Don't Throw Your House Away !

Careful! Your house is full of carbon.
Here are some difficult questions to ask yourself and your architect before you throw it all away.

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Mike Tuck Studio

We are a small but dedicated team of designers with a broad range of interests and specialties. We work on all kinds of projects from house renovations to school masterplans and the conservation of listed buildings, but the lasting focus of our practice continues to be domestic renovations and we want to do what we can to decarbonise this sector of construction.

In the face of the climate crisis, millions of UK homes need a deep and thoughtful thermal retrofit so that we can decarbonise our energy sources, but thermal retrofit needs decarbonising too and we are increasingly concerned with the carbon-heavy nature of popular thermal retrofit methods. Plastic-based foam insulation boards such as PIR (polyisocyanurate) insulation are derived from fossil fuels, and their inorganic structure won't allow a house to breathe. **We will not succeed in decarbonising our homes if we wrap them all in plastic.**

To us, a sustainable practice means working with existing building elements and reclaiming materials from demolition wherever possible, on the principle that the most sustainable materials are those that already exist. We see it as our role as architects to explore what the material culture of this practice is, and to prove that the sustainable choice can also be beautiful.

This guide was funded by the Royal Institute of British Architects, and produced by Ellen Peirson, George Regnart and Mike Tuck at Mike Tuck Studio.

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Mike Tuck **Studio** RIBA

IMAGE CREDIT: ELLEN PEIRSON

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IMAGE CREDIT: ELLEN PEIRSON

Introduction!

Embodied carbon is usually measured as the global warming potential of greenhouse gas emissions associated with the construction of a building: the extraction, manufacture, transport, assembly, maintenance, replacement and waste of all materials that make up the building and construction process. For this project we have generally used A1–A3 measures of global warming potential that quantify the greenhouse gas emissions from the product stage of a material's life cycle: raw material extraction (A1), transportation to manufacturing (A2), and manufacturing processes (A3). Collectively known as 'Cradle to Gate' emissions, they account for impacts before the product leaves the factory. These figures therefore do not account for carbon sequestered by a material either before it is extracted or during its life, as this carbon will later be released into the atmosphere when the material breaks down, leading to an underestimation of the embodied carbon.

The embodied carbon of the UK construction sector accounts for over 10% of national carbon emissions. Yet, to date, government research and policy has focused on the regulation and reduction of operational carbon use. Private residential work in the UK is the largest single construction sector (around £37bn annually) and yet it has been slow to make progress with decarbonisation compared to the commercial sector.

That is to say, that your house is jam-packed full to the brim with carbon - and what you do with that carbon is completely up to you. Will you throw it all away, or will you keep the carbon locked in your home, and out of the atmosphere?

Residential extensions in the UK typically involve the use of traditional building materials, such as brick, blockwork, and steel, which have high embodied carbon. They involve a lot of waste, where swathes of material is removed to make open plan spaces.

Largely, the decisions you make that will have the biggest impact on the carbon emissions of your home renovation, will be the strategic ones you make at the very beginning of the project. Wherever possible, materials should be reclaimed or plant-based, and the existing building material just be kept in your house.

Have you ever been anxious about the carbon emissions of taking an extra flight? Tried to reduce your meat and dairy impact as you see the destruction its wreaked on the Earth? Cycled or walked to work to do your bit to improve your neighbourhood's air quality? Well, the emissions associated with the concrete foundations of a typical London house extension could fly you from London to New York and back twice, and the steel in a typical loft conversion contains the same embodied carbon as the average person's meat, dairy and beer consumption for an entire year.

Nobody is asking you to regulate your house's carbon consumption, but if you want to, this guide will give you some helpful tips!

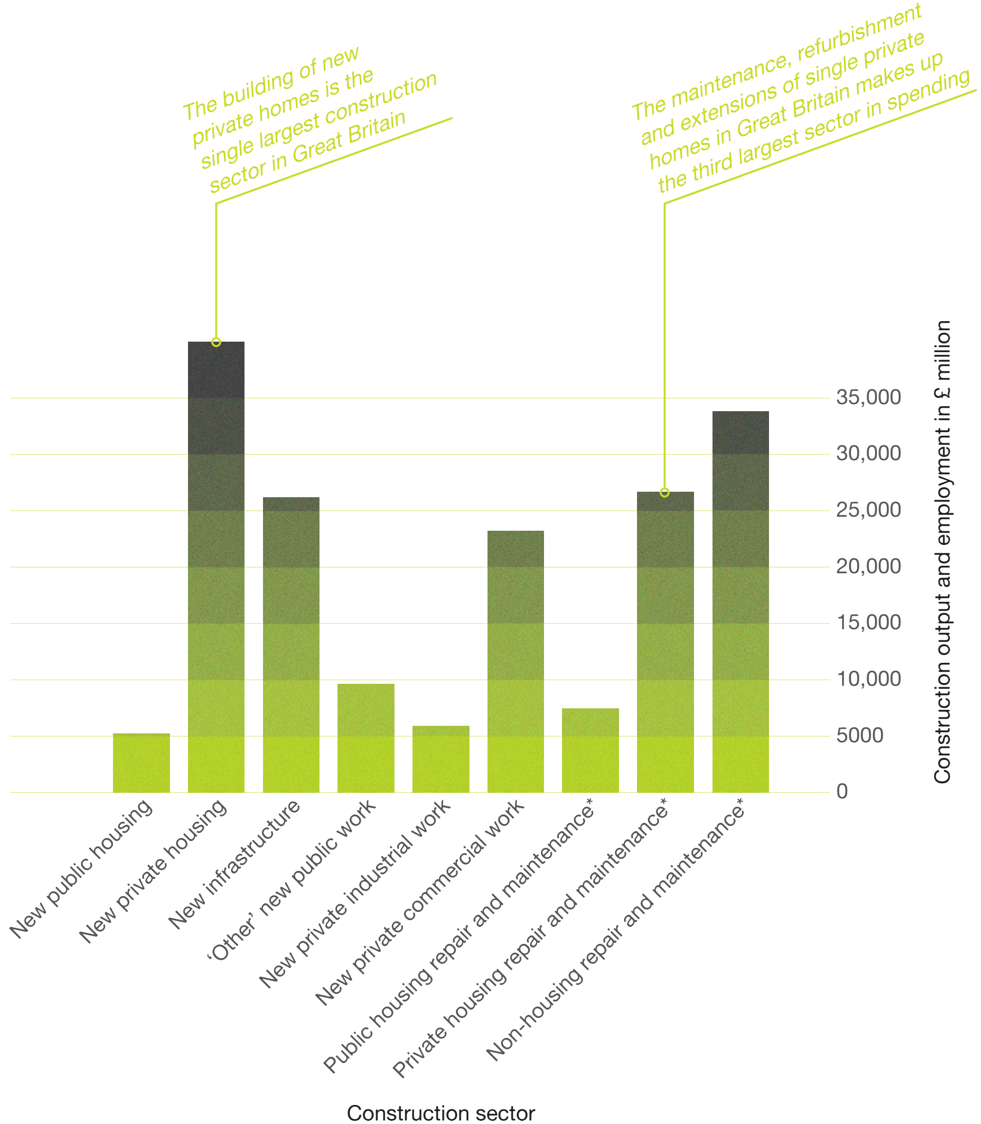
Of the UK construction industry, small-scale residential architecture – that is private residential maintenance, renovation and extension projects – is one of the largest construction sectors, valued at £26bn annually, which is equal to the infrastructure sector. The idea of owning a home, and making it one's own, is as tied to our national identity as steel production, and so it is no surprise that spending in this sector is so high. But as well as fuelling our economy, this domestic consumerism produces huge amounts of waste, and in turn, carbon emissions. Buying a house now often involves knocking walls down, ripping floors up and throwing appliances away: pasts obliterated in old houses in the name of domestic change. This is thought of as being a deeply personal endeavour, but there are global flows of materials and supply chains that run through a home, and they have consequences far beyond its four walls.

Still, many of our homes are cold, damp and have been treated poorly over the decades. They need retrofitting and decarbonising, but this process should not eradicate the carbon that is already 'locked into' these houses, and dishonour the numerous histories they hold. Homes are always haunted by previous inhabitants, and an architecture that denies this is not an ecological one.

Like food, the home is ultra-processed: reams of gypsum sandwiched between paper in plasterboard; MDF cabinets of wood fibre, urea formaldehyde and paraffin wax, wrapped in petroleum-based veneers; hard-wearing Quartz countertops of mined silica. What do we do with these harmful materials that are already in our homes? And surely we shouldn't put more in?

CONSTRUCTION OUTPUT AND EMPLOYMENT IN GREAT BRITAIN BY SECTOR BETWEEN AUG 2019 TO JULY 2024, MEASURED BY £ MILLION

Reference: Output in the construction industry, Office for National Statistics



* ONS have confirmed that 'repair and maintenance' includes extensions


IMAGE CREDIT: ELLEN PEIRSON

Where is the carbon in my house?

Much of the carbon content of your home is already in it - your job is to keep it there, and make sure anything you are adding is reclaimed or plant-based.

It is suggested by the Institute for Global Environmental Strategies (IGES) that a reasonable 1.5 degree lifestyle comes with an annual carbon budget per person of 2500kg of CO_2.

A typical ground floor side-return extension will have 2268kg of CO_2 in the concrete foundations and slab, over 1000kg of CO_2 in the brick and block work, almost 900kg in associated steel posts and lintels, and over 800kg of CO_2 in new aluminium windows and doors. All of these new products, and added together to the services, finishes and roofing, amounts to 8900kg of CO_2! This is before you've even furnished the kitchen, and it's five times your yearly carbon budget. If you want to do your loft conversion as well, that's an additional 6000kg of CO_2.

