Embodied Carbon in Structures: Insights, Solutions, & RJC's Commitment

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In sustainable building construction, a critical factor often goes unnoticed: embodied carbon. Let's explore the significance of this silent emissions contributor and understand why it's crucial for global climate goals.

WHAT IS EMBODIED CARBON?

Embodied carbon refers to the carbon emissions produced during the life cycle of building materials, from raw material extraction to manufacturing, transport, installation, and end of life. Most of these emissions occur before a building is even in use.

THE FOUNDATION: A TORONTO-BASED CASE STUDY

The insights and perspectives shared throughout this article are rooted in the comprehensive study titled, "Embodied Carbon in Residential Structures: A Toronto Based Case Study," which was jointly conducted by RJC Engineers and BDP Quadrangle, dated September 12, 2023.

This research underscores the environmental significance of embodied carbon, especially during the manufacturing and construction phases of buildings. For a deeper dive into the study's findings, we recommend exploring the full publication.[1]

OFTEN OVERLOOKED: THE IMPACT OF EMBODIED CARBON

While operational emissions from buildings in use have been the primary concern for decades, the industry is shifting focus toward this often-neglected contributor. The reason for this shift in attention is twofold. Firstly, as building designs become more energy-efficient, and fuel is switched to cleaner energy sources, the relative contribution of embodied carbon to the total carbon footprint of a building increases. Secondly, the immediacy of the emissions from building materials – released during extraction, production, and construction phases – means they have an immediate impact on our environment, even before a building is operational. Recognizing and addressing embodied carbon, therefore, becomes essential in achieving true sustainability in the built environment.

WHY EMBODIED CARBON MATTERS NOW

With the International Energy Agency reporting that buildings and their construction account for 36 per cent of global energy use and 39 per cent of energy-related carbon dioxide emissions, it's clear that the building sector plays a pivotal role in the global carbon emissions landscape.

So why is this the case? Here are some critical aspects to consider:

- **Rapid urbanization:** By 2060, two-thirds of the predicted 10 billion global population will live in cities. This urban boom translates to massive construction activities.
- **Material impact:** Certain materials like concrete, steel, and aluminum have high embodied carbon footprints. For instance, the production of cement, a primary ingredient in concrete, is responsible for eight per cent of the world's carbon dioxide (CO2) emissions.

THE BUILDING SECTOR'S CARBON FOOTPRINT

Architecture 2030 and many industry experts have highlighted that the built environment contributes a staggering 40 per cent to global CO2 emissions annually. Out of this, building operations account for 27 per cent, with embodied carbon following

