Designing sustainably with North American resources

Dan Bergsagel, Eli Rose and Jessica Martinez introduce IStructE members in the UK and around the world to some of the key sustainable design resources developed in the USA.

The IStructE is an international thought-leader on sustainability in structural engineering, but it is not the only cross-industry structural engineering organisation collecting, developing and disseminating relevant information on sustainability. In the USA, two sustainability-focused groups organised within the Structural Engineering Institute (SEI) fulfil a similar role to the IStructE's Climate Committee.

The first group, the Resources Working Group (RWG) which operates within SEI's SE 2050 committee, supports engineering practices to work towards structural systems with net-zero embodied carbon by 2050. The SE 2050 commitment has over 150 signatory firms across North America since its launch in 2019, with notable clusters in California, New York, Colorado, Washington and Texas. These firms cover a wide range of practice sizes, with 30% having 11–50 staff, another 30% having 51–200 staff, 15% with fewer than 10 staff, and 15% with more than 500 staff.

The second group, the SEI Sustainability Committee, is made up of over 40 individual engineers from across the USA and Canada working on specific subtopics within task groups.

Together, the groups have produced a suite of useful resources focused on sustainability and embodied carbon with the goal of mitigating the impact of the structural engineer's work on the environment. The resources are aimed at structural engineers in North America but are relevant beyond it. This article presents an introduction to a selection of their recently produced resources across three categories: Educate – collecting and sharing relevant information and guidance to a wide audience; Reduce – providing tools and benchmarking analysis to influence design strategies and processes; and Report – defining frameworks to align and steer industry practice across firms. Many of these resources can be found on the SE 2050 website **(https://se2050.org)**.

Educate

The first resources are aimed at climate capacity building – strengthening the knowledge base of the wider structural engineering community by providing accessible introductory information. Links to key resources are provided in **Box 1**.

Top 10 things every structural engineer should know

This five-part series of 10 important facts **(Figure 1)** is a primer for structural engineers to begin tackling the sustainability topic. Covering embodied carbon, concrete, steel, masonry and wood, these concise documents are a useful primer for engineers new to the topic. They were published as a series of Public Service Announcements over a six-month period in *STRUCTURE Magazine*, the US equivalent to *The Structural Engineer*, and are available as standalone two-page pdfs.



FIGURE 1: Example Top 10 list – embodied carbon

Box 1. Educate resources

- **Top 10 lists**
  https://se2050.org/top-ten-lists/
- **Design guidance**
  https://se2050.org/resources-overview/structural-materials/lean-design-guidance/
- **Specification guidance**
  https://se2050.org/resources-overview/structural-materials/specification-guidance/
- **Green rating systems**
  https://se2050.org/resources-overview/embodied-carbon-in-green-rating-systems/

Design and specification guidance

After priming engineers on these basics, they can be directed to a nested set of tabs on the SE 2050 website that offer strategies for how to reduce embodied carbon in their work. The design strategies are divided into sections on build less, build smart, evaluate design methods, implement circular economy design principles, and build light. Each section is subdivided into a tab on specific topics. For example, the 'Build Smart: Early Design Decisions' section includes subsection tabs on 'Site location and substructure' and 'Floor Bay Studies'. Each subsection includes a short text description of the sustainability opportunity, and some supporting further reading references.

The same approach is taken for specification guidance, providing narrative options for how specifications can be drafted using different sustainability levers to reduce embodied carbon for the whole project (transparency and disclosure, transportation, carbon banks) or for specifying for the procurement of the primary construction materials.

Green rating systems

While structural engineers can have impact in their design work and specification strategy, these sustainability strategies are often adopted as good practice and not mandated by clients or included specifically in the scope of work. Green rating systems – such as LEED and BREEAM – are often the only direct measure a client uses to measure the sustainability of their project.

Revisions to green building rating systems are increasingly elevating

Table 1: North American green rating systems

Scheme name
GBI Green Globes for NC 2024
USGBC LEED BD+C, Version 5
BREEAM INT v7
ILFI Living Building Challenge 4.0
ILFI Zero Carbon Standard 1.0
ILFI ZE Certification
ILFI CORE
PHIUS+ 2018
ISI Envision, Version 3
CaGBC Zero Carbon Building
IWBI WELL Building Standard, Version 2.0

the importance of embodied carbon, placing structural engineers at the centre of project teams' efforts to achieve sustainability goals. To help engineers navigate these evolving requirements, the SE 2050 website provides a centralised resource where engineers can access detailed descriptions of embodied carbon opportunities across 18 different green rating systems in use in North America and across Europe **(Table 1)**.

Reduce

Early structural design decisions have an outsized influence on embodied carbon, yet engineers often have limited information to draw on to support crucial discussions with the project team that can shape the brief and influence the concept design. These resources provide structural engineers with valuable tools to compare structural systems against each other, to compare design options against industry benchmarks, and to provide realised examples to support the feasibility of impactful yet still unconventional methods. Links to key resources are provided in **Box 2**.

