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Evidence and recommendations on measures to improve the sustainability of the built environment, particularly considering embodied carbon

Executive Summary

- We highlight the need for a holistic, whole life cycle approach to low impact built environment design.
- This holistic approach should be incentivised through the planning system and building regulations by incorporating requirements for both whole life carbon measurement/regulation and circular economy statements.
- Building retrofit should be prioritised over new build developments, and this should be incentivised through VAT reductions on retrofit materials, and stamp duty incentives for energy and water efficient homes.

1. Introduction

The authors of this note have expertise across whole life carbon measurement and reduction, circular economy, industrial ecology, structural optimisation, fire engineering, sustainable urban drainage, and building retrofit. Our expertise and work in these areas is used to form responses to some of the Committee's specific questions below.

2. 'How can materials be employed to reduce the carbon impact of new buildings, including efficient heating and cooling, and which materials are most effective at reducing embodied carbon?'

To reduce the embodied carbon of new buildings we should: 1) design for adaptability to ensure buildings can meet changing needs; 2) design for deconstruction to facilitate future material recovery and reuse; and 3) use the minimum quantity of new materials whilst considering adaptability and deconstruction. These strategies could be encouraged through the introduction of circular economy statements as part of planning applications. Circular economy statements have been introduced in Greater London for large development schemes. The circular economy aims to keep resources at the highest value possible for a long as possible. London's Circular Economy Statements require applicants to outline how they have reduced waste in their design approach, including how they have incorporated circular economy strategies such as design for adaptability and deconstruction.

1) **Design for Adaptability.** The intention of *design for adaptability* is the creation of buildings that can be easily changed to suit future needs. This could be as simple as designing a building that can be internally reconfigured to change the building use or adapt it to a changing climate. Buildings that can adapt to changing needs should last longer, thus keeping their materials at the

highest possible value - as a building. There are case studies of buildings that are adaptable, which illustrate the design strategies in practice. In addition, circular economy assessment tool, regenerate, has design strategies to help embed circular economy principles into building design. This includes design for adaptability strategies across building layers, e.g. strategies for the building structure, services, skin and space. To increase uptake of this design strategy we recommend encouraging design for adaptability through the **adoption of circular economy statements as part of planning applications** (see above, and section 9 for further details).

2) **Design for Deconstruction**. Structural materials typically have a high embodied carbon. Embodied carbon includes all the greenhouse gas emissions associated with the manufacture, transport, maintenance, and end-of-life processing of materials. To reduce their impact it is essential to use materials for as long as possible. Many structural elements are sufficiently durable that they could be used beyond a single building's lifetime. However, it is often difficult to salvage existing structural components. In order to facilitate reuse over multiple life cycles, new buildings should be designed with their end-of-life in mind. Consideration should be given to how they can be deconstructed easily rather than demolished, so that usable materials can be salvaged in a form that is suitable for immediate reuse without recycling. We thus recommend that **new buildings should be designed for deconstruction to facilitate future reuse of components.** This approach can be encouraged through the adoption of circular economy statements, as outlined above, and in section 9.

3) **Structural efficiency.** Ensuring the materials that form building structures are used in the most efficient way possible frequently plays a secondary role to overall cost efficiency of projects. Indeed the most materially efficient solution may not be the most cost effective solution. Standardisation, rationalisation (design simplifications), and ease of construction are common contributors to overuse of materials, and there are few incentives to minimise material usage. These factors are further compounded by the excessive loading requirements specified at an early design stage. Speed and simplicity of construction has led to the widespread use of relatively inefficient forms of construction, for example using reinforced concrete flat slabs instead of thinner slabs with downstand beams, and in steel frame design, the use of a small set of standard steel sections rather than using the minimum size steel required. To reduce the embodied carbon of the materials used to construct a building it is essential to refocus on approaches that incorporate lean design: the minimisation of material use, and to find ways to make such approaches cost effective. To achieve this, computational design optimisation methods, which have been developing rapidly in recent years, can be applied to optimise building structures. These optimisation methods could also include design for deconstruction and design for re-use considerations. In order to improve structural efficiency and deliver structures with a lower embodied carbon, we recommend **adopting carbon targets for the structure of buildings**, e.g. the Structural Carbon Rating Scheme (SCORS).

3. *'What role can nature-based materials play in achieving the Government's net zero ambition?'*

Our interpretation of nature-based materials is construction materials that are either grown, e.g. timber, or found in nature, e.g. rammed earth. Such materials have a vital role to play in achieving net zero in the built environment, both in new construction and in building retrofit. Compared to conventional building materials, such as steel and concrete, nature-based materials often have a lower embodied carbon due to reduced processing and lower energy requirements during manufacturing.

Grown, bio-based materials remove carbon dioxide from the atmosphere during their growth. This carbon is effectively stored within the material whilst it is in use, a process known as carbon sequestration. Carbon sequestration occurs in materials where the carbon dioxide stored within the material is more than the greenhouse gases emitted to process the bio-based material into a construction material, resulting in negative embodied carbon values.