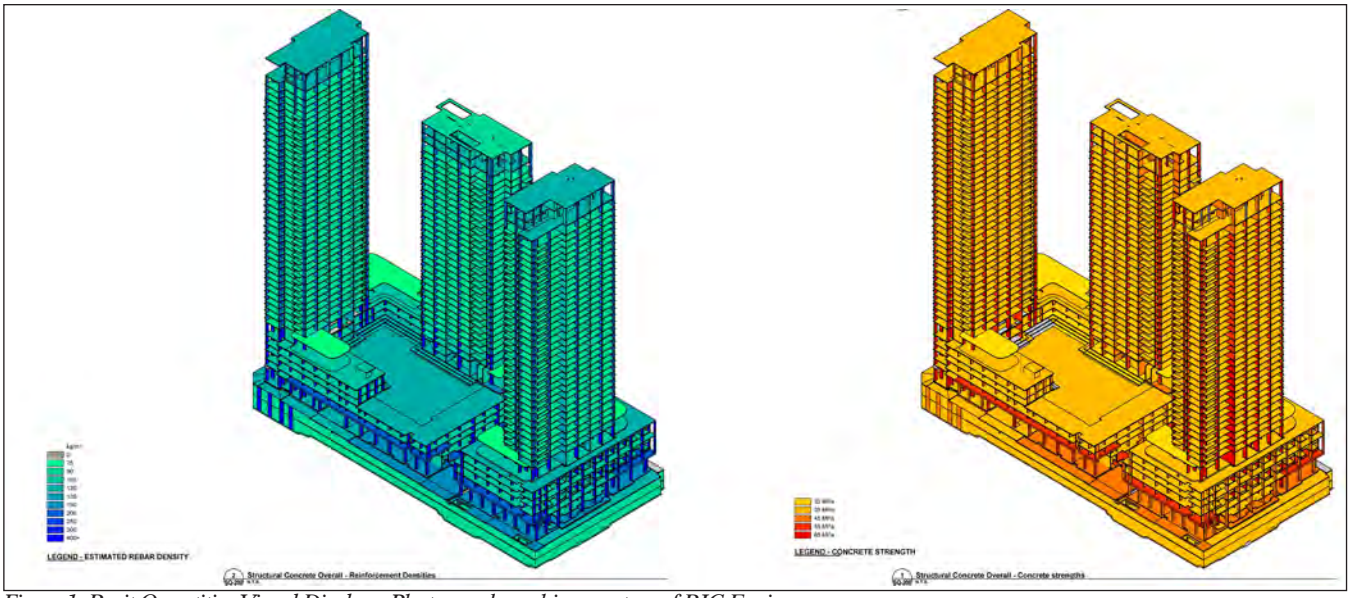

Figure 1: Revit Quantities Visual Displays. Photos and graphics courtesy of RJC Engineers.

closely at 13 per cent and rising. While operational emissions from power usage have been the focal point for years, embodied carbon from construction materials has recently gained attention as a significant part of this footprint.

SIGNIFICANCE OF EMISSIONS IN THE BUILDING INDUSTRY: A SUMMARY

- Buildings alone are responsible for nearly 40 per cent of the global energy consumption.
- Around 30 per cent of the total CO2 emissions are attributed to buildings.
- As the world's urban population grows, so will the demand for new buildings, thereby increasing the potential for embodied carbon emissions.

MATERIALS WITH HIGH EMBODIED CARBON

- **Concrete:** Often used in construction, its production emits a large amount of CO2.
- **Steel:** While recyclable, its initial production is carbon-intensive.
- **Aluminum:** High energy requirements for production result in significant carbon emissions.

REDUCING EMBODIED CARBON: WHAT CAN BE DONE?

In the quest to combat embodied carbon, every segment of society must come together and play its part.

The Structural Engineers 2050 Commitment Program (SE2050) is an industry-wide response. The commitment is clear: achieve net zero carbon structures by 2050. RJC

We want you to write for us!

Have an idea showcasing best practices related to the design, construction, performance, retrofit, and maintenance of the building envelope?

The Ontario Building Envelope Council (OBEC) is excited to be planning the Fall 2024 issue of *Pushing the Envelope Canada*. If you're a building science specialist with a story to share, please send a short abstract (50-100 words and the author's contact information) for consideration.

Articles should showcase best practices related to the design, construction, performance, retrofit, and maintenance of the building envelope. They can also include the latest developments related to materials, products, and components associated with building envelopes.

Note: Articles can not be product or company promotional. Articles may speak about products but would need to speak to their use, successes, challenges – they can not "sell" products or services.

SUBMIT YOUR ABSTRACT TO JENNA COLLIGNON, EDITOR OF THE MAGAZINE, AT JCOLLIGNON@MATRIXGROUPINC.NET, AND COPY MOHAMMED DAWOUD AT MDAWOUD.EIT@GMAIL.COM, ANTOINE POSSIK AT ANTOINE@NORTHERNCAULKING.COM, AND SHERRY DENESHA AT SHERRY@ASSOCIATIONCONCEPTS.CA.

OVERALL QUANTITY TAKEOFF - STRUCTURAL STEEL

Category	RJC BUILDING ID	RJC SUBCATEGORY	MATERIAL NAME	STEEL MASS	PORTION OF STEEL MASS
Structural Columns		COLUMN	Steel 350W	0.1 t	0%
Structural Columns		COLUMN	Steel 345WM	19.5 t	12%
Structural Columns		COLUMN	Steel 350W- CLASS H	1.2 t	1%
Structural Columns		COLUMN	Steel A500	2.7 t	2%
Structural Framing		BEAM	Steel 345WM	115.3 t	71%
Structural Framing		BEAM	Steel 350W	0.6 t	0%
Structural Framing		BEAM	Steel, Existing	1.2 t	1%
Structural Framing		GIRT	Steel 350W	0.7 t	0%
Structural Framing		GIRT	Steel 350W- CLASS H	1.2 t	1%
Structural Framing		GIRT	Steel A500	11.6 t	7%
Structural Framing		OWSJ	Steel 350W	5.9 t	4%
Structural Framing		TRUSS	Steel A500	2.2 t	1%
Structural Framing		VBRACE	Steel A500	1.0 t	1%
Grand total: 696				163.4 t	100%