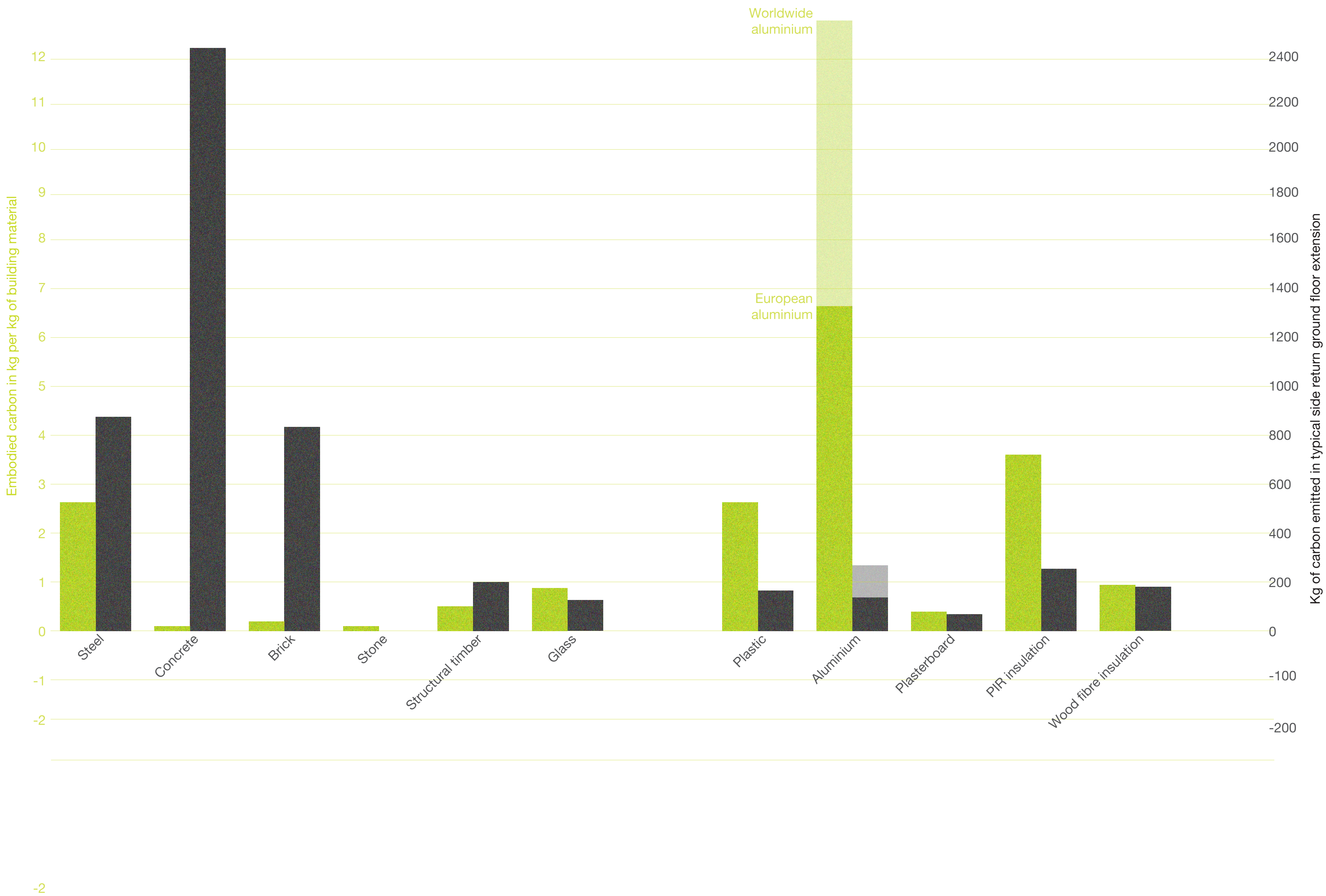

Ground floor and loft extension
14 900kgCO2e

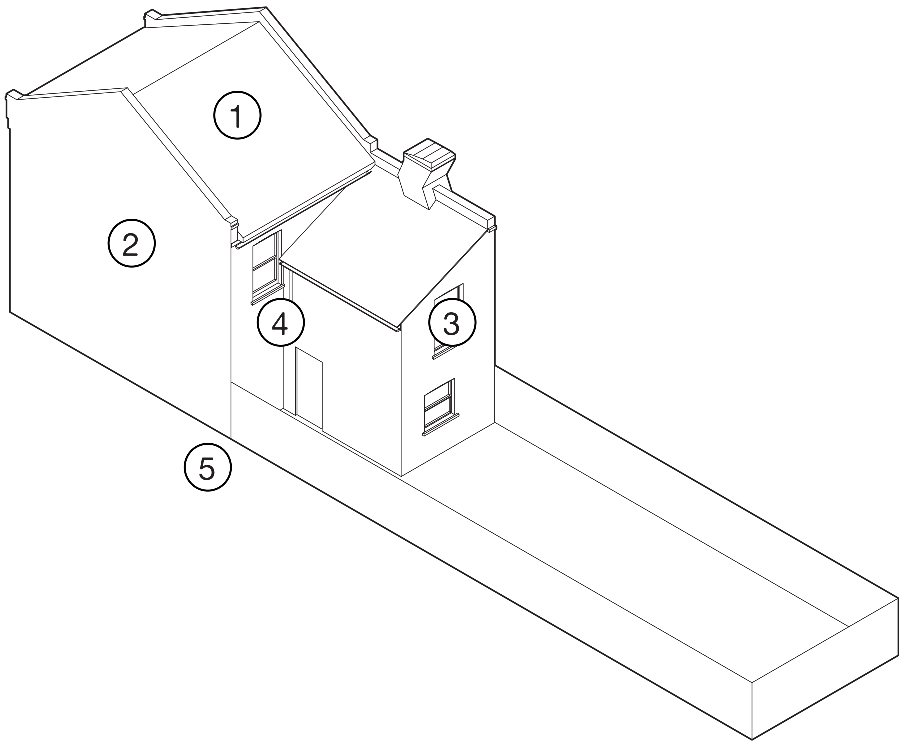

A return flight from
London to New York
1180kgCO2e


New iPhone 16 Plus
74kgCO2e


One year's worth of
meat consumption
790kgCO2e


Yearly use of an
average UK car
1393kgCO2e

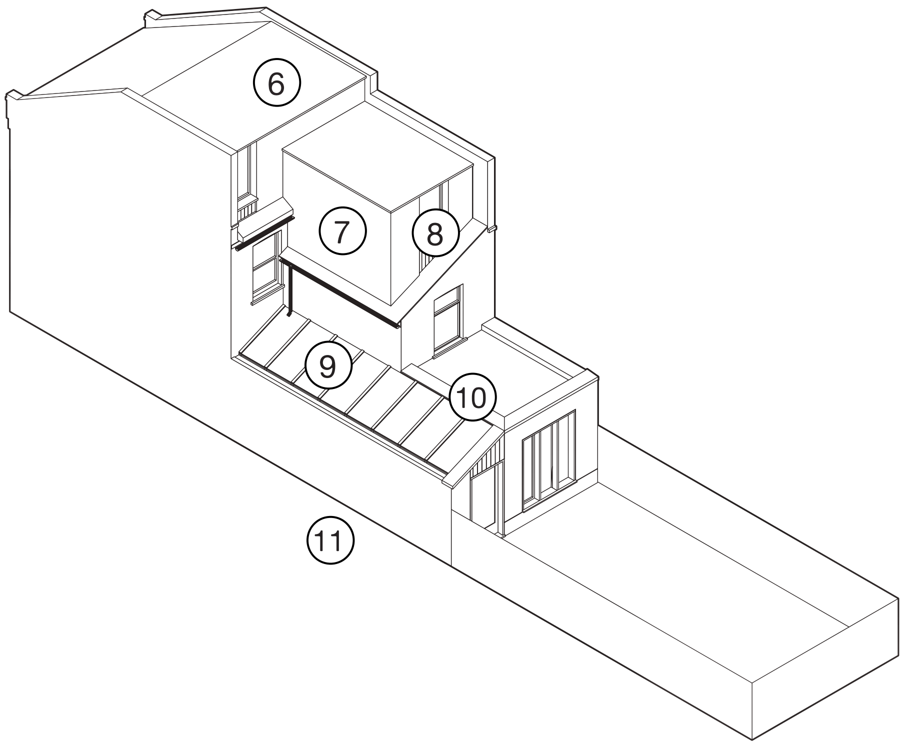

Worldwide aluminium
European aluminium
Embodied carbon in kg per kg of building material
Kg of carbon emitted in typical side return ground floor extension
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-100
-200
Steel
Concrete
Brick
Stone
Structural timber
Glass
Plastic
Aluminium
Plasterboard
PIR insulation
Wood fibre insulation
-2



SPENT CARBON

These materials have already locked in carbon during their production. When they are still functional, it is important to preserve and maintain them to avoid generating new emissions.

1. Existing roof tiles are typically made from concrete, clay, natural slate, or man-made slate. Roof extensions can look to reuse the tiles that will be removed to create a new opening as hanging tiles facade treatment to the dormer walls. There are frequently active and logical circular economies existing around roof tiles, with many looking to replace broken tiles with ones that match there existing tiles.
2. Party walls are integral to the structure of terraced houses and cannot be demolished – the carbon stays!
3. In many older London terraced houses, PVC windows might have replaced the original timber frames. While timber or aluminium windows may be more aesthetically pleasing, the PVC already represents locked-in carbon. Replacing functional PVC windows prematurely releases this embodied carbon into the atmosphere.
4. The heavy brick flank walls of the main house and outrigger embody a significant amount of carbon due to their material mass. Any structural modifications, such as creating new openings on the ground floor, require additional carbon-intensive elements like steel beams and lintels.
5. The original foundations of a London terraced house were designed for the load of the existing structure. Adding extensions or extra floors increases the load, often necessitating underpinning or foundation reinforcement. These processes use carbon-heavy materials like concrete and steel. To mitigate this, try to work within the limits and logic of the existing foundations, and only resort to underpinning when structurally essential.



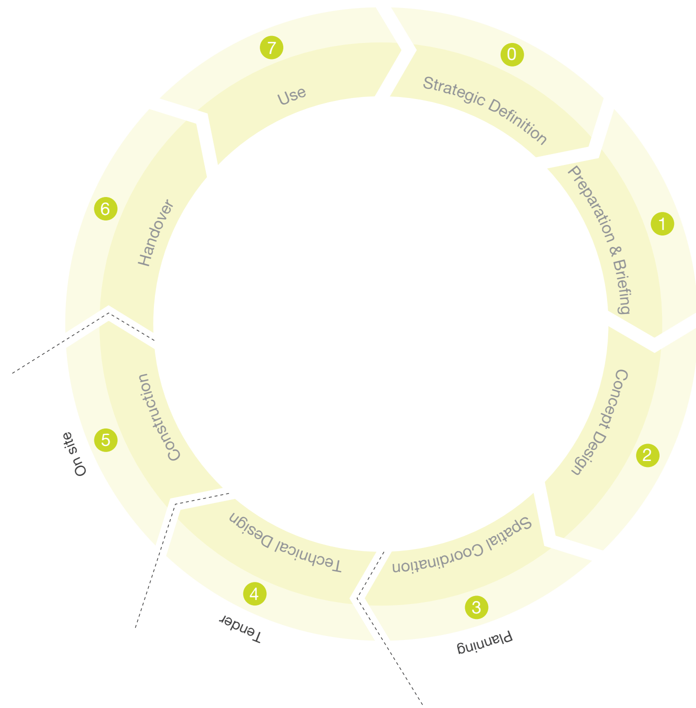
ADDED CARBON

You will be adding a lot of material to your home as you refurbish and extend it, as well as making decisions on the layout of your house that have carbon-heavy structural implications.

6. Dormer extensions involve superstructure but no substructure, making them intuitively less carbon intensive than ground floor extensions. The superstructure will be where the bulk of the carbon is, and therefore this should be carefully considered.
7. Selected low-carbon, natural materials for the dormer walls that minimise emissions and offer energy efficiency. Under permitted development, there is little scope for creativity in facade treatments, but if the council mandate slate, you can ensure it is natural slate instead of man-made. Natural insulations like woodfibre and hempcrete are amazing – they are carbon sinks, capturing emissions from the atmosphere, but they are also hygroscopic, meaning that they have better thermal properties than a PIR insulation of the same U-value (measure of thermal transmittance) due to their ability to draw in moisture from the environment. They will reduced the embodied carbon of your extension, keep you warm, and give you a much healthier air quality.
8. You will need new windows for your extension, but consider tapping into circular economies from larger scale construction through initiatives such as Green Windows, who sell on windows that were either mismeasured or surplus to requirements on large developments. These are often one offs so must be bought/reserved at the planning stage and designed around.
9. A side return extension can create a wide open plan space but also requires a huge amount of structure. How open plan does your space really need to be, and is it worth the carbon?
10. Wrap-around extensions open two sides of a structure, supporting the corner of your house with a complicated grid of steel. Is this necessary to you, or can you extend to the side and out to the back, while maintaining a lot of the brick walls, and only using shorter lintels instead? Smaller openings require much less carbon in order to span.
11. Underpinning may be necessary to support the increased load ont the foundations of your house. Also, if there are existing trees with deep roots near the proposed extension, then you may require deeper foundations. Work with the existing trees to avoid felling or moving them.

What questions do I need to ask, and when?

A successful building project hinges on careful planning, clear communication, and informed decision-making. The RIBA Plan of Work provides a structured framework divided into stages, each offering critical opportunities and project markers, so you can ensure you ask the right questions about sustainability at the right time.

