Submission to: Environmental Audit Committee Call for Evidence: “Sustainability of the Built Environment”

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Introduction

The Centre for Natural Material Innovation in the Department of Architecture at the University of Cambridge is a cross-disciplinary centre, bringing together people and research in plant sciences, biochemistry, chemistry, fluid dynamics, engineering, and architecture. Through innovative research and experimentation, we aim to transform the way we build to achieve zero carbon emissions. Our work enables the substitution of artificial materials such as concrete and steel with nature-based materials such as timber and bamboo, and replacement of structural carbon fibre and glass fibre with hemp and flax-based biocomposites. We collaborate with other leading research institutions globally, including in the USA, China, Australia, Uruguay and others.

We are delighted that the committee is launching an inquiry into embodied carbon following the excellent review of operational carbon in EAC report HC 346 “Energy Efficiency of Existing Homes”. In addition to providing evidence for this inquiry, we are also working with Gonzalo Muñoz and Nigel Topping, high-level climate champions for the COP-25 and COP-26 conferences, respectively, to support the UK’s leadership in this area at the COP-26 conference.

We are also working with the United Nations Global Alliance of Building Councils (GlobalABC), supporting in the area of green building code development around sustainable construction using nature-based solutions (NBS) such as engineered timber and bamboo. We are discussing with the FAO their analysis on world forest cover in 2050.

Our centre will also be giving evidence to the Chilean Parliament's Future Challenges Commission regarding the greater adoption of timber in construction there as part of the "Forestry Future for a Sustainable Chile" strategy.

It is encouraging that the UK government has indicated an intention to support greater adoption of timber in construction[1]. Nature-based solutions for construction could form a key part of eliminating the estimated 39% of total global greenhouse gas emissions associated with buildings[2].

In advocating for nature-based solutions for construction, such as engineered timber and natural insulating materials, the UK has the opportunity to lead by example at the upcoming United Nations COP-26 conference. In particular, the EAC has the opportunity to engage with the United Nations Race to Zero global campaign to support the greater uptake of nature-based solutions at the UK level.

1. To what extent have the Climate Change Committee's recommendations on decarbonising the structural fabric of new homes been met?

The Climate Change Committee has recommended greater use of timber in buildings since at least as early as 2019. In its 2019 report "UK Housing Fit for the Future", the Climate Change Committee recommended the implementation of new policies to support the reduction of the whole-life carbon impact of new homes, targeting embodied and sequestered carbon. Increasing the number of new homes built in the UK each year using timber from 27,000-50,000 to 270,000 was estimated to triple the amount of carbon stored in UK homes to 3 Mt annually. The CCC also recommended support for greater assessment and benchmarking of whole-life carbon in buildings.

In any assessment of the impact of greater adoption of timber in the construction of new homes in the UK, it is important to point out the differences between timber uptake in the devolved nations. While timber use in Scotland is high (83% as of 2016), timber use in England, Wales, and Northern Ireland is comparatively low, at 23%, 31%, and 17%, respectively[2]. Importantly, house building in England comprises around 83% of all construction of new homes in the UK

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[1] "The Government Response to the Committee on Climate ... - Gov.uk." 1 Oct. 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928005 /government-response-to-ccc-progress-report-2020.pdf. Accessed 7 May. 2021. [2] "Bringing Embodied Carbon Upfront | World Green Building Council." https://www.worldgbc.org/news-media/bringing-embodied-carbon-upfront. Accessed 12 May. 2021.

[2] "Annual survey of UK structural timber markets - Scottish Forest and ...." 15 Oct. 2017, http://www.forestryscotland.com/media/370371/annual%20survey%20of%20uk%20structural%20timber%20markets%202016.pdf. Accessed 7 May. 2021.

(as of 2015)[3], making greater adoption of timber in England a top priority in achieving meaningful timber adoption in the UK.

