential: Material profile

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Recommendations if reuse is pursued:

- Further work is needed to evaluate the potential to recover plasterboard from the existing site or from nearby construction sites.
- Synchronization with other sites that require plasterboard can minimise the volume entering the waste stream.
- Specifications should minimise generation of offcuts and allowances for flexibility can create the opportunity to stagger boards to make use of any offcuts generated.
- Procurement considerations, such as high recycled-content, should be prioritised.
- Options for a responsible sourcing scheme should be explored (DEFRA 2013).
- Actions to combat waste include: labelling boars, using packaging system to enhance stability of the pack and reduce slippage, and safe handling guidance (DEFRA 2013).

Plasterboard

Re-use potential: Material profile

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Resources and references:

- Plasterboard Sustainability Action Plan, 2013, DEFRA, Link.
- Putting plasterboard waste to good use, 2016, EU, Link.
- Plasterboard waste recovery from smaller building sites, WRAP, Link.
- Circular Economy for the Construction Sector, 2016, Gypsum to Gypsum, Link.
- Plasterboard Recycling, n.d., British Gypsum, Link.

Sources and stockists:

- No identified sources of reclaimed plasterboard identified to date.

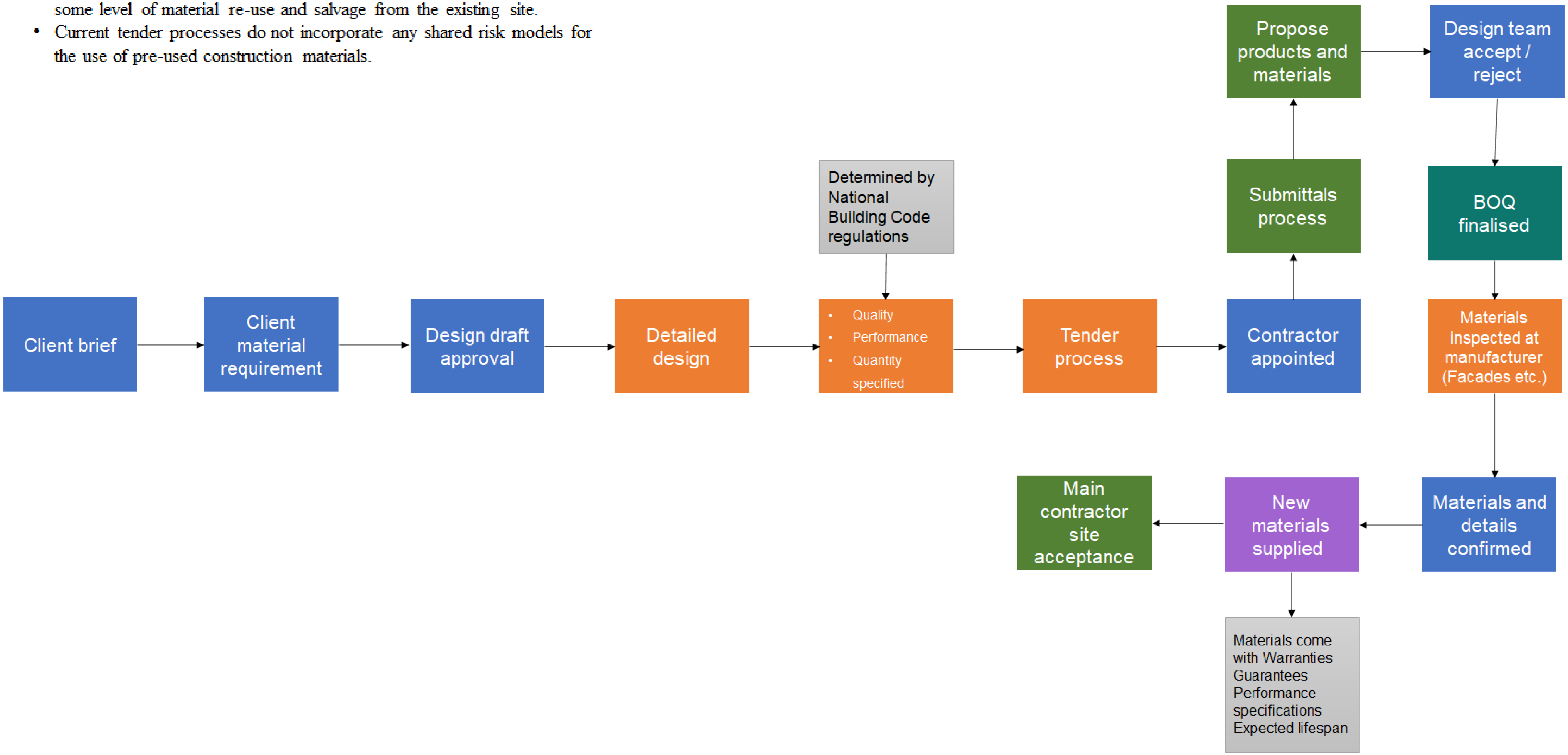
Project workflow vision

In evaluating how we can transition to integration of re-used materials within a construction project, we first need to understand the current design and procurement process.
With this mapped, we next identify the points in the process where considerations for pre-used materials will need to be considered to successfully facilitate material re-use.
The following three pages present our mapped business-as-usual scenario, followed by our vision.

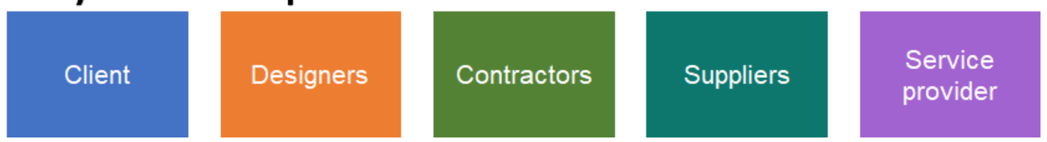
Building construction material procurement
Business as usual

Assumptions

- New builds do not procure any pre-used materials for the purpose of this study.
- Refurbishment projects or demolition projects are likely to incorporate some level of material re-use and salvage from the existing site.
- Current tender processes do not incorporate any shared risk models for the use of pre-used construction materials.