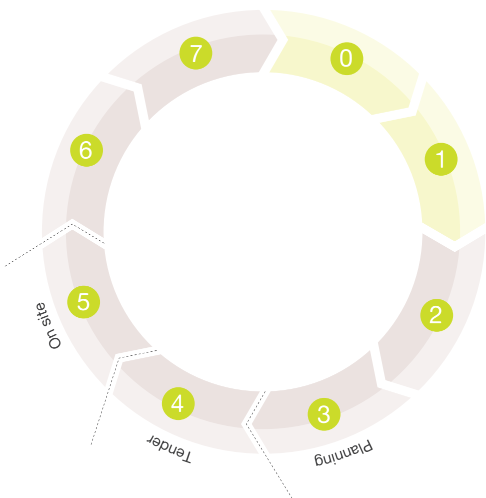


RIBA Stages

WHAT IS RIBA STAGE 0-1?

What do I need?

This stage is not about design but is where you consider and interrogate what your brief for the project is, in line with what your desired outcomes are. This is a crucial part of the project and where the architect can add a lot of value, though it is often conducted through conversations and quick sketches – the aim is to assess options and consider where the project is feasible and is achievable within the various regulatory and structural restrictions. It is also the point where the architect will help you identify necessary consultants.



QUESTIONS TO ASK AT RIBA STAGE 0-1

1. Do I need an extension or loft conversion?
   Assess your current space and needs thoroughly. Could reconfiguring existing rooms meet your requirements without additional construction? Consider whether the benefits of an extension or loft conversion justify the carbon footprint and cost.

2. Is it better for me to move house instead?
   Before committing to a large-scale refurbishment, consider whether relocating might be a more sustainable option. Particularly in London, the cost of construction is often not realised in the value of your house these days, so if more space is what you require, it may be worth moving to a larger property.

3. Will I use the spaces I want to create?
   Will they add genuine value and functionality, or could they become underused? Prioritise spaces that enhance daily life.

4. Where are the drainage locations on-site?
   Avoid designs that require spanning or diverting drainage, as these often involve carbon-intensive structures.

5. What are the ground conditions and tree locations?
   Understand soil conditions and identify trees with problematic roots. This information supports efficient foundation design and helps avoid unnecessary excavation or carbon-intensive underpinning later in the project.

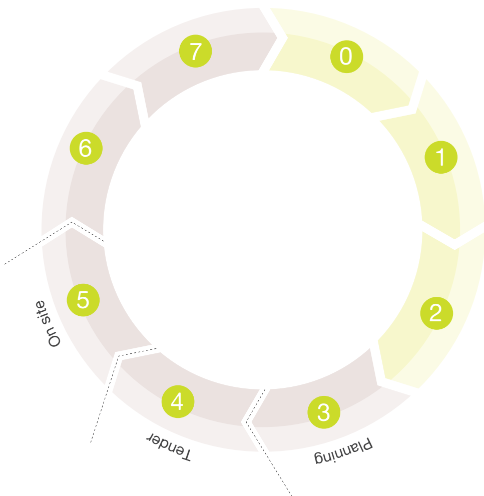
6. Is a loft conversion a viable alternative to a ground-floor extension?
   Loft conversions generally have a lower carbon footprint than extensions. Can internal spaces be reconfigured to free up the ground floor and make the most of a loft?

7. Are there planning constraints or local regulations to consider?
   Research local planning policies and guidance early. Constraints might influence the structure and material choices of extensions and conversions. For example, dormers are required to be set back from the existing eaves by 200mm, and if this takes the new dormer wall off of the existing rear wall of the house, then additional steel is required.

WHAT IS RIBA STAGE 2?

What do I want?

This is where we start to draw! We will start to develop initial options and consider key concepts and ideas that will start to give shape to your brief. These designs will not be sufficient to take to a contractor and build from them, but will allow you to imagine the size and kind of spaces you want to create. It is also when we will engage with the planning authority for pre-application advice, if necessary, and other consultants.



QUESTIONS TO ASK AT RIBA STAGE 2

1. Can I retain the existing structure and retrofit?
   Assess whether the existing walls, floors, and roof can be preserved and upgraded to improve energy efficiency. Retrofitting minimises demolition waste and embodied carbon, making it a more sustainable option.

2. If parts of the structure need demolition, can they be used elsewhere?
   Can bricks, timber, or masonry be reclaimed for use in the refurbishment? Consider using demolished materials as hardcore, aggregate, or reclaimed finishes to reduce waste and embodied carbon.

3. If structural elements such as walls need to be removed, can my engineer support the spans with timber or engineered timber (like glulam or laminated veneer lumber) instead, or use reclaimed steel? Timber and engineered wood products are renewable materials with lower embodied carbon than virgin steel. Reclaimed steel has virtually no embodied carbon aside from the emissions associated with transportation and any new connections required. However, there are supply issues and finite sources, making it more challenging to source.

4. What are the carbon implications of supporting an existing storey?
   Extensions like side-return or wrap-around extensions, which support upper floors, often require more steel and concrete. Could a simpler rear extension reduce the carbon footprint while meeting your needs?

5. Audit fixtures and fittings for potential reuse or repair.
   Identify doors, handles, cabinetry, sanitaryware, and other fixtures that can be repaired, reused, or refurbished. This reduces waste and embodied carbon associated with new materials.

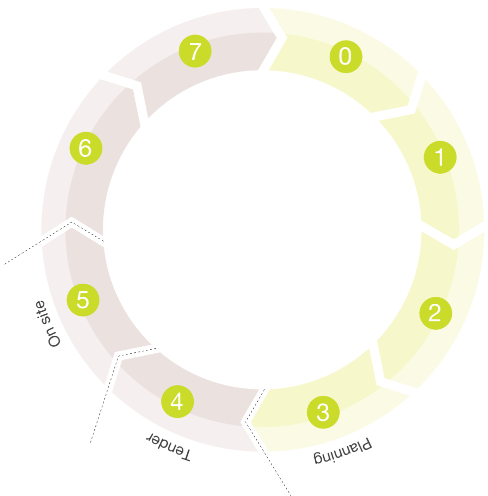
6. Can the existing internal finishes be retained or upgraded?
   Explore whether existing insulation or finishes can be upgraded rather than removed and replaced.

7. As well as reclaiming materials from the house itself, when introducing new materials can these be reclaimed or recycled? Consider reclaimed bricks and steel for structural work, and reclaimed timber, sheet materials, sanitaryware, tiles, flooring and much more for internal finishes.

WHAT IS RIBA STAGE 3?

How does it come together?

This is the stage where we prepare to submit a planning application or confirm compliance with permitted development rights. This is a key milestone in the design process that most projects will need to pass through, and mostly the point at which the envelope and external material choices will be set in stone. At the same time, Stage 3 is all about spatial coordination. We develop the design in greater detail, refining layouts and ensuring that all the major components of the building, including structure, mechanical, electrical, and plumbing systems, are well integrated. This is where we test the proposals to ensure they meet the brief, and we validate the assumptions made during the earlier concept stages by drawing up more precise and coordinated design information.



QUESTIONS TO ASK AT RIBA STAGE 3

1. Can roof heights be set at a level to allow for the use of timber structural elements?
   Timber beams are often greater in depth. The National Planning Policy Framework (NPPF) and states: 'There is a presumption in favour of sustainable development', and therefore if the increased roof height goes against recommended roof levels in the area's local planning guidance, to allow for timber construction, this case should be made in the planning application's supporting documentation.

2. Can roof heights and wall thicknesses be set at a level to allow for the use of natural or non-plastic insulations?
   Natural insulations, such as cork, hemp, or woodfibre, offer excellent thermal performance with a lower environmental impact than PIR insulations, however greater thicknesses are needed, which must be planned for.

3. Can natural rather than artificial slates be specified?
   Natural slates, made from stone, are highly durable, long-lasting, and can be recycled at the end of their life. They have a lower carbon footprint compared to artificial slates, which are often made from petrochemicals or require high-energy processes.

4. Can reclaimed brick or roof tiles be used?
   Assess whether these materials comply with Building Regulations, especially in terms of strength and durability. Investigate insurance implications.

5. Can you avoid aluminium or PVC windows?
   Aluminium and PVC windows have high embodied carbon due to their extractive raw materials of bauxite or and petroleum. Can alternatives like timber windows be used instead?

6. Can reclaimed windows and doors be used?
   Reclaimed windows and doors are a sustainable choice, reducing waste and the need for new manufacturing. Ensure they meet thermal, structural and security Building Regulations. Check these items are covered by insurers.

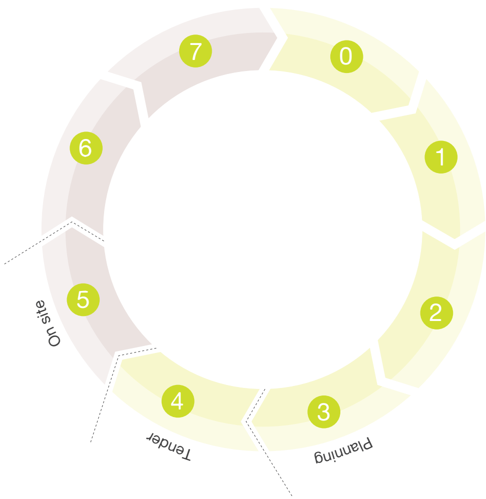
7. Can we externally insulate existing walls?
   External insulation typically requires rendering or cladding. Under Permitted Development (PD) rights, you can add external insulation without planning permission provided the materials match the existing appearance, but using brick slips or tiles will require a rigid insulation product like PIR, for it to fix to. Natural insulation can be rendered, but planning permission will be required if the new materials do not match the existing.

WHAT IS RIBA STAGE 4?

How will we build it and who will build it?

This is where we finalise the construction methods – the materials, structure, and systems we will use. We will prepare technical drawings, and depending on the project, a specification and schedule of works, which will be coordinated with the structural engineer's designs. The Stage 4 package can then be sent to builders to price the project, and on smaller projects can be taken forward with little involvement from an architect to construct the project directly with a contractor.

This is split into two sections: the technical design that governs the structural materials and methods employed, and the internal finishes that are more easily changed, but still hold a significant amount of carbon. Even if you are choosing to not extend your home, this is an important opportunity to keep track of the more overlooked carbon that you will introduce into your home.



QUESTIONS TO ASK AT RIBA STAGE 4

Technical design

1. Have we analysed ground and soil investigations with an engineer to optimise foundation depths and widths? By understanding the site's geology, we can reduce material use and costs while ensuring structural integrity.

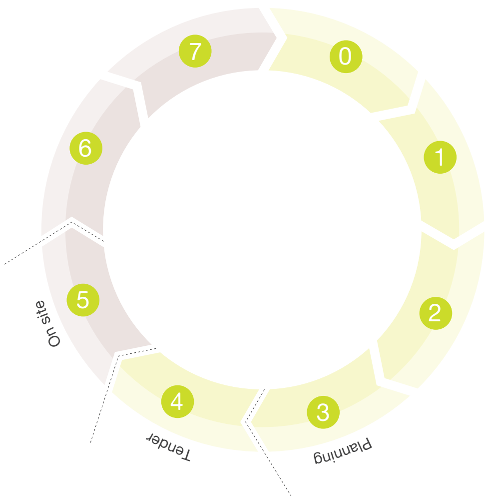
2. Where fireproofing is required, can we avoid intumescent paint? Intumescent paints often contain volatile organic compounds (VOCs) and other harmful chemicals that pollute the air. The production of them is energy intensive and disposal at the end of their life can be problematic, as the chemicals may leach into the environment. Using inherently fire-resistant materials or designing structural elements that meet fire safety standards without additional treatments, can be more sustainable and cost-effective.