Since the publication of the CCC's 2019 report, the Greater London Authority (GLA) has introduced draft guidance for whole-life carbon assessment of building projects, which will be required for projects referred to the mayor, but are recommended for all major buildings in the jurisdiction of the GLA. The final guidance will be issued in Summer 2021[4]. This is a promising first step. Our recommendation is that whole-life carbon assessments be required for all new buildings in the UK. Such a policy would allow for benchmarking of whole-life building performance which is critical for accurately assessing progress towards reducing the whole-life emissions of construction across the UK in line with decarbonisation targets.

The Government could do more to encourage the greater adoption of timber in the construction of UK homes. France, for example, has mandated that all new public buildings must contain 50% natural materials (timber, hemp, straw)[6]. A similar policy for UK construction could create the demand volume and predictability needed to stimulate a domestic natural building materials industry in the UK.

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?

An evaluation of embodied carbon reduction strategies for construction conducted for the International Energy Agency showed that the use of timber in place of concrete, masonry and steel was one of the most successful strategies to reduce embodied carbon. Seven case-studies were analysed, excluding the benefit of carbon sequestration for timber, and a 27% to 77% reduction in the cradle-to-gate or "upfront carbon" emissions of timber structures was found[5].

With regards to operational efficiency, engineered timber buildings are inherently draught-free due to the precision of the offsite manufacturing inherent in their construction process, permitting good thermal performance. By contrast, as building efficiency goes up and

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[3] "Annual survey of UK structural timber markets - Scottish Forest and ...." 15 Oct. 2017, http://www.forestryscotland.com/media/370371/annual%20survey%20of%20uk%20structural%20timber%20markets%202016.pdf. Accessed 7 May. 2021.

[4] "Whole Life-Cycle Carbon Assessments guidance ... - London.gov.uk." https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/london-plan-guidance-and-spg s/whole-life-cycle-carbon-assessments-guidance-consultation-draft. Accessed 5 May. 2021. [6] "France Wants All Public Buildings to Be Made of at Least 50% Wood ...." 12 Feb. 2020, https://www.architecturaldigest.com/story/france-wants-all-public-buildings-to-be-made-of-at-least-50-woo d-by-2022. Accessed 6 May. 2021.

[5] "Design and construction strategies for reducing embodied impacts ...." http://oro.open.ac.uk/52956/. Accessed 5 May. 2021.

operational energy goes down, the additional carbon emitted by the thermal mass pedalled by the concrete industry will not be recovered through lowering energy use over the lifetime of the building[6,7].

The use of plant-based insulating materials such as wood fibre insulation, could also allow for achieving required thermal performance (reducing operational emissions) while having lower embodied emissions than conventional insulating materials[8] and storing sequestered carbon long-term.

Importantly, future embodied emissions reductions for steel and concrete, the structural materials which engineered timber can largely replace in new construction, may be limited due to process emissions associated with unavoidable chemical reactions in their production[9]. Future reductions in energy efficiency per ton of steel and cement are believed to be limited to no greater than 24% and 13%, respectively[10].

Replacing concrete with timber in new construction could also alleviate the severe environmental degradation and depletion of dwindling sand resources associated with the production of mineral building materials[13]. Mining infrastructure and mineral supply chains are responsible for considerable deforestation in vulnerable ecosystems, such as the Amazon, where mining-induced deforestation in Brazil alone was responsible for 9% of all Amazon forest loss in 2005-2015[14].

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

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[6] "Environmental Impact of Buildings What Matters?." 15 Jul. 2015, https://pubs.acs.org/doi/10.1021/acs.est.5b01735. Accessed 7 May. 2021.
[7] "Material efficiency strategies to reducing greenhouse ... - IOPscience." 16 Apr. 2019, https://iopscience.iop.org/article/10.1088/1748-9326/ab0fe3. Accessed 7 May. 2021.
[8] "Comparative analysis of building insulation ... - ScienceDirect.com." https://www.sciencedirect.com/science/article/pii/S1364032120303294. Accessed 5 May. 2021.
[9] "Buildings as a global carbon sink | Nature Sustainability." 27 Jan. 2020, https://www.nature.com/articles/s41893-019-0462-4. Accessed 5 May. 2021.
[10] "Carbon Emissions of Infrastructure Development | Environmental ...." 23 Sep. 2013, https://pubs.acs.org/doi/10.1021/es402618m. Accessed 5 May. 2021. [13] "Buildings as a global carbon sink | Nature Sustainability." 27 Jan. 2020, https://www.nature.com/articles/s41893-019-0462-4. Accessed 5 May. 2021. [14] "Buildings as a global carbon sink | Nature Sustainability." 27 Jan. 2020, https://www.nature.com/articles/s41893-019-0462-4. Accessed 7 May. 2021. [15] "Buildings as a global carbon sink | Nature Sustainability." 27 Jan. 2020, https://www.nature.com/articles/s41893-019-0462-4. Accessed 5 May. 2021.