OVERALL QUANTITY TAKEOFF - ESTIMATED CONCRETE AND REBAR

MATERIAL NAME	VOLUME	ESTIMATED REBAR MASS
35 MPa	700 m³	5000 kg
Concrete, Existing	1950 m³	0 kg
Grand total: 327	2650 m³	5000 kg

Figure 2: Embodied carbon calculations for materials.

is proud to be a signatory of this program. Some highlights include:

- **Accountable engagement:** The program isn't just about commitment but about active engagement on projects and sharing insights, which is crucial for collective progress.
- **Intensive data representation:** The program offers embodied carbon intensity diagrams. These visual aids help firms compare their structural material quantities and embodied carbon intensities against an established baseline, fostering a competitive spirit for betterment.
- **Growing momentum:** Numerous companies, including RJC, have taken the pledge, indicating a growing industry consensus and commitment toward this goal.

Following, we share other methods engineers and structural designers can implement to tackle the embodied carbon challenge.

Life Cycle Assessments (LCA): An LCA is a method used to evaluate the environmental impacts of products, materials, and services. By understanding these impacts, it's possible to make more informed, sustainable choices. LCAs provide a comprehensive overview of the environmental impacts of materials and products. With such data, decisions can be more aligned with sustainability goals.

Sustainable Material Choices: Beyond LCAs, a conscious shift towards materials with a lower carbon footprint can make a considerable difference. For example, opting for materials with lower carbon footprints, making use of recycled or upcycled materials, or implementing innovative construction methods to minimize waste.

Innovations in Construction: New methods, such as modular and prefabricated construction, can reduce waste and the overall carbon footprint of a project.

POLICYMAKER INITIATIVES FOR EMBODIED CARBON REDUCTION

Governments and policymakers hold the power to shape the future of sustainable construction through regulations, incentives, and targets. Here are just some of the ways all levels of government can make change happen:

- Setting embodied and operational carbon targets to signify the issue's importance.
- Reviewing building requirements to minimize embodied carbon impacts.
- Shortening the approval process for sustainable projects to expedite green development.
- Rethinking financial incentives to prioritize low-carbon developments.

DEVELOPER STRATEGIES FOR CARBON-CONSCIOUS CONSTRUCTION

Land developers play a pivotal role in determining a project's carbon footprint by setting goals and choosing sustainable materials and methods. Here's what can be done according to industry experts:

- Prioritizing the reuse of existing buildings over new constructions;
- Designing for extended building lifespans and future adaptability;
- Using lower carbon products and materials;
- Engaging in integrated design approaches for optimized construction; and