3. Can we design out cold bridges to eliminate the need for plastic insulations? Cold bridges can lead to energy inefficiency and condensation problems. This approach may reduce or eliminate the reliance on high-performing plastic insulations, favouring more sustainable materials without compromising thermal efficiency.

4. Can we use reclaimed steel instead of virgin steel? Steel retains its strength incredibly well, and can therefore be reused, either from the existing site, or using a supplier such as Cleveland Steel who source steel from other buildings demolition. Unlike virgin steel manufacturers, Cleveland Steel will not provide steel connection drawings as standard, and therefore the structural design should prioritise using single lengths of steel so that these drawings are not needed.

5. Can I use lintels instead of a steel beam, and what is the lintel made out of? Smaller openings that use lintels should be prioritised over wider ones requiring large steel beams. Your structural engineer will often default to specifying a steel lintel, but a prestressed concrete lintel generally contains half the amount of carbon, or a reclaimed steel lintel uses next to no carbon. Alternatively an ecological option would be to span these openings using stone or timber. These options may be more expensive but come 'ready finished' as beautiful materials that can be incorporated into the house aesthetic.

6. Where steel might be necessary, can we use a compound timber/steel flitched beam to reduce the amount of steel required? Flitch plates combine steel with timber to achieve structural strength while using less steel. This involves splitting a timber beam in half, rotating one side by 180 degrees, and bolting a steel plate in-between the two sides.



Internal finishes

1. Can existing windows be reglazed instead of replaced?
   This can improve energy efficiency and extend their lifespan while preserving the building's character and reducing waste.

2. Are there existing materials that can be repurposed?
   Reclaimed timber can be used for flooring, cladding, or joinery, while rubble can serve as fill material or in landscaping.

3. Could existing kitchen units be reused and refurbished?
   Depending on the condition of the existing units, this can vary approach. Some doors may just need painting and perhaps new handles, while others kitchen base units could be repurposed with new hinges and doors.

4. Can we reuse existing bathroom sanitaryware?
   Options include re-enameling tubs, polishing fittings, or integrating new sanitaryware with existing ones. Additionally, various suppliers sell reused or reclaimed sanitaryware, such as Restore Habitat for Humanity, or Broken Bogs.

5. Are new rainwater goods necessary?
   If the current rainwater systems are in good condition, they can be reused by cleaning, repainting, or making minor alterations.

6. Can internal doors be retained and upgraded for fire performance?
   When extending into the loft, the aditional floor will often mean that internal doors need to become fire resistant doors. This might involve adding fire-resistant linings or seals – but be careful, it may involve nasty intumescent paints. Doors that cannot be upgraded can be reused on areas that do not require fire rating, such as bathrooms and cupboards.

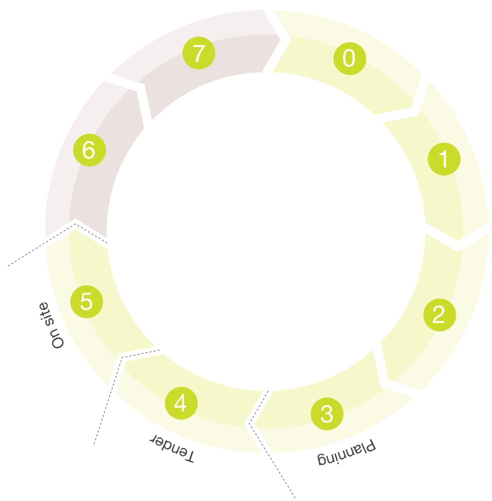
7. Can you use internal woodfibre insulation on the existing walls?
   Wood fibre insulation is a natural, sustainable material that offers excellent thermal performance and breathability, which makes it ideal for retrofit situations, where it still allows walls to breathe, avoiding damp (this will not affect air tightness targets).

8. What wall finishes are being used?
   Plasterboard is made of gypsum, which is full of carbon and not good for indoor air quality. Where you are using woodfibre insulation, this can be plastered directly onto with a lime plaster and mesh system. Or, wood wool boards can be used, which can also be plastered directly onto. Ensure that all plasters are lime-based, not cement, and paints are VOC-free.

WHAT IS RIBA STAGE 5?

How can we help?

There are a number of ways an architect can be involved in the construction of a project, and this will depend on the complexity of the build, the budget, and client experience. A full service would involve administering the building contract on your behalf and carrying out regular site inspections and valuations to certify payments due, issue certificates and Architect’s Instructions and deal with on-site queries. Alternatively the architect can occasionally visit the site to give advice and respond to queries on a time-charge basis.



QUESTIONS TO ASK AT RIBA STAGE 5

1. Is the skip company operating a zero-to-landfill scheme?
   This ensures that all construction waste is managed sustainably. Such companies recycle, reuse, or recover waste materials, diverting them from landfills and reducing environmental impact. Are the skip companies commitments verifiable?

2. Can any items being removed be reused by others?
   Before disposing of materials removed during demolition or renovation, identify what items are still serviceable and could benefit others. Organisations like Habitat For Humanity accept donations of reusable building products such as fixtures, fittings, appliances, and surplus materials. Donating these items not only minimises waste but also supports communities in need and promotes a circular economy. Create a detailed inventory of reusable items and coordinate with relevant charities or salvage organisations to facilitate the donation process.

3. What happens to excess finishing materials like tiles and flooring? Do suppliers offer buy-back schemes?
   Excess finishing materials often accumulate due to overestimation or changes in design. Unused tiles, flooring, and similar products can become waste if not managed properly. Some suppliers may accept returns of unopened packages or offer credit for future purchases. Alternatively, these materials can be stored for maintenance purposes, sold, or donated.

4. Can demolished masonry or foundations be used as aggregate in new construction? Micro crushers can be an effective way of producing aggregate from this rubble for applications like sub-base layers, fill material, or even new concrete mixes, subject to structural engineer approval. This approach reduces the need for transporting waste off-site and decreases the demand for new raw materials.

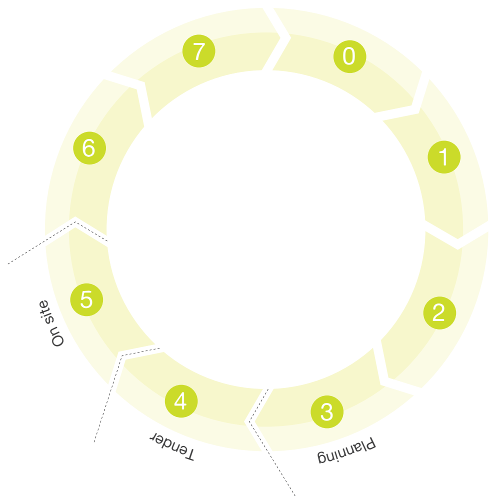
5. Is the contractor building with the specified products and methods?
   At this stage, it’s essential to verify that the contractor is actually using the materials and construction methods outlined in the architect’s drawings and specifications. Site inspections and clear communication between the architect, contractor, and client help ensure fidelity to the design intent, sustainability goals, and performance requirements. Substitutions or shortcuts can undermine energy efficiency, material health, and long-term durability, so consistent oversight is key.

WHAT IS RIBA STAGES 6-7?

Are we there yet?

RIBA Stage 6 is the Handover and Close Out phase of your project. This stage marks the completion of construction work and the formal handover of the building to you, the client. Contractually, this is called Practical Completion. This includes handing over all necessary certificates and documentation on the building.In the 12 months following, defects should be remedied by the builder, and at the end of this period a Final Certificate is issued. If the architect has been administering the contract for you, they will continue to do so, in closing it out. This is also when the architect likes to hear from you about how the building is working across the seasons, how you are using the spaces, and what you might have done differently.

RIBA Stage 7 is the In Use phase of your project. This stage commences after the building has been handed over and is occupied. It focuses on the operational life of the building, ensuring it functions as intended and continues to meet your needs over time. This is a Post Occupancy Evaluation (POE) and one way we like to continually learn how to build better. On small-scale and homeowner projects, a POE is typically light touch, and not a commissioned piece of work, but done informally in conversation with your architect.



QUESTIONS TO ASK AT RIBA STAGE 6

1. Do we have all the necessary certifications for any reclaimed products used in the building?
   Certifications should verify that reclaimed materials meet the required building standards and regulations.

2. Are the end-users informed about maintenance cycles needed to prolong the building's longevity, such as using appropriate plugs when hanging items on wood wool boards?

3. Have you recorded lessons learned from the build to improve future projects and communicated them to your architect, wider design team and contractor?

QUESTIONS TO ASK AT RIBA STAGE 7

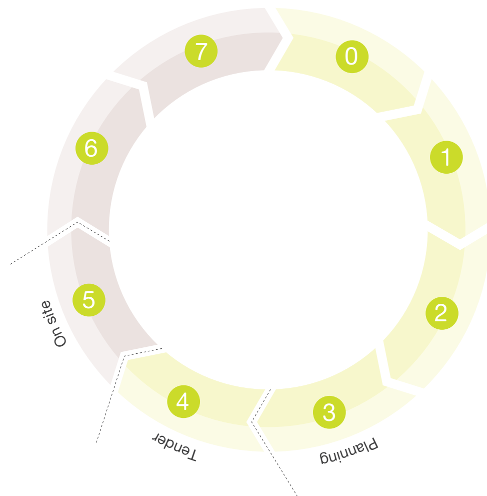
4. Are you aware of the key maintenance issues in your new home to help preserve the house?
   You should feel informed about the essential upkeep tasks necessary to maintain the performance and longevity of your home.

5. Would you be interested in undertaking a post-occupancy evaluation to assess the home's performance and your satisfaction?

6. Have you compiled a building manual that includes details of carbon-intensive materials to facilitate future reuse?
   This should outline all materials used, including carbon-intensive ones, has been prepared to assist in future repairs, upgrades, or recycling efforts.

How will I build it?

The technical design stage is what gives your ideas form and where the sustainable principles employed are translated into what will become built carbon figures. Embodied carbon is cemented when you determine how much steel, concrete, and other high-carbon materials will be used. It prevents common issues such as overuse of materials, thermal bridging, or defaulting to common and carbon-intensive solutions like high-performance plastic insulations or virgin steel. Proper detailing is crucial because it eliminates inefficiencies, prevents over-engineering, and ensures that sustainable solutions are both practical and achievable.



Ground floor extensions

Ground floor extensions tend to be the most carbon-intensive way to extend your home due to the extensive use of materials required for both the substructure, such as concrete foundations, and the superstructure, requiring heavy lengths of steel. Optimising foundation design and using reclaimed or low-carbon materials for walls and structure, as well as opting for suspended timber floors instead of concrete slabs can significantly reduce emissions. Retaining existing structural elements and sourcing materials from reclamation yards should also be prioritised.

