

Reducing embodied carbon in structural materials

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An examination of why structural material choices matter, how lean engineering can reduce embodied carbon, and the changes needed to encourage wider uptake in Malaysia.

What is embodied carbon

The carbon emissions from a building, known as the total or lifetime carbon, are split into embodied and operational carbon. Embodied carbon is emissions caused by extraction, manufacture, transportation, assembly, maintenance, replacement, deconstruction, disposal and end-of-life aspects of the materials and systems that make up a building. On the other hand, operational carbon is emissions associated with operation (for example, cooling, powering and providing water).

Why embodied carbon in structural materials matters

Reports show that depending on the type of building, typically 30–70% of a building's carbon emissions are from embodied carbon, and of this, 60% is from structural materials.

30–70%

Typical embodied share of total building carbon emissions

60%

Structural materials' share of embodied carbon, as reported in the article

5–10%

Reported contribution of the cement industry to global emissions

Reported figures reproduced from the original 2021 publication; they are not presented as current industry benchmarks.

Until recently, globally, embodied carbon has taken second stage to operational carbon. But as buildings become more and more operationally energy efficient, embodied carbon will soon form a critical portion of a building's total carbon. Therefore, to meet carbon reduction targets, embodied carbon cannot be ignored, especially embodied carbon in structural materials. This is especially true for Malaysia, as reinforced concrete (which consists of cement) is the primary structural material used, and the cement industry contributes towards 5–10% of the global carbon emissions.

The considerations for reducing embodied carbon impacts of structural building materials

The following should be considered:

- Selecting material with lower embodied carbon
- Leaner design
- Designing out waste
- Reusing materials

31-storey residential tower | case study

Lean structural design		28%
40% cement replacement		20%
Combined reduction		48%

Case study findings reported by Ohr: the 28% design reduction and further 20% cement replacement reduction are presented as a combined 48% reduction in the original article.

A case study conducted by Ohr found that applying lean design philosophy to optimise the design for a 31-storey residential tower reduced the embodied carbon by 28%. Using 40% cement replacement further reduced the embodied carbon by 20%, giving a total reduction of 48%. Also, the optimised design used flat slab system with typical fabric reinforcement compared to the original beam and post system, designing out reinforcement and formwork wastes.

So why aren't more of these considerations applied in Malaysia?

Given its obvious environmental benefits, why aren't more of these considerations applied in Malaysia? These are some of the reasons why:

1. Perception (and reality for some matters) that there are no commercial benefits. Some examples:
 - Flat slab systems are perceived to be more expensive than beam and post, which is not necessarily true.
 - Lean design approach requires investment in decent consulting fees by the building owner/developer. The industry perceives this as an extra cost when in reality, lean design reduces not only negative environmental impact but also the construction cost from the reduction in materials.
 - There is a general misconception that concrete mix with cement replacement is more expensive, affects strength and increases the construction programme.
 - IBS and proprietary systems could cost more than conventional systems.
2. Absence of implementation incentives that are of meaningful commercial value. For example:
 - Although CIDB levy is exempted when IBS is used, the cost of using IBS could be significantly more than the levy, making it not an attractive incentive.
3. Absence of mandatory policies. For example:
 - Despite Malaysia being one of the world's largest timber producers and timber being dubbed as the material of the 21st century due to its green credentials, it is precluded from use as structural material in the UBBL.
 - Only 3–6% of the total GBI score is for the choice of building materials and solutions. And this is not explicitly for structural materials. On a built, the options with the least commercial impact take precedence over structural materials and solutions.

What can be done – policies, incentives and efforts that would lead towards reduction of embodied carbon in structural materials

1. Incentivise* the reduction of embodied carbon in structural building materials or implement mandatory requirements addressing these:

- Use of cement replacement
- Use low carbon materials and solutions
- Production and use of recycled aggregates
- Demonstration of the designing out of wastes
- Demonstration of lean design (from the start of design stage)
- Reuse of existing buildings

* The incentives need to be of real commercial value for there to be industry uptake.

2. Allocate more points in the GBI for reducing embodied carbon impacts of structural building materials or have an independent but parallel assessment framework specifically for embodied carbon.

3. Make it a national agenda to enable the use of structural timber.

- Promote the use of structural timber through policies that enable and incentivise the use
- Invest in researching fast-growing species that can be used for structural purposes and promote the planting of these
- Promote fabrication of structural timber (including engineered timber) for local use
- Invest in developing the skills needed for design, fabrication and construction

This article is based on the presentation that the author made at a roundtable session discussing reducing embodied carbon in the built environment, organised by Climate Governance Malaysia and CEO Action Network. The recording was made available on Climate Governance Malaysia's website.

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