Reducing Emissions

As mentioned above, plant-based building materials, namely engineered timber and plant fibre-based insulation can play a key role in achieving the Government's net zero ambitions, by enabling reductions in embodied and operational emissions while securely storing carbon in built structures.

Switching to engineered timber construction at scale for new buildings in the UK could result in dramatic embodied emissions reductions. A 2020 study found that if 90% of the world's new urban buildings were constructed using engineered timber, about half of the embodied emissions associated with this construction could be avoided, before accounting for benefits associated with long-term carbon storage[15].

Focussing on the the UK specifically, a 2019 report by the Climate Change Committee and the Bangor Biocomposites Centre found that individual UK homes built using timber frames instead of masonry could have 20% lower embodied emissions[11]. Greater reductions in embodied emissions (around 60%) were predicted for replacing concrete structures with engineered cross-laminated timber. Furthermore, this report found that a widespread transition to timber for home construction in the UK through to 2050 could achieve embodied emissions reductions in home building of 0.8-1.0 $MtCO_{2,e}$ per year, while sequestering a further 1.0-1.3 $MtCO_{2,eq}$ each year. Importantly, the report further shows that the carbon savings associated with greater uptake of timber construction are achievable at negligible additional cost, because timber construction systems are almost identical in price to their masonry and concrete alternatives.

Fire Safety

Recent amendments in the UK's building regulations threaten to limit timber's application to residential and low-rise buildings. Fire regulations deal with timber as a construction material either by limiting the height of the building structure or by requiring the timber structure to be encapsulated into non-combustible cladding panels and thus limiting the areas of exposed timber in a structure. Research has demonstrated that timber used as a primary structural material can provide sufficient fire protection, when encapsulated in non-combustible

[11] "Wood in Construction in the UK: An Analysis of Carbon ...." 18 Jul. 2019, https://www.theccc.org.uk/publication/wood-in-construction-in-the-uk-an-analysis-of-carbon-abatement-potential-biocomposites-centre/. Accessed 26 Oct. 2020.

materials[12,13]. Moreover, resilient evidence-based solutions have been developed for the fire-safe application of engineered timber in housing buildings[14,15,16].

The tragedy of the Grenfell Tower fire triggered a review of building codes and fire safety regulations[17]. Even though the use of engineered timber as a primary structural material did not form any part of the deficiencies identified in the report, the government proceeded to ban all combustible materials on external walls of high-rise residential buildings above 18 meters[18]. However, the term “external walls” does not accurately represent the interactions between the various building components in high-rise buildings. Further clarifications and amendments are necessary to focus the ban of combustible materials on cladding panels only and make a clear distinction between cladding and primary structure. Avoiding such amendments has already had significant repercussions in the use of engineered timber as a structural material and has inhibited growth in the engineered timber industry[19]. Further delays would have a negative impact in addressing the shortage of housing and educational infrastructure in the UK in a cost-efficient and sustainable manner, in line with its legally binding commitments to reduce greenhouse gas emissions.

An amendment to the current ban would enable the definition of a clear model of risk ownership and render engineered timber part of a holistic design strategy and an evidence-based approach for fire-safe multi-family timber structures.

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[12] "Fire Performance of Mass-Timber Encapsulation Methods and the ...." 30 Aug. 2016, https://www.fpl.fs.fed.us/documnts/pdf2016/fpl_2016_hasburgh002.pdf. Accessed 7 May. 2021.