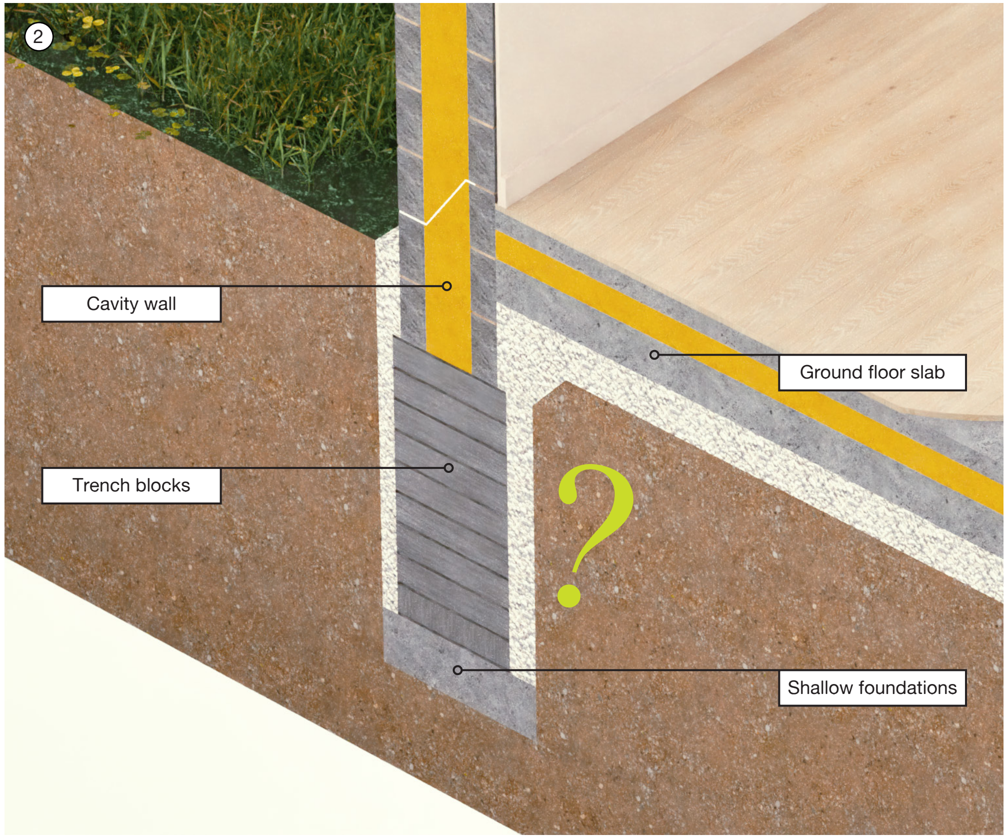
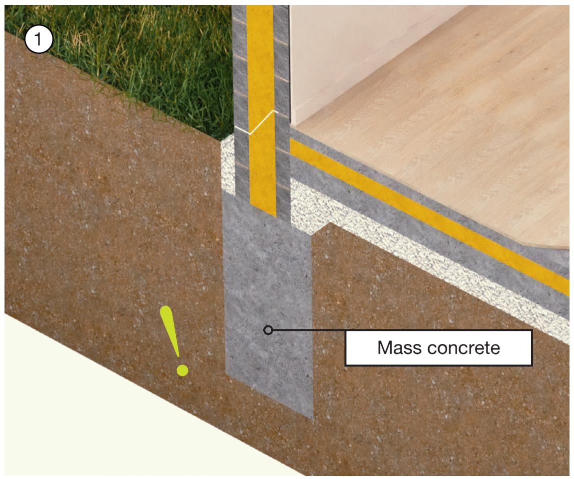


IMAGE CREDITS: GEORGE REGNART



< Typical

Suggested ^

FOUNDATIONS

WHAT SYSTEM IS TYPICALLY USED?

1. To support the walls of a proposed extension, it is common to construct deep foundations from mass concrete.

WHAT ARE WE SUGGESTING?

2. Alternatively, you can discuss with the Structural Engineer using shallow and wide strip foundations, with trench blocks on top. Even better, recycled blocks could be used for this.

WHY?

Concrete foundations are typically constructed by full-filling trenches. This is easy to implement, and avoids the additional safety protocols of workers spending time in deep trenches that could collapse. However, aerated blocks, which are made in a factory to introduce bubbles and reduce the concrete content, can be laid exactly where they are needed, and reduce the overuse of concrete.

HOW DO I DO IT?

Ask your structural engineer to design the foundations to use as little concrete as possible

Conduct a soil test to determine exactly how deep the foundations need to be and avoid them being over-engineered.

Ask your design team whether it is possible to replace the trench foundations with brick or stone

WHAT IS THE CARBON SAVING?

Trench blocks have a density of 600kg/m3 compared to 2400kg/m3 for conventional concrete. If 75 per cent of the foundation depth is replaced with trench blocks we could expect a reduction from approximately 1400kgCO2 in the case study house down to 600kgCO2 which is a saving of 800kgCO2. **This is more carbon than a one way flight to New York**.

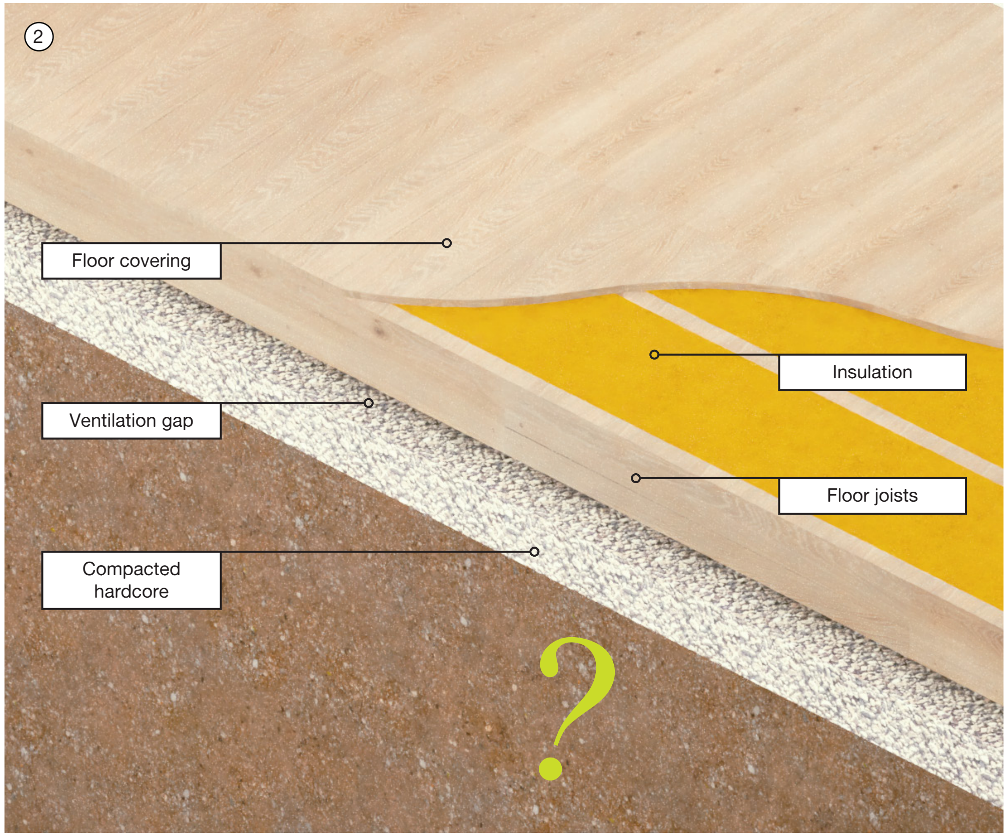
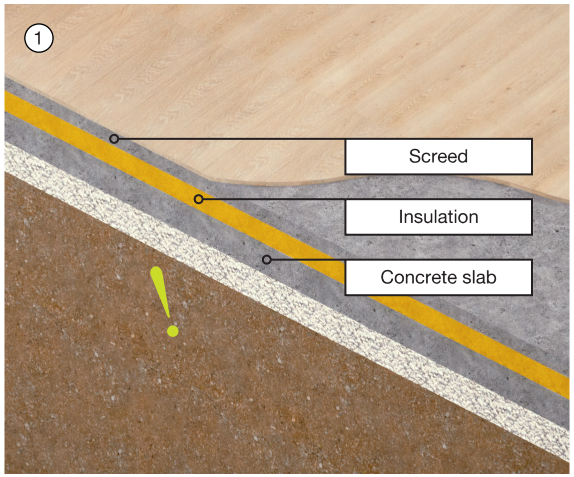


IMAGE CREDITS: GEORGE REGNART



< Typical

Suggested ^

GROUND FLOORS

WHAT SYSTEM IS TYPICALLY USED?

1. To support the new floors and walls of an extension it is common to pour large new concrete slabs and screed sandwiching PIR insulation. There are many benefits to this way of constructing however the carbon impact is vast.

WHAT ARE WE SUGGESTING?

2. Alternatively, you could discuss with the structural engineer and architect about using a suspended floor system. There are many benefits for installing a suspended floor allowing air to circulate from the existing suspended floor, reduction of moisture, allowance of using natural insulations, avoidance of damaging to near by tree roots and reduce drying times of concrete.

WHY?

Concrete slabs are typically installed due to their durability, cost, maintenance and ease of installation, it requires less excavation and may be less imposing upon neighbouring foundations. Commonly on a residential project concrete is mixed in large mixer trucks that are continually rotating and using energy. Concrete used on site is charged at the volume for which is used on site this makes them a known quantity that is quick and easy to implement. To allow ventilation to pass to the existing ventilated cavity beneath the house new plastic ducting an vents are needed.

HOW DO I DO IT?

Ask your design team about the possibility of using suspended timber floor systems.

WHAT IS THE CARBON SAVING?

This could save over 1000kgCO_2 in concrete slab and screed, which is the equivalent to **450 beef steaks**.

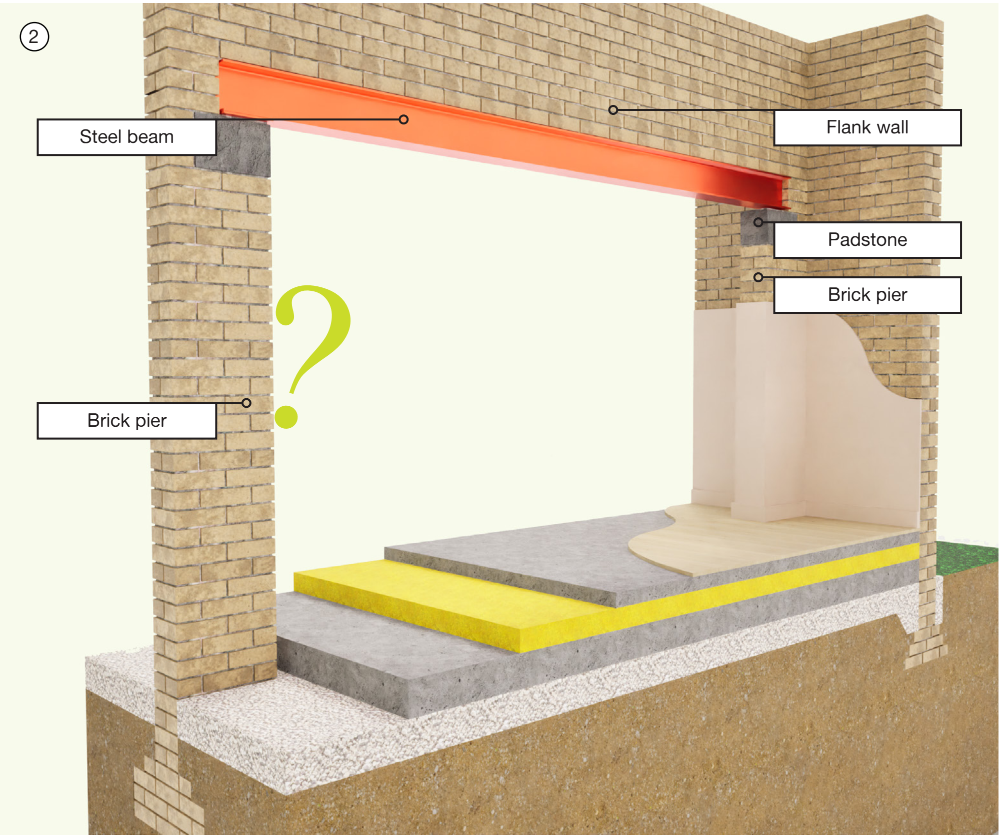
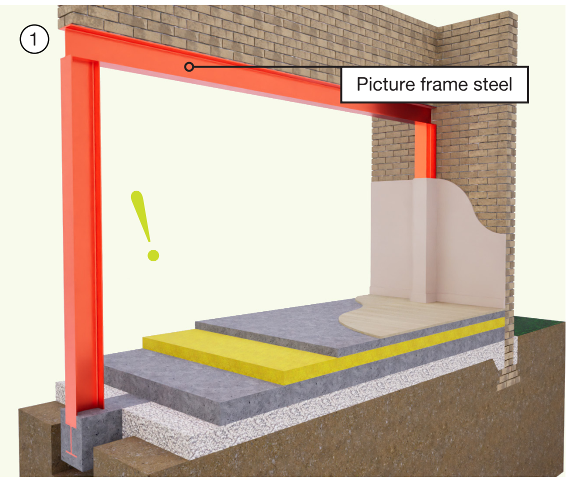


IMAGE CREDITS: GEORGE REGNART



< Typical

Suggested ^

BRICK PIERS

WHAT SYSTEM IS TYPICALLY USED?