We highlight the impact of manufacturing processes on the embodied energy/carbon of nature-based materials. Air dried timber, for example, has a lower embodied energy compared to other construction timber products due to the lower energy demand in manufacturing. For grown, bio-based materials, end-of-life must be carefully considered to ensure the carbon remains sequestered. For example, priority should be given to material reuse and recycling over incineration or landfill.

Our research has shown that the embodied carbon of woodfibre board, when used to retrofit solid walls to improve their thermal efficiency, pays back in operational carbon savings in less than 2 years, and if carbon sequestration is considered, the initial embodied carbon is negative, thus requiring no payback. We found that material selection to reduce embodied carbon emissions during retrofit of England's housing stock plays an important role in meeting carbon budgets.

There is considerable interest in replacing energy intensive structural components, such as concrete and steel, with engineered timber products. Cross-laminated timber (CLT) has recently grown in popularity with clients and design teams, but there are some concerns over its performance in fire in certain applications. To facilitate greater uptake of cross-laminated timber we recommend **more research is conducted to better understand the performance of mass timber, such as CLT, in fire**. We also recommend that existing **legislation is investigated to identify if it is unnecessarily restricting the use of mass timber**, and if so, appropriate means to remove these restrictions should be explored.

Nature-based materials are also relevant to building drainage. For example, media used in sustainable drainage can be derived from recycled building materials and/or natural soils and aggregates. Natural plants also contribute to sustainable drainage and green infrastructure.

Given the significant potential benefits, especially given the challenge of reaching net zero, the use of nature-based materials in construction should be promoted via governmental policies and financial incentives to deliver whole life carbon reduction in the built environment. We recommend **investigating the potential for VAT reductions or subsidies for low carbon, biobased materials,** to ensure they have a procurement cost that is similar to, or lower than, their energy intensive equivalents.

4. 'What role can the planning system, permitted development and building regulations play in delivering a sustainable built environment? How can these policies incentivise developers to use low carbon materials and sustainable design?'

The planning system is instrumental in delivering a sustainable built environment. Permitted development, planning and building regulations must align with the need to deliver net zero by incentivising and requiring a built environment that minimises whole life carbon.

From a planning perspective, we recommend the following:

1. **Require whole life carbon estimates as part of planning applications.** A national database to submit such estimates to would assist in developing benchmark ranges for different building types. Whole life carbon reduction targets could then be set as part of planning or building regulations. To support this, data and tools should be maintained to facilitate calculations and support decision making.
2. **Require Circular Economy Statements as part of planning applications,** as required in the London Plan, see section 9 for further details.

5. 'What methods account for embodied carbon in buildings and how can this be consistently applied across the sector?'

A recent review paper of the use of *life cycle assessment (LCA)* in the design process reported that it was often only available late in the design process i.e. after the key decisions had already been made. The review noted that efforts are being made to incorporate LCA into design tools but challenges remain. There has been a rapid increase in the availability of tools designed to provide easy calculation of the embodied carbon of structural designs. A number of guides now exist, including 'How to calculate embodied carbon' from the Institution of Structural Engineers; and 'Whole life carbon assessment for the built environment' by the Royal Chartered Institution of Surveyors. A 2017 review of current industry practice on measuring embodied carbon recommended that "**Governments mandate for improved data quality and support the development of a transparent and simplified methodology**." We support this recommendation, which remains valid in 2021.

Current tools to measure embodied impact at a building level include:

- IMPACT, developed by BRE, has been embedded in a number of software tools, including Oneclick.
- The Structural Carbon Tool, based on the IStructE guide 'How to calculate embodied carbon'.
- Plugins for building information modeling software, such as Autodesk Revit, e.g. Hawkins Brown Emissions Tool H\B:ERT
- Tools which link design and embodied carbon e.g. Parametric And Numeric Design Assessment (PANDA)

Many of these tools use as their basis the Inventory of Carbon and Energy (ICE) database.

6. 'Should the embodied carbon impact of alternative building materials take into account the carbon cost of manufacture and delivery to site, enabling customers to assess the relative impact of imported versus domestically sourced materials?'

A whole life cycle approach should be undertaken when completing embodied carbon calculations. This includes estimates of the impact of manufacture of materials, delivery to site, construction on site, maintenance, deconstruction and end-of-life scenarios. See section 5.0 for details of calculation procedures and tools.

It is often appropriate to focus on the initial embodied impacts at early design stages, those from the manufacture of materials, because sourcing locations may not be known. Once key design decisions have been made, investigation of transport impacts should be included, including different sourcing options. Our research has shown, particularly for heavy weight materials, that transport impacts can be considerable. There is research that suggests maximum transport distances for reused materials to ensure the transport impacts don't outweigh the carbon benefits of reuse. End of life scenarios, e.g. reuse, recycling, downcycling or incineration, should also be considered.