[13] "We need to talk about timber: fire safety design in tall buildings - The ...." https://www.istructe.org/journal/volumes/volume-98-(2020)/issue-3/we-need-to-talk-about-timber-fire-safety-design-in/. Accessed 7 May. 2021.

[14] "Needs For Total Fire Engineering Of Mass Timber ...." https://www.research.ed.ac.uk/portal/en/publications/needs-for-total-fire-engineering-of-mass-timber-buildi ngs(3ba16576-72f8-485b-a39d-42ecb5775ba3).html. Accessed 7 May. 2021.

[15] "Document Library Structural Timber Association." https://www.structuraltimber.co.uk/library. Accessed 7 May. 2021.

[16] "Rethinking Timber Buildings - Arup." https://www.arup.com/perspectives/publications/research/section/rethinking-timber-buildings. Accessed 7 May. 2021.

[17] "Building a Safer Future - Gov.uk." https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707785 /Building_a_Safer_Future_-_web.pdf. Accessed 7 May. 2021.

[18] "Building (Amendment) Regulations 2018: Circular 02/2018 - GOV.UK." 29 Nov. 2018, https://www.gov.uk/government/publications/building-amendment-regulations-2018-circular-022018. Accessed 7 May. 2021.

[19] "Ban on combustible materials in external wall systems ... - GOV.UK." 29 Nov. 2018, https://www.gov.uk/government/publications/ban-on-combustible-materials-in-external-wall-systems-impact-assessment. Accessed 7 May. 2021.

Supply Chain Opportunities for Plant-based Building Materials.

Currently there is very low capacity in the UK of engineered timber and plant-based material manufacturing. There is a real opportunity to establish a detailed manufacturing strategy for the production of CLT and plant based insulation materials for both the UK and the overseas markets post-Brexit. There is interest by multinational companies to invest in the UK to do this but it does need a positive approach from the UK government. It is said that the priority must be new tree planting and the preservation of old growth trees and we agree. But crop-based tree plantations can exist alongside to enable the building sector to move towards net zero[20].

There is strong regulation against illegal harvest practices in Europe and North America, with the Forest Stewardship Council (FSC)[21] and the Programme for the Endorsement of Forest Certification (PEFC)[27] certifying that timber comes from responsibly managed forests. Timber sourced from sustainably managed forests in Europe is not likely to pose a deforestation risk[28]and could be used in the implementation of the UK Proposals for Carbon Capture Use and Storage (CCUS) for Net Zero for any proposed wood fibre insulation and engineered timber factories on Teesside ahead of COP26[22]. The development of the Great North Forest when at maturity could provide a long-term sustainable source of timber with immediate managed replanting. We look forward to clarity coming from the eligibility criteria being set by the UK Government in the coming months[23].

The EU Forest Law Enforcement Governance and Trade (FLEG-T) measurement of non EU forest products exported to the EU, and into the UK, has been endorsed by Lord Goldsmith last September in recognising under FLEG-T the sustainability and community accountability of the benchmark being achieved in both in Indonesia and other countries such as Gabon who are seeking to both maintain virgin forests under REDD+ and obtain high value jobs for their citizens from the export of crop grown timber[24].

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[20] "Climate Positive Forest Products (CPFP) | The Forests Dialogue." https://theforestsdialogue.org/initiative/climate-positive-forest-products-cpfp. Accessed 13 May. 2021.
[21] "Forest Stewardship Council: Home Page." https://fsc.org/en. Accessed 12 May. 2021. [27] "PEFC International." https://www.pefc.org/. Accessed 12 May. 2021. [28] "The wood from the trees: The use of timber in ... - ScienceDirect.com." https://www.sciencedirect.com/science/article/pii/S1364032116306050. Accessed 5 May. 2021.
[22] "Net Zero Teesside | The UK's first decarbonised industrial cluster." https://www.netzeroteesside.co.uk/. Accessed 13 May. 2021.
[23] "Cluster sequencing for carbon capture, usage and ... - GOV.UK." 7 May. 2021, https://www.gov.uk/government/publications/cluster-sequencing-for-carbon-capture-usage-and-storage-cc us-deployment-phase-1-expressions-of-interest. Accessed 13 May. 2021.
[24] "Net Zero Teesside | The UK's first decarbonised industrial cluster." https://www.netzeroteesside.co.uk/. Accessed 13 May. 2021.