1. Open plan living is on trend and desired in residential living. To open up a floor plan underneath existing first floor structure new steel is required. This usually comes in the form of a picture frame steel which consists of 4 steel beams with the ground beam encased in concrete.

WHAT ARE WE SUGGESTING?

2. Alternatively the amount of steel inserted could be decreased significantly by retaining some of the existing brick piers. New joinery could then be inserted to conceal these piers if they are not the desired aesthetic. Not only are picture frame steels carbon intensive due to the amount of steel being implemented but also the ground bearing steel requires to be encased in concrete.

WHY?

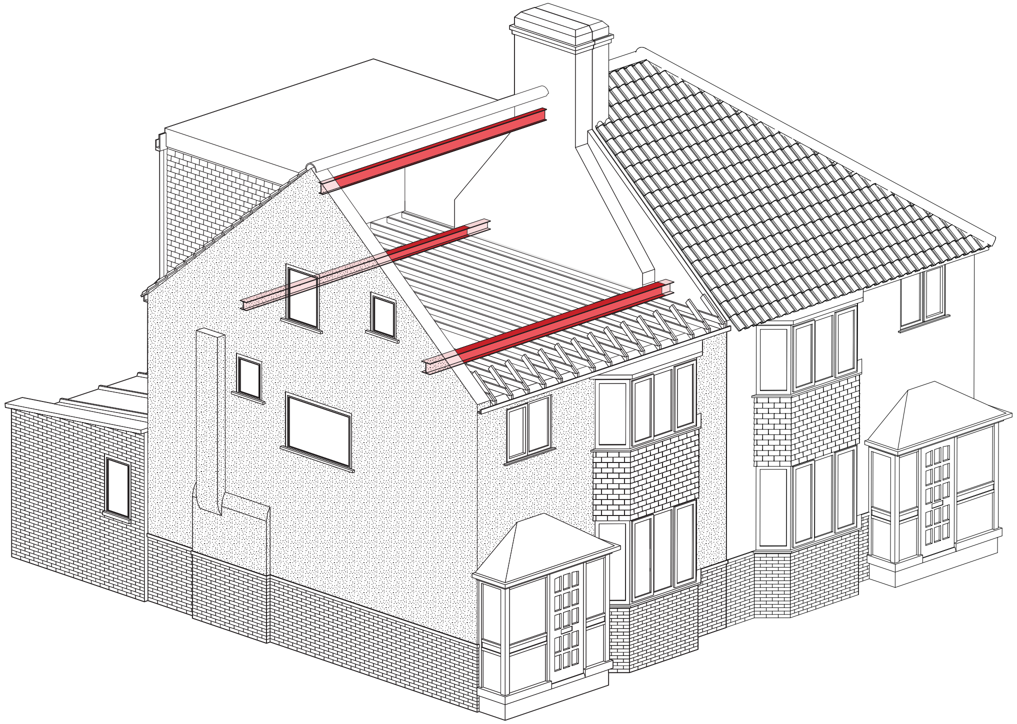
Not only are picture frame steels carbon intensive due to the amount of steel being implemented but also the ground bearing steel requires to be encased in concrete to avoid rusting and spread load in to the ground.

HOW DO I DO IT?

Interrogate the existing plan of your home at an early stage. Where does the existing first floor wall align with the ground floor plan? If you are looking to extend, is it possible to retain masonry piers to avoid additional concrete & steel. Are there ways in which deep piers can be concealed by kitchen cabinets or other items of joinery?

WHAT IS THE CARBON SAVING?

This could reduces the carbon of the steel work by approximately 480kgCO_2. This is the equivalent of **a petrol car travelling almost 3000km**.



^ Typical loft steel locations

Loft conversions

Lofts typically require at least three new steel elements to support the structure: a ridge steel, a floor mid-steel, and a steel beam supporting a low stud wall that breaks the span of the street-facing pitched roof. However, with careful planning, some of these can be reduced or eliminated.

Reclaimed steel providers may not always have the exact size required, meaning a deeper steel might need to be used as a substitute. This carries the risk of longer lead times, which can make contractors hesitant to procure reclaimed steel, as they often prefer to order from their usual suppliers to avoid project delays.

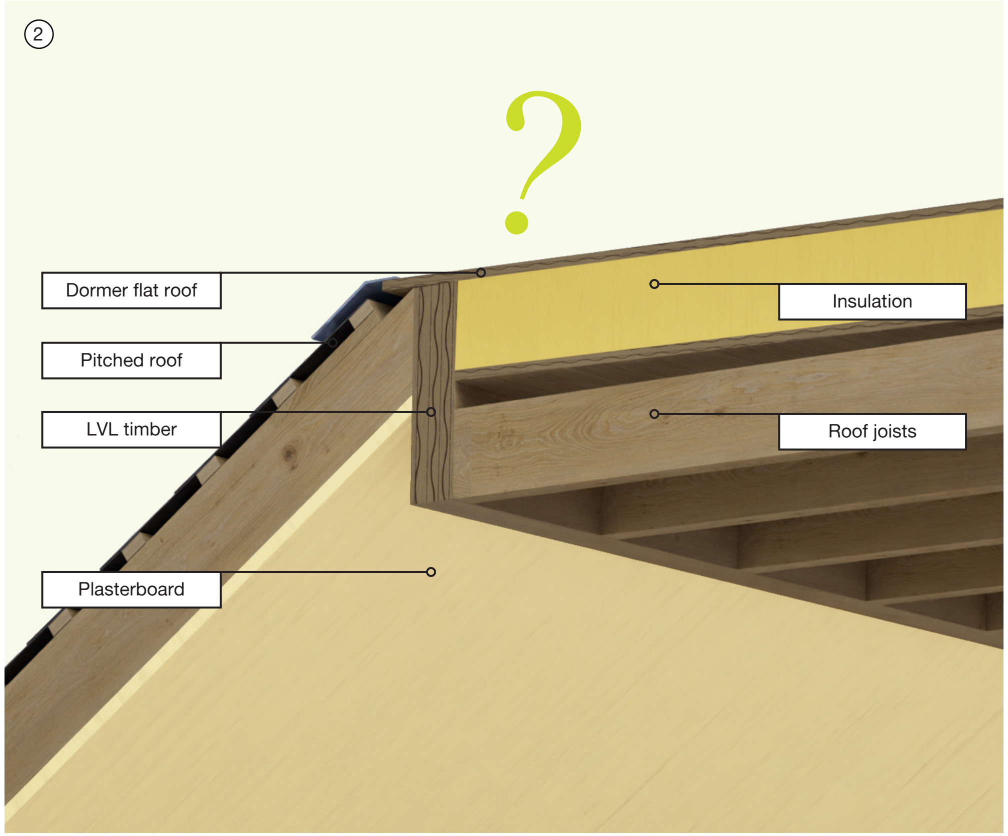
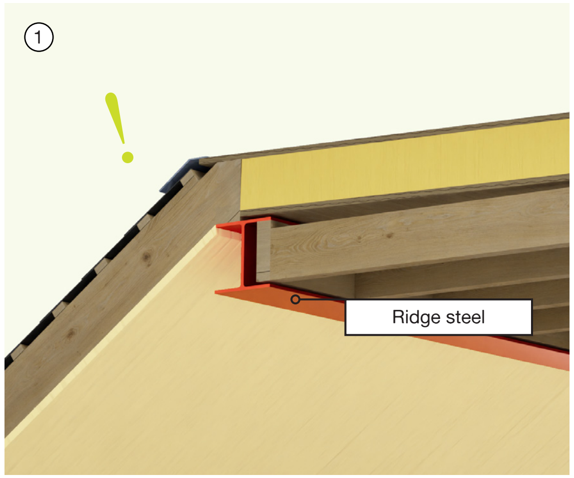


IMAGE CREDITS: GEORGE REGNART



< Typical

Suggested ^

RIDGE STEEL

WHAT SYSTEM IS TYPICALLY USED?

1. To support the ridge of the roof it is common for the structural engineer to specify a steel to span the width of the property.

WHAT ARE WE SUGGESTING?

2. Alternatively the ridge steel can be substituted for a laminated veneer lumber (LVL) beam or a reclaimed steel.

WHY?

Steel is specified to span this width because it is a known material in the construction industry, it is readily available and allows for thin roof build ups. Once on site it is also common that the contractor requests the steel be spliced and reassembled on site, as the full length is too large to get on-site and to the roof. The addition of connections and processing increases carbon emissions. The use of an LVL instead of steel means there is no risk of a cold bridge: a phenomenon where heat bypasses insulation through more conductive materials (like steel or concrete) at key locations in a construction. This can lead to cold spots, and potentially condensation and damp.

HOW DO I DO IT?

At an early stage, determine what the maximum floor to ceiling height can be. Deliberate whether this can be reduced for alternative structural methods. Discuss with the structural engineer the possibility of using reclaimed steel or LVL timbers. The design team must be aware that using reclaimed steel may result in larger roof build ups than minimum which could affect floor to ceiling heights within the loft space.

WHAT IS THE CARBON SAVING?

A 4.8m long ridge steel holds 170kgCO_2. An LVL beam engineered to take the same load holds 30kgCO_2. This saves 140kgCO_2, which equates to **100 litres of milk production**. If we were to include the carbon that the LVL sequesters (which we don't), the carbon emissions would be negative.