Research from a whole life cost perspective has also highlighted the importance of taking a life cycle approach. For example, when reinforced concrete structures in a seismic zone are optimised on a total life cycle cost basis they could save up to 45% of costs compared to traditional approaches that focus only on initial costs. In conclusion, we recommend that a **whole life cycle approach is taken**.

7. *'How well is green infrastructure being incorporated into building design and developments to achieve climate resilience and other benefits?'*

Green infrastructure (GI) refers to a network of multi-functional green space, which supports natural and ecological processes. Examples of GI include parks, playing fields, woodland, allotments, gardens, green roofs/walls and 'blue infrastructure' such as streams, canals and other water bodies. GI provides ecosystem services, such as enhanced wellbeing, outdoor recreation and access, enhanced biodiversity and landscapes, food and energy production, urban cooling, and the management of flood risk.

Existing guidance from Natural England tends to emphasise the role played by local authorities in delivering GI as part of urban planning. At the building scale, GI can include green (vegetated) roofs, stormwater planters, rain gardens & ponds. At the development scale, roadside swales or bioretention cells, potentially combined with street trees, can be used to generate GI corridors. Sheffield City Council's Grey-to-Green scheme provides an excellent example of retrofitted sustainable drainage features. Furthermore, conventional drainage is carbon intensive; GI-based drainage generally uses less carbon intensive materials and incorporates plants, contributing to carbon sequestration

Whilst many excellent examples of buildings and housing developments that incorporate green/blue sustainable drainage features exist, **current building and planning regulations are insufficient to ensure that this is yet the norm**.

Proponents of sustainable drainage have repeatedly highlighted issues around ownership and adoption as presenting significant barriers to the more widespread transition from buried drainage infrastructure to sustainable drainage systems that can contribute to GI. The roles and responsibilities of homeowners, developers, local authorities, water utilities and the environmental regulator need to be clarified and simplified. The unitary approach adopted by Welsh Government appears to have led to more rapid progress compared with the rest of the UK.

Green roofs, for example, can contribute to the more sustainable management of rainfall runoff, but may not be sufficient to fully protect downstream locations from inundation in extreme events, such that the local authority/water utility may still need to provide additional infrastructure. **Developer incentives and householder drainage charges need to be reviewed to accommodate this model of shared responsibility and shared benefit.** Initiatives to better-engage communities in the co-design or rainwater management measures and open spaces may also be beneficial. Finally, the way in which the UK water utilities are funded to provide drainage services acts against maximising opportunities for sustainable drainage usage; nature-based options that lack defined inlets and outlets may not meet current definitions for drainage assets.

8. *'How should re-use and refurbishment of buildings be balanced with new developments?'*

Reuse and refurbishment should be prioritised compared to new build construction from an embodied carbon perspective as environmental impacts are typically reduced. Reuse and refurbishment is relevant for buildings and infrastructure, including urban drainage. CIRIA has issued guidance on retrofitting to manage surface water. **Only where needs cannot be met by adapting existing buildings/infrastructure, should new build developments be pursued.** See our responses in sections 4 and 9 for *how* this could be incentivised and encouraged.

9. *'What can the Government do to incentivise more repair, maintenance and retrofit of existing buildings?'*

Extending the life of buildings will play an important role in reducing embodied emissions, work from the International Energy Agency suggests around a 10% reduction from cement and steel alone. Retrofit will also be essential to improve thermal efficiency and reduce operational energy demand. We recommend the following to encourage repair, maintenance and retrofit of existing buildings:

1) **Remove VAT on building materials for retrofit**, particularly those which would improve thermal efficiency, or contribute to sustainable urban drainage, e.g. insulation, double/triple glazing, composite doors and materials for Sustainable drainage/GI.
2) **Implement stamp duty incentives thermally efficient** (as per UKGBC report) **and water efficient homes**.
3) **Remove permitted development allowances to demolish buildings** if replacing with housing; this only incentivises demolition. Instead, a circular approach, including adaptive reuse should be explored, see point 4) for further details.
4) **Require Circular Economy (CE) Statements as part of planning applications.** The requirement in the London Plan should be adapted for national use. CE Statements should require a three step approach for developments with an existing building on-site. Requiring exploration of: a) adaptation and reuse of the existing building; b) partial building reuse, e.g. of the facade or structure where a) is not possible; c) deconstruction and component/material reuse where a) and b) are not appropriate.
5) **As part of granting 'notice of intent to demolish' permits, pre-demolition audits should be required**, in order to highlight the potential resources available for reuse and plan for their management accordingly, e.g. temporary storage of those secondary materials until their reuse in other projects. Requiring materials passports, e.g. madaster, for new and existing buildings would make this information available for all buildings in the long term.
6) **Further increase landfill tax** to divert materials from landfill and encourage reuse and recycling of materials.

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