The domestic supply of construction-grade timber in the UK has been historically underappreciated[25]. Advocating for building with timber must be directly linked to advocating for building with timber from sustainable sources. The Welsh Government announced on the 14th of May their plans to "grow homes" with Welsh timber with a Climate Change superministry that brings together both the growers of trees with the builders of low embodied carbon timber houses.[26]

There can be a future where both the use of trees as a carbon sink can sit aside plantation trees as a NBS to carbon emissions in the built environment. But to underline the importance of carbon sequestration long term, there must be a question mark over the continued endorsement of biomass power stations in the UK.

End of Life

Due to its inherently prefabricated and modular nature, engineered timber is highly compatible with emerging digital design and fabrication methods which allow for a circular approach to the construction economy. By supporting the design and construction of timber structures whose components can be easily reused in future construction, the UK government could establish an increasingly large and easily verifiable carbon sink in its built environment. Such long-term carbon storage is a powerful tool for achieving the Government's net-zero ambitions. The Government should investigate carbon storage in timber building elements as part of a new carbon credit taxonomy which takes into account the benefit of carbon storage in the built environment. RH Anne-Marie Trevelyan MP announced in February 2021 that the UK Carbon Credit scheme "would be even more ambitious than the EU system it replaces[27]. We anticipate that it will include carbon credits for the use of timber in buildings.

Schools and other Public Buildings

In addition to housing, engineered timber is highly appropriate for schools and other publicly procured buildings. By 2024, the UK is expected to face a shortage of as many as 120,000 school places[35]. Building these schools using timber instead of steel and concrete could significantly reduce the embodied emissions associated with this construction, while securely

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[25] "UK construction can't see the wood for the trees - Construction ...." 1 Mar. 2015, https://www.constructionmanagermagazine.com/insight/we-cant-see-wood-trees/. Accessed 5 May. 2021.

[26] "Welsh Labour Manifesto" http://www.maniffesto.com/wp-content/uploads/2021/04/WEB-14542_21-Welsh-Labour-Manifesto_A5.pdf Page 36 accessed 12th May 2021

[27] "UK carbon trading system to launch in May | Financial Times." 26 Feb. 2021, https://www.ft.com/content/1157028b-d074-476b-862c-9eec70010dfc. Accessed 13 May. 2021.

[35] "England faces school place emergency, say councils - The Guardian." 31 Aug. 2018, https://www.theguardian.com/education/2018/aug/31/england-faces-school-places-emergency-say-council ls. Accessed 7 May. 2021.

storing large volumes of carbon in these structures, contributing towards meeting the Government's net zero targets. The UK government should promote the use of engineered timber in publicly procured buildings, such as hospitals and schools, in addition to housing.

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 UK Government's Future Homes Standard[28] so far appears to only reference the minimisation of operating emissions. Omitting embodied emissions in new construction standards misses a critical opportunity for the UK's new planning strategy, through a "whole-life" emissions approach to achieving true net-zero construction, to catalyse an industry transition towards the fully decarbonised construction sector which the Government has legally committed to achieving by 2050.

As mentioned above, requiring whole-life carbon assessments at planning stage for all new construction in the UK would support the data collection required to measure whole-life emissions in proposed new buildings. Future building regulations should incorporate whole-life emissions targets which are reduced year-on-year in line with carbon budgets. Requiring embodied carbon emissions reductions will result in specifiers choosing low-carbon materials, and improving their design methods to achieve materially-efficient designs. Requirements that new buildings comprise some proportion of natural materials could also stimulate the UK natural building materials industry.