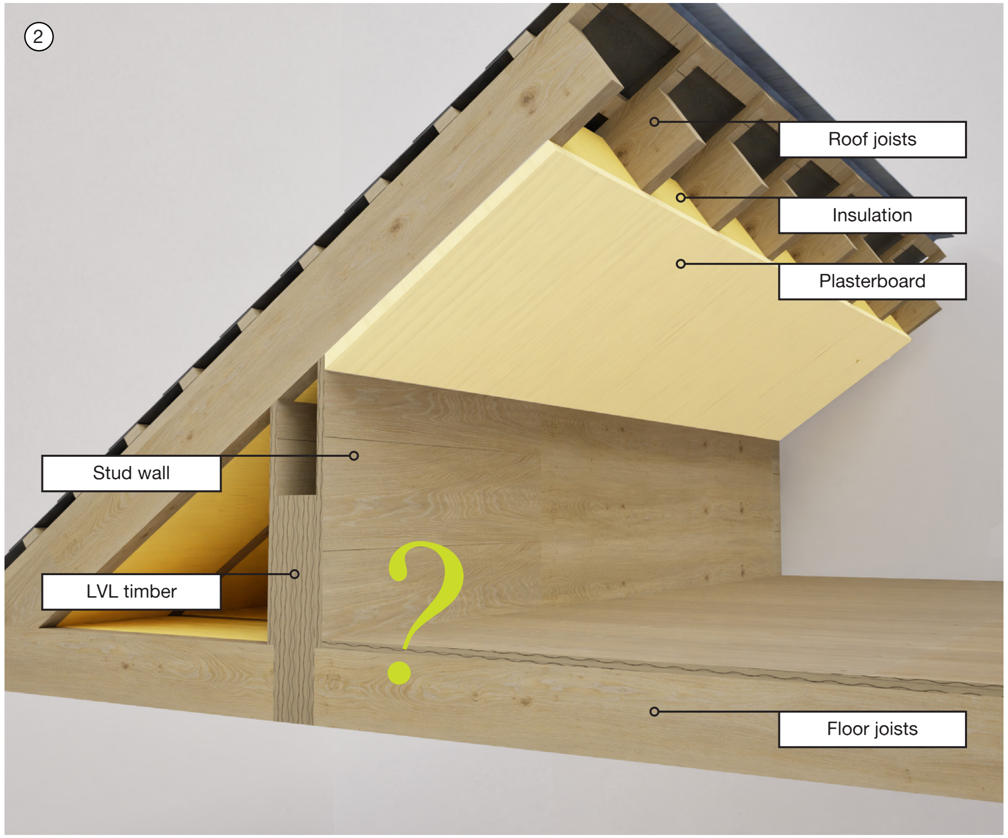
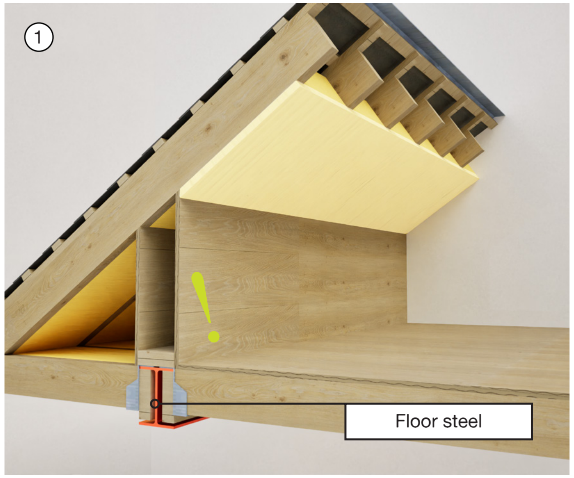


IMAGE CREDITS: GEORGE REGNART



< Typical

Suggested ^

FLOOR STEELS

WHAT SYSTEM IS TYPICALLY USED?

1. To support the front pitch of the roof it is common for the structural engineer to specify a steel to span the width of the property.

WHAT ARE WE SUGGESTING?

2. The floor steel can potentially be omitted by using stiffened spine wall in the existing house below. Spine walls in houses can be stiffened using plywood sheathing if approved by the structural engineer and building control.

WHY?

Steel is typically specified to be inserted in to the floor build up to minimise increase in floor levels. Once on site it is common that the contractor requests the steel be spliced for access and delivery purposes. The addition of connections and process also increases the carbon footprint of the scheme. The insertion of steel within this location of the floor also can cause issues to the finished ceiling of the floor beneath and structure of the loft floor.

HOW DO I DO IT?

Discuss with the structural engineer the possibility of using reclaimed steel or LVL timbers.

The design team must be aware that using reclaimed steel may result in the roof build ups being larger than minimum which could affect floor to ceiling heights within the loft space.

WHAT IS THE CARBON SAVING?

A 4.8m long floor steel holds 171kgCO_2. An LVL beam engineered to take the same load holds 31kgCO_2. This saves 140kgCO_2, which equates to **producing 560 bottles of beer**. If we were to include the carbon that the LVL sequesters in its life (which we don't), the carbon saving would be negative.

Are we finished yet?

Industrial processes shape the spaces we live in. What we think of as ‘home’ is increasingly built from synthetic, ultra-processed materials, mirroring the artificial ingredients in ultra-processed foods. These environments promise convenience but come at an invisible cost – pollution, waste, and a disconnect from the natural world.

Every material choice you make in a renovation carries embodied carbon, and though a huge chunk of the carbon is the solid structure of the house, there are some nasty products used as finishes too, both in the carbon impact they have on the planet, and also the harsh chemicals that go into making synthetic materials, and ultimately end up in the air you breathe and the food you eat. Just as we’ve begun questioning the impact of processed food on our health, we must also interrogate the materials that form our homes.

Material selection also shapes a building’s longevity. Durable, adaptable materials age gracefully and can be reused or repurposed, whereas synthetic composites and chemically treated products often degrade beyond repair. Sourcing locally reduces transport emissions and supports local circular economies, keeping valuable resources in use rather than in landfill.

This section explores how to select materials that lower embodied carbon, extend the life of your home, and create healthier, more sustainable spaces. Whether it’s avoiding plastic-based insulation, choosing natural finishes, or working with reclaimed materials, every decision has a consequence. The question is: will your home be built for convenience, or for resilience?

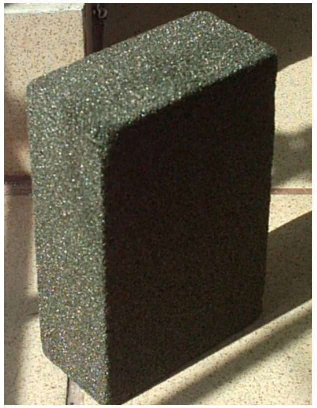
Woodfibre

Cork

Hemp

Mineral wool

Sheep's wool



Foamglass

Alternatives ^

Typical >

Polyisocyanurate insulation

IMAGE CREDITS (L-R): MIKE TUCK / LUCA PIFFARETTI / RA BOE, WIKIPEDIA / ACHIM HERING / SHADOKAT AT ENGLISH WIKIPEDIA / RADOMIL / SEALLE

INSULATION

Plastic-based insulation is widely used in modern construction, but it comes with significant risks. It is carbon intensive, releases toxic gases like carbon monoxide and hydrogen cyanide when exposed to fire, and is difficult to recycle. It can also create damp by trapping moisture.

ALTERNATIVES

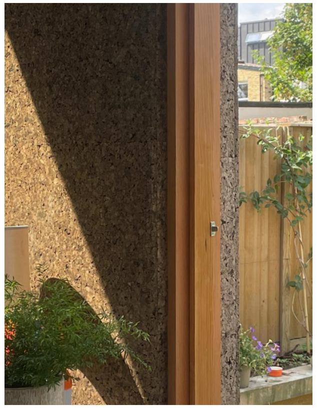
- Woodfibre is excellent for thermal and acoustic insulation
- Cork is renewable, durable, and resistant to pests and moisture
- Hemp is biodegradable, and naturally regulates humidity
- Mineral wool is fire-resistant and widely available with lower embodied carbon than plastic-based options
- Sheep's wool is breathable, and highly effective at moisture control
- Foamglass is made from recycled windscreens, and is non-combustible

THINGS TO LOOK OUT FOR?

- Some natural insulations require breathable finishes such as lime plaster, which you should discuss with your supplier
- Natural alternatives tend to be thicker than PIR insulation, which may impact room layouts and construction details.
- Ensure untreated natural products are appropriately protected against pest infestations
- External insulation can make it less likely that condensation forms internally (by moving the dew point outward) whereas internal insulation can increase this risk. Breathable external insulation can be thicker than internal insulation, as the risk of condensation internally has been mitigated. When using breathable insulations, ensure you also use a breathable finish, such as lime render or a vapour open paint
- Avoid spray foam as it can permanently bond to surfaces, making otherwise recyclable materials unrecyclable

HOW DO I DO IT?

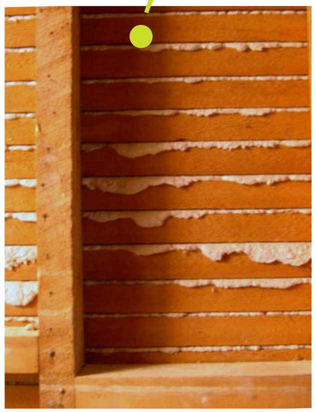
- Discuss alternatives with your architect or contractor to ensure the best fit for your project
- Contact specialist suppliers such as Mike Wye or Ty Mawr for advice on sustainable insulation options



Cork

Timber panelling

Wood wool boards



Lath and plaster

Alternatives ^

Typical >

Gypsum plasterboard

IMAGE CREDITS (L-R): GEORGE REGNART / LUKE HAYES / MIKE TUCK / ASMITHMD1 / AMAXSON AT ENGLISH WIKIPEDIA

DRYLINING

Gypsum plasterboard is a common choice for residential properties, but it comes with significant drawbacks. Its production is carbon-intensive, and if exposed to moisture or broken down, it may release toxic gases.

ALTERNATIVES

- Cork is a natural, renewable material harvested from cork oak bark, providing excellent thermal and acoustic insulation
- Timber panelling can be used to line walls, which can also create beautiful spaces
- Wood wool boards are a breathable and insulating panel made from wood fibres bonded with cement or magnesite, often used for soundproofing and moisture regulation. They can be plastered directly onto, or left exposed
- Lath and plaster is a traditional wall construction method using wooden laths covered with layers of lime or clay plaster, offering breathability and flexibility

THINGS TO LOOK OUT FOR?

- Natural materials often require compatible, breathable finishes – consult your specifier for suitable options
- Some alternative materials may come at a higher cost

HOW DO I DO IT?

- Ensure your contractor has experience with alternative drylining systems – ask about their past projects
- Consult specialised suppliers like Mike Wye or Ty Mawr for expert advice on materials and installation


Recycled concrete blocks

Strocks


Lightweight aerated blocks


Portland stone bricks


Clay blocks


Hempcrete blocks

Alternatives ^

Typical >

IMAGE CREDITS (L-R): MIKE TUCK / H.G. MATTHEWS / LEO MIREGALITHEO / ALBION STONE / KOZUCH / OLIVIER DUPORT / MIKE TUCK

BLOCKWORK

Masonry is heavy, and the more weight added above ground, the more concrete is required below. The production of cement, the extraction of aggregates, and the use of virgin materials in block manufacturing all have significant environmental impacts – many of which can be reduced with alternative materials.

ALTERNATIVES

- Recycled concrete blocks are made with reclaimed aggregate, lowering demand for virgin aggregates
- Strocks are made by HG Matthews from straw and clay, offering excellent insulation and low embodied carbon
- Lightweight aerated blocks reduce overall structural weight and concrete use
- Portland stone bricks are blocks of high-quality limestone made to the exact measurements of a brick. They are therefore easier for most contractors to work with on site, and are stronger and have a lower embodied carbon than regular clay bricks
- Clay honeycomb blocks are lightweight, breathable, and highly insulating, ideal for low-energy buildings
- Hempcrete blocks combine hemp fibres and can be used alongside a structural material. Unlike concrete blocks, they do not have the structural properties to be used alone

THINGS TO LOOK OUT FOR?

- What percentage of recycled content is included in the materials?
- How heavy is the specified product?
- Where is the product manufactured, and how far does it need to be transported?

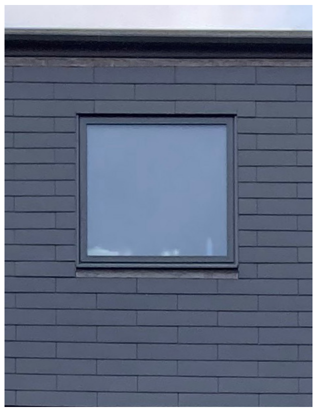
HOW DO I DO IT?