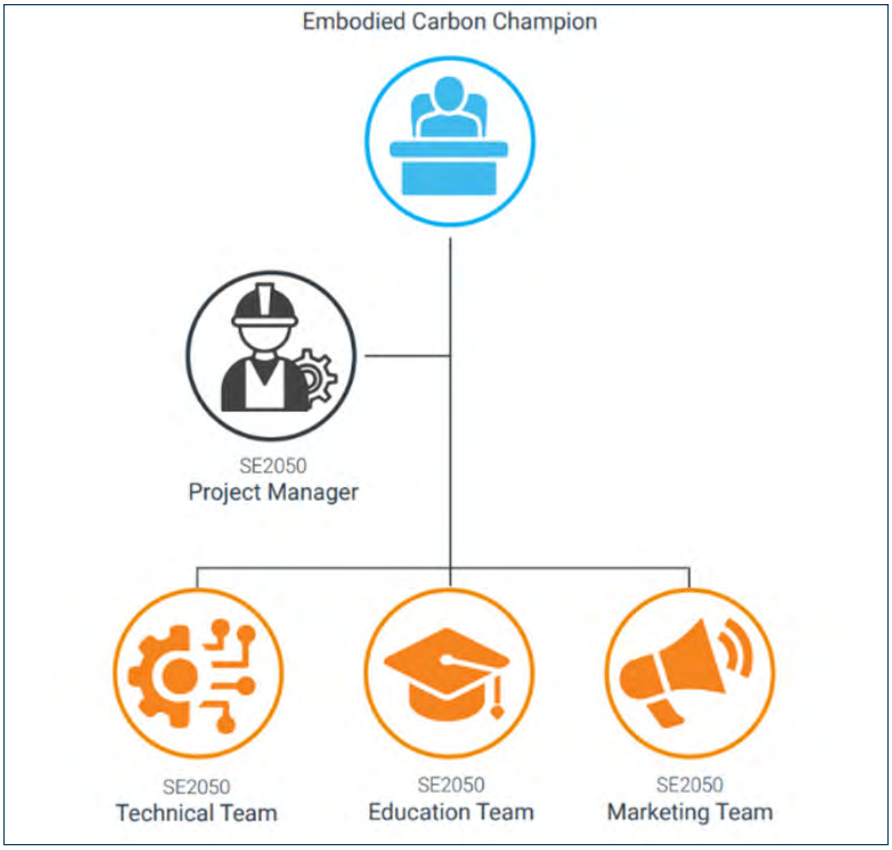

Figure 3: The Embodied Carbon Team.

- Implementing innovative construction techniques to reduce carbon intensity.

RJC ENGINEERS' COMMITMENT TO SUSTAINABLE BUILDING PRACTICES

With over seven decades in the industry, RJC champions sustainability and innovation in construction while actively shaping a greener future.

Here's how RJC's dedicated strategies and practices align with industry initiatives and our drive toward sustainable construction.

SE2050: Joining the Industry's Commitment: RJC proudly aligns with the SE2050 Commitment Program mentioned above. This program, directed towards structural engineers and firms, aims for zero-carbon structures by 2050. As a signatory, RJC has promised not just to understand and reduce but to aim for net-zero carbon by the targeted year.

RJC's Embodied Carbon Action Plan (ECAP): At the heart of RJC's commitment is our Embodied Carbon Action Plan. More than a roadmap, ECAP represents a proactive approach:

1. **Education plan:** RJC prioritizes professional development and internal training, ensuring all understand their commitment to SE2050.
2. **Knowledge sharing narrative:** Through seminars, webinars, and conferences, RJC brings clients and partners into their carbon reduction journey.
3. **Reduction strategy:** RJC aims for net-zero designs by 2050, deploying tools, gathering design data, and setting clear benchmarks.
4. **Reporting plan:** With a focus on transparency, RJC accurately tracks embodied carbon, aligning with standards like SE2050.

This plan isn't just about reduction – it's about bringing forward innovative ideas and education to the wider industry. It details how RJC plans to leverage its strengths to decrease carbon emissions from projects creatively and practically.

INTRODUCING RJC'S IN-HOUSE REVIT QUANTITIES TOOLS

The firm has developed the RJC Revit Quantities Tools, an innovative solution to calculate structural material quantities more efficiently. This tool simplifies a traditionally time-consuming and error-prone process. The quick and accurate data obtained is crucial for embodied carbon calculations. The data from the tool isn't just numerical – it can be presented graphically or in tables, offering clients and contractors clear insights into construction costs and embodied carbon measures.

TOOL OVERVIEW

Traditional methods of computing quantities from Revit models have been labour-intensive and prone to inaccuracies. RJC has bridged this gap with:

- **Precision and speed:** The tool allows for swift, high-quality data extraction.
- **Accurate data:** With accurate data on structural materials, more precise embodied carbon calculations are possible.
- **Versatility:** Data can be showcased graphically or tabulated, aiding clients and contractors in making informed decisions.

Reach out to our team today to learn more about this effective materials calculator tool.

THE PATH AHEAD: A COLLABORATIVE EFFORT

Embodied carbon, once an overlooked aspect of the construction industry, is now at the forefront of sustainable structural engineering. With companies like RJC leading with commitments and tangible tools, the path to net-zero carbon structures by 2050 becomes clearer and far less intimidating. That said, the journey to net-zero carbon structures by 2050 is not just an RJC goal – it's a global imperative. With embodied carbon taking center stage, collaboration, innovation, and commitment from industry leaders and governments are the keys to a sustainable future.

Interested in diving deeper into embodied carbon or exploring how RJC's expertise can elevate your projects? For insights, collaborations, or tailored solutions, Reach out to our team today. ■

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REFERENCE:

1. RJC Engineers & BDP Quadrangle. "Embodied Carbon in Residential Structures A Toronto based case study." https://www.rjc.ca/rjc-media/published/embodied-carbon-residential-structures-toronto-based-case-study.html.