A 2019 report prepared by AECOM for the CCC outlined three strategies for incorporating embodied and sequestered carbon into building regulations[29]. These are: 1) "voluntary action & Government leads by example through procurement", whereby the Government monitors and limits embodied carbon in the buildings it procures 2) "whole-life elemental carbon intensity targets", whereby limits on embodied carbon are set for individual building products, and 3) "whole building life-cycle carbon intensity targets", whereby limits on embodied carbon are set for whole buildings. As of yet, no action has been taken by the Government to implement these recommendations. Other countries, including the Netherlands, Finland, France, and Sweden

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[28] "The Future Homes Standard: changes to Part L and ... - Gov.uk." 1 Oct. 2019, https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings. Accessed 23 Oct. 2020.

[29] "Options for incorporating embodied and sequestered carbon into the ...." 10 Jul. 2019, https://www.theccc.org.uk/publication/options-for-incorporating-embodied-and-sequestered-carbon-into-th e-building-standards-framework-aecom/. Accessed 15 May. 2021. [38] "Whole life carbon assessment for the built environment - RICS." https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the--built-en vironment-november-2017.pdf. Accessed 6 May. 2021.

have already or are currently incorporating embodied carbon accounting (and reductions targets) into their building regulations.

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

Standardised embodied carbon accounting methods have been described in detail by a number of UK industry bodies, including RICS[38] and IStructE[30]. Future accounting methods should also capture the benefits associated with long-term carbon storage in natural materials in buildings.

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?**

“Cradle-to-gate” embodied carbon assessments of building materials take into account carbon costs associated with manufacture (captured in modules A1-A3)[31]. Transportation to the construction site (module A4) may or may not be accounted for in embodied carbon analysis associated with building products, depending on the scope of the analysis performed.

Transportation of wood products does not typically comprise a large fraction of their embodied energy in cradle-to-gate analyses[32]. In the UK, timber transport is associated with 6% of total emissions for sawnwood production[42]. Transportation impacts associated with imported wood products could be higher, and depend strongly on the modes of transport used[43]. Embodied carbon impacts of wood products could include such transportation impacts to convey these differences to the customer. However, the assumption should not be made that domestically sourced materials always have lower associated embodied emissions, as these may vary significantly between products.

In addition to potentially reduced transportation impacts, there are other benefits associated with the expansion of a domestic wood products industry in the UK: namely, the creation of

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[30] "IStructE guide, How to Calculate Embodied Carbon - The Institution ...." 21 Aug. 2020, https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/. Accessed 6 May. 2021.
[31] "How to calculate embodied carbon - The Institution of ... - IStructE." 21 Aug. 2020, https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/. Accessed 15 May. 2021.
[32] "Life-cycle Analysis of Wood Products: Cradle-to-gate Lci of ...." https://wfs.swst.org/index.php/wfs/article/view/1268. Accessed 6 May. 2021. [42] "Understanding the Carbon Footprint of Timber Transport in the ...." 20 Apr. 2010, https://timbertransportforum.org.uk/attachments/article/117/TTF%20Publications%202010%20Understand

revenue streams to fund sustainable forest management, job creation, and reduced reliance on foreign imports during periods of supply disruption or increased demand.

9. How should reuse and refurbishment of buildings be balanced with new developments?

Adaptive reuse and refurbishment typically have lower carbon impacts than new construction and should generally be considered before new construction. Timber, as a relatively lightweight structural material, offers an excellent opportunity for adaptive reuse of existing concrete buildings through the addition of stories built using timber without requiring significant modifications to foundations or structure[44]. The Government should introduce a policy whereby concrete buildings are never demolished, but rather are added to as needed using additional timber structure.

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

The Government should not charge VAT on refurbishments, and provide additional support for refurbishments using natural-based materials.

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ing%20the%20Carbon%20Footprint%20of%20Timber%20Transport%20in%20the%20UK.pdf. Accessed 6 May. 2021.

[43] "The wood from the trees: The use of timber in ... - ScienceDirect.com." https://www.sciencedirect.com/science/article/pii/S1364032116306050. Accessed 6 May. 2021.

[44] "Super Tall Timber: design research for the next generation of natural ...." 24 Jan. 2017, https://www.tandfonline.com/doi/full/10.1080/13602365.2016.1276094. Accessed 6 May. 2021.