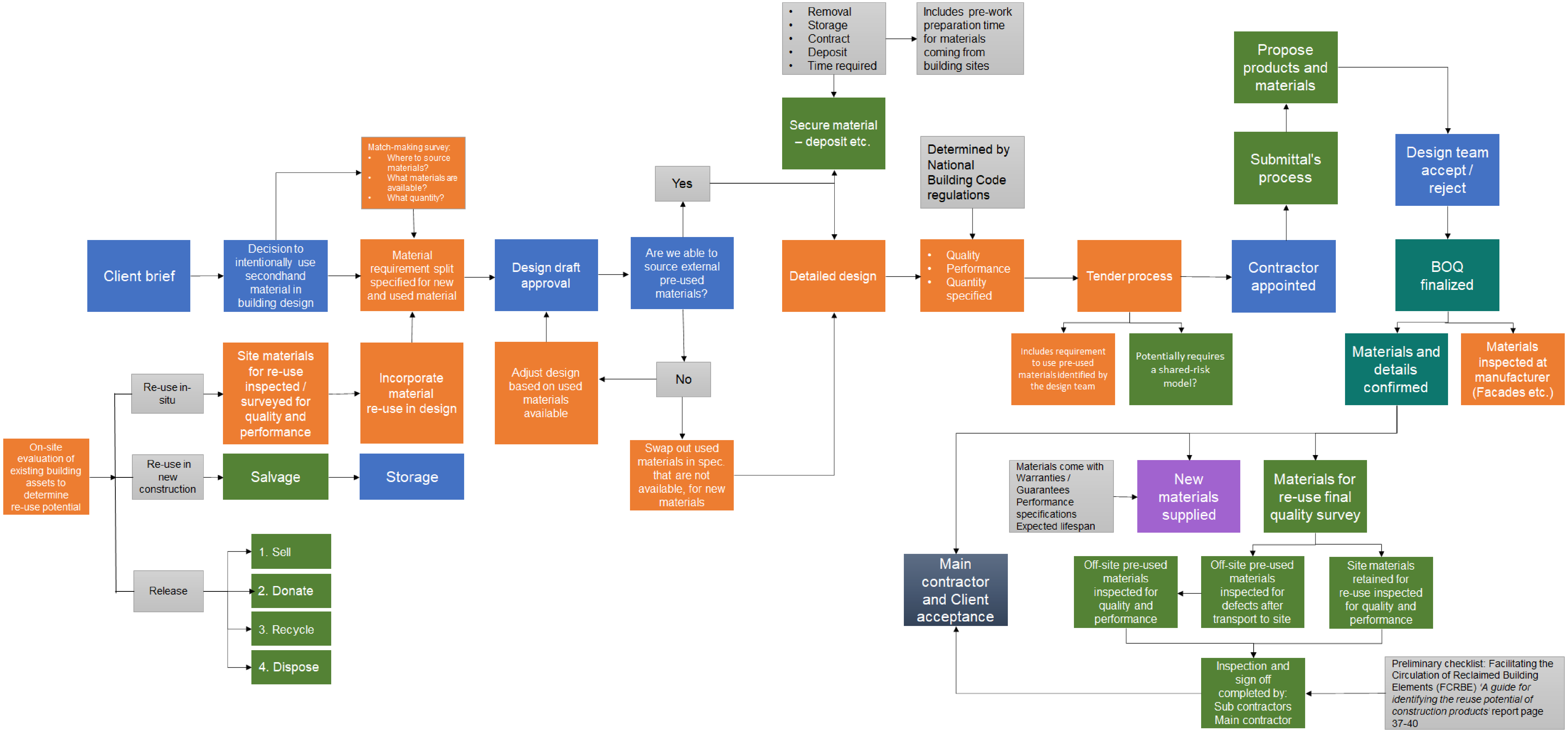


Key for responsibilities

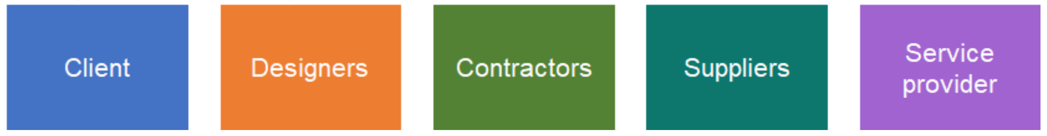


Building construction material procurement
Circular approach to facilitate material re-use

This workflow presents our vision for the additional steps required from design to construction for pre-used materials to be successfully incorporated within a project.