- Discuss with the structural engineer about the strength and suitability of alternative products
- Talk to suppliers such as HG Matthews, Mike Wye or Ty Mawr

Welsh slates

Alternatives ^

Concrete roof tiles



Man-made tile

< Typical

IMAGE CREDITS (L-R): LUCA PIFFARETTI / MATEJ BAT'HA / MIKE TUCK

ROOF WORKS

The carbon footprint of roof finishes can vary greatly and should be considered. Green roofs can enhance energy efficiency, support local biodiversity, and improve the outlook for surrounding occupants. They absorb the sun's energy in summer and insulate in winter.

ON PITCH ROOFS, AVOID:

- Man-made slates, which are synthetic and often made from fibre cement or plastic
- Cement tiles, made from a cement-based mix
- Concrete tiles, which are more durable than cement tiles but resource heavy due to added aggregate

Consider:
- Locally sourced natural slate
- Reclaim tiles by tapping into local circular economies
- Zinc, which is lightweight, 100 per cent recyclable and long-lasting

ON FLAT ROOFS, AVOID:

- Asphalt, petroleum-based roofing material that is waterproof but environmentally damaging
- GRP (Glass Reinforced Plastic), a fibreglass roofing system that is difficult to recycle

Consider:
- Green roof systems
- Rubber roofs, made from EPDM (a synthetic rubber), known for its durability, flexibility, and long lifespan

THINGS TO LOOK OUT FOR?

- Where is the material sourced from?
- Can existing roof joists support the weight of the new material?
- Light-coloured roofing materials can help reflect sunlight
- Consider whether the chosen roof finish is suitable for solar panels

IMAGE CREDIT: ELLEN PEIRSON

THE KITCHEN

Modern kitchens are ultra-processed – and that's bad for both our health and the environment. Typical kitchen materials include MDF cabinets made from wood fibre, urea formaldehyde, and paraffin wax, all wrapped in petroleum-based veneers. Hard-wearing quartz counter tops are composed of mined silica. When homes are refurbished, kitchens are often ripped out and discarded in favour of trend-driven replacements, leading to unnecessary waste.

QUESTIONS TO ASK

- Where is your kitchen coming from? Consider the origins of your materials and their environmental impact
- What are the materials made of? Look for responsibly sourced cabinet materials with low or no VOC (volatile organic compound) content
- Does the worktop contain high levels of silica? Avoid composite materials like MDF, which may contain high levels of formaldehyde
- Can virgin materials be replaced with natural or recycled alternatives? Opt for reclaimed wood, recycled countertops, or other eco-friendly options
- Is it possible to retain or repurpose existing elements? Consider keeping cabinet carcasses and simply replacing doors or handles
- Are the appliances energy-efficient? When replacing appliances, choose energy-efficient models to reduce long-term environmental impact
- Is the kitchen designed for adaptability? A well-designed kitchen should be durable, flexible, hygienic, and allow for future modifications

HOW DO I DO IT?

- Visit https://living-future.org/declare/ for guidance on healthy, sustainable building materials
- Discuss sustainable alternatives with your architect or contractor to reduce the carbon footprint of your kitchen and lower its ecological impact

IMAGE CREDIT: ELLEN PEIRSON

THE BATHROOM

Don’t throw your bathroom away. If it’s in good condition but not to your taste, consider donating or selling it – someone else may want it. Bathrooms are the biggest source of water-related carbon emissions in the home. Thoughtful design and material choices can help reduce both water and energy consumption.

THINGS TO LOOK OUT FOR?

- What are your tiles made of and can they be reclaimed?
- Can you use natural flooring? Options like linoleum, recycled rubber, or cork are more sustainable
- Could recycled plastic sheets or natural stone be used for splashbacks and countertops? Large-format materials can also reduce grout and maintenance.
- Can any existing sanitaryware or brassware be retained? Reusing elements reduces waste and embodied carbon.
- Is alternative energy for water heating an option? Consider solar water heating or heat pump systems.
- Are energy-saving faucets available? Many suppliers now offer models that reduce water consumption without compromising performance.

QUESTIONS TO ASK:

- If using natural internal insulation on external walls, discuss with your architect how to avoid trapping moisture when waterproofing the bathroom
- Talk to your contractor about ways to reduce water flow and improve efficiency

HOW DO I DO IT?

- Visit local second hand or circular economy stores selling sanitary and brassware such as Habitat for Humanity’s ReStore, Renee Materials or Broken Bogs
- Visit https://living-future.org/declare/ for guidance on healthy, sustainable building materials

Appendix!

Embodied Carbon Typical Ground Floor "Side-return" Extension

Assumptions : L shaped loft 4.5m wide x 7m deep terraced
house with additional 4m outrigger

	Area	Depth	Density	Kg	kg c02/kg	kg co2/declared unit		
Substructure								
Concrete foundations (1.2m deep)	5.5	1.2	2400	15840	0.09		1425.60	ICE Db v3.0
Concrete pad (1.2m deep)	1	1.2	2400	2880	0.09		259.20	ICE Db v3.0
Concrete slab	18	0.15	2400	6480	0.09		583.20	ICE Db v3.0
Hardcore sub-base	18	0.15	2240	6048	0.0048		29.03	https://www.greenspec.co.uk/building-design/embodied-energy/
Superstructure								
Brick	23.5	0.1	1700	3995	0.213		850.94	ICE Db v3.0
Blockwork (aerated)	23.5	0.1	750	1762.5	0.093		163.91	ICE Db v3.0
Steelwork (assume picture frame steel)				450	1.55		697.50	ICE Db v3.0
Steel posts	2.8			57.4	1.55		88.97	ICE Db v3.0
Lintels	3.5			71.75	1.55		111.21	ICE Db v3.0
Timber roof structure 150x50 c24 @ 18% timber per m2	10.08	0.15	500	756	0.263		198.83	ICE Db v3.0
Rooofing & Facades								
Windows & Doors							837.00	https://www.greenspec.co.uk/building-design/embodied-energy/
Roof Windows	5					62.521	312.61	ICE Db v3.0 (Glass, sky light or roof, with frame)
Bitumen Asphalt roof	12		4	48	5.99		287.52	https://api.environdec.com/api/v1/EPDLibrary/Files/3dfc1fa2-759b-465c-1d03-08d91e80c3d9/Data
Roofing plywood	12	0.018	500	108	0.68		73.44	
Rockwool Cavity Batt Wall insulation	23.5	0.1	25	58.75	1.05		61.69	
PIR Roof Insulation	6	0.12	30	21.6	3.48		75.17	https://www.greenspec.co.uk/building-design/embodied-energy/
PIR floor insulation	18	0.1	30	54	3.48		187.92	https://www.greenspec.co.uk/building-design/embodied-energy/
Lead Flashing	1	0.005	11340	56.7	1.57		89.02	https://www.greenspec.co.uk/building-design/embodied-energy/
Services								
Plastic plumbing				65	2.61		169.65	estimate 65kg of pvc and connectors
Wiring				25	2.6		65.00	estimate25kg wire
Light fittings and sockets							68.00	estimate (need more data)
M&E							94.00	estimate (need more data)
Radiators							220.00	estimate (need more data)
Finishes								
Screed	18	0.07	2400	3024	0.159		480.82	https://www.greenspec.co.uk/building-design/embodied-energy/
Plasterboard	18	0.0125	800	180	0.38		68.40	https://www.greenspec.co.uk/building-design/embodied-energy/
Dulux Paint	18				2.12		38.16	https://www.greenspec.co.uk/building-design/embodied-energy/
Vinyl floor	18	0.02	1200	432	2.92		1261.44	https://www.greenspec.co.uk/building-design/embodied-energy/
WC suite				95	1.51		143.45	https://www.greenspec.co.uk/building-design/embodied-energy/
Kitchen units							Need data	
Internal doors and ironmongery							Need data	
Skirtings and Architraves							Need data	
Total							**8941.66**	
Total embodied carbon per m2							**993.52**	kg/m2

Embodied Carbon Typical Loft

Assumptions : L shaped loft 4.5m wide x 7m deep terraced house with additional 4m outrigger

Substructure	None	Area	Thickness	Density kg/m3	kg mass	kgC02/kg	C02	
Superstructure								
Floor Steels (2 x 4.8m 152x152 x 30)		NA	NA		288	1.55	446.40	ICE Db v3.0
Ridge steel (1 x 4.8m 152x152 x 23)		NA	NA		110.4	1.55	171.12	ICE Db v3.0
Timber floor structure 150x50 c24 @ 18% timber per m2		7.83	0.15	500	587.25	0.263	154.45	https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/A-brief-guide-to-calculating-embodied-car
Timber wall structure 100x50 c24 @ 18% timber per m2		7.65	0.1	500	382.5	0.263	100.60	https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/A-brief-guide-to-calculating-embodied-car
Timber roof structure 150x50 c24 @ 18% timber per m2		7.83	0.15	500	587.25	0.263	154.45	https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/A-brief-guide-to-calculating-embodied-car
Intumescent paint						2.31	11.55	https://www.greenspec.co.uk/building-design/embodied-energy/
Roofing & Facades								
Man-made slate facades (mineral fibre)		42.5					680.00	Cedral tileshttps://www.roofgiant.com/resources/files/cedral-roofs-brochure-sept-2020_9.pdf
Man-made slate pitched roof (mineral fibre)		32					512.00	
Windows							558.00	https://www.greenspec.co.uk/building-design/embodied-energy/
Roof windows							279.00	https://www.greenspec.co.uk/building-design/embodied-energy/
Asphalt membrane		43.5	0.005	2000	435	0.389	169.22	ICE Db v3.0 using 50th percentile
PIR Wall insulation		34.85	0.1	30	104.55	3.74	391.02	https://www.specifiedby.com/recticel-insulation/eurothane-gp#product_properties_section_anchor
PIR Roof Insulation		43.5	0.12	30	156.6	3.74	585.68	https://www.specifiedby.com/recticel-insulation/eurothane-gp#product_properties_section_anchor
Plywood (roof)		87	0.018	600	939.6	0.68	638.93	ICE Db v3.0
Plywood (wall)		24	0.018	600	259.2	0.68	176.26	ICE Db v3.0
Lead Flashing		3.2	0.005	11340	181.44	1.57	284.86	https://www.greenspec.co.uk/building-design/embodied-energy/
Services								
Plastic plumbing					35	2.61	91.35	estimate 35kg of pvc and connectors
Wiring					25	2.6	65.00	estimate25kg wire
Radiators					63	2.47	155.61	https://api.environdec.com/api/v1/EPDLibrary/Files/81661ad2-72dc-4c1c-1a88-08dc25c78130/Data
Light fittings and sockets					5	2.61	13.05	estimate 5kg of pvc and connectors
Finishes								
Plasterboard		78.35	0.0125	800	783.5	0.38	297.73	https://www.greenspec.co.uk/building-design/embodied-energy/
Dulux Paint		67.5				2.12	143.10	https://www.greenspec.co.uk/building-design/embodied-energy/
Timber floor		43.5					266.00	ICE Db v3.0
Bathroom suite					95	1.51	143.45	https://www.greenspec.co.uk/building-design/embodied-energy/
Tile Finishes		4	0.02	2000	160	0.74	118.40	https://www.greenspec.co.uk/building-design/embodied-energy/
Internal doors and ironmongery					75	0.379	28.425	https://www.sciencedirect.com/science/article/abs/pii/S0959652623039033
Skirtings and Architraves		2	0.15	500	150	0.263	39.45	https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/A-brief-guide-to-calculating-embodied-car
Total							**6635.64**	kg
Total embodied carbon per m2							**152.54**	kg/m2

IMAGE CREDIT: ELLEN PEIRSON