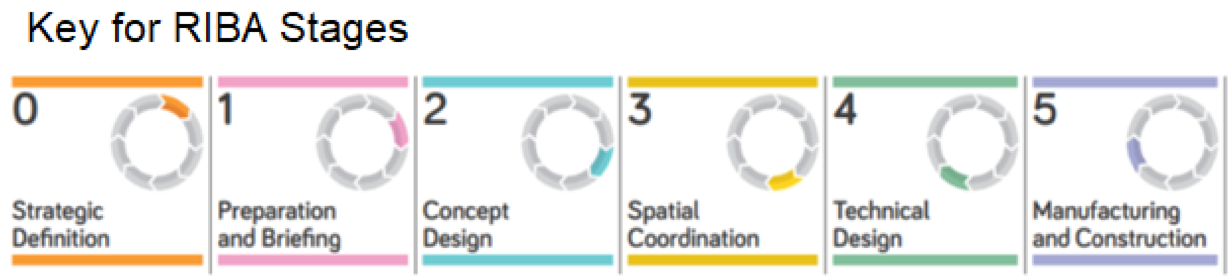


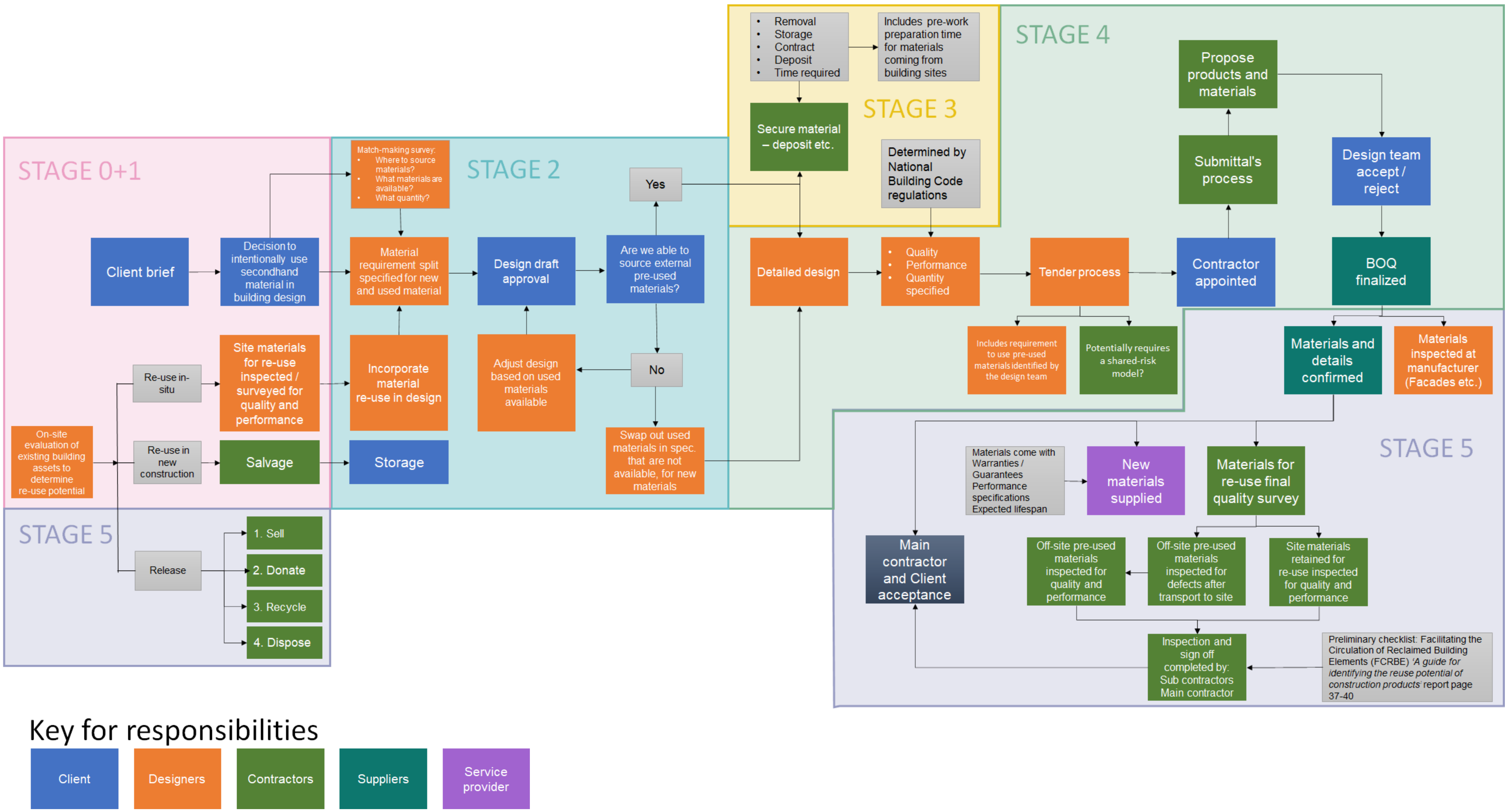
Key for responsibilities



Building construction material procurement
Circular approach to facilitate material re-use

This slide provides indication as to how these workflow stages relate to the RIBA Stages of design. They are indicative, and this should be updated as project experience dictates. This assumes a design-bid-build delivery.





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Want to find out more, discuss your ideas for materials re-use, or share your case studies? Connect with us at:
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