Box 2. Reduce resources

- **Embodied carbon intensity diagrams**
  https://se2050.org/resources-overview/embodied-carbon-intensity-diagrams-2/
- **Data analysis findings**
  www.structuremag.org/article/data-insights-from-over-500-building-projects-for-low-carbon-structures/
  https://ascelibrary.org/doi book/10.1061/9780784485927
- **Circular economy case studies**
  https://se2050.org/resources-overview/case-studies/sei-circular-economy-case-studies/
- **Embodied Carbon Estimator**
  https://se2050.org/ecom-tool/

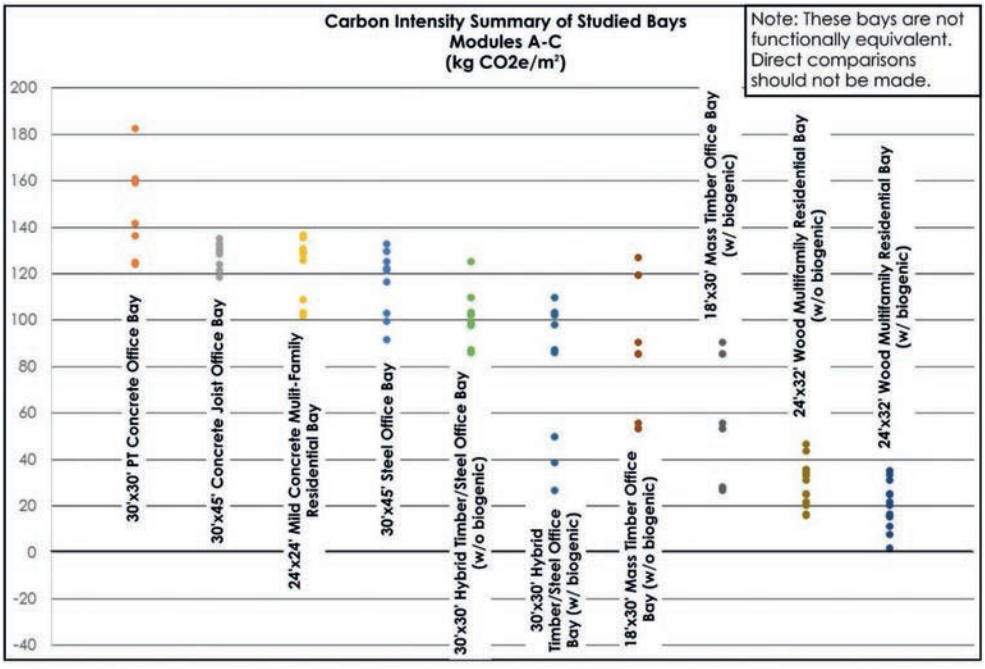


FIGURE 2: Embodied carbon intensity diagram studies

Embodied carbon intensity diagrams

Much of the embodied carbon impact of building structures is associated with floor framing. The embodied carbon intensity diagrams (ECIDs) are a series of peer-reviewed and sensitivity checked structural studies that provide rough order-of-magnitude comparisons of common structural framing systems during early design **(Figure 2)**. The framing systems were not designed to be functionally equivalent or to prescribe a preferred structural solution, but are intended for high-level comparisons.

Part of the value of the ECIDs is in the process used to produce them; developed in two phases, the ECIDs evaluated seven representative framing systems (including various concrete, steel and mass timber systems). Multiple volunteer structural engineers independently designed each system using common criteria, while experienced life-cycle analysis (LCA) practitioners modelled each resulting design using three different commercially available LCA tools. Comparing results across multiple structural designers and LCA tools provides a realistic spread for embodied carbon values, and reaffirms that embodied carbon estimates are influenced not only by engineering decisions, but also by software, carbon factor databases, and modelling choices.

SE 2050 database and analysis report

One of the most powerful aspects of the SE 2050 commitment programme towards net-zero-embodied-carbon structural systems by 2050 is the requirement for all signatory firms to submit embodied carbon calculations from building projects to a central anonymised database.

The database has proven to be an excellent source of aggregated real data. A data analysis report published in 2024 – based on over 500 submitted projects – produce some useful results, such as setting mean, median and 80th percentile global warming potential (GWP) intensity benchmarks for different project typologies and buildings with different primary horizontal gravity systems. The Data Science Team which produced the initial report is in

the process of expanding its analysis to incorporate data from more than 1,000 submitted projects. This data will further refine embodied carbon benchmarks and inform future guidance, and will continue to be updated as the database project count expands and data quality improves.

Case studies

An important strategy for practising structural engineers in reducing embodied carbon is to be able to explain precedent demonstrations of successful project interventions. For established design and construction methods, these precedents can typically be drawn from a firm's own project portfolio. However, for innovative and newly developed methods – such as the application of circular economy principles – many firms may not have yet completed good case studies to demonstrate viability to a client.

SE 2050 is building a collection of case studies from signatory firms to help share these project precedents, while the SEI Circular Economy Case Studies **(Figure 3)** database expands this resource beyond signatories. The Circular Economy database collects case studies that exemplify good practice in structural component reuse, design for disassembly, and deconstruction. These case studies are published in short summary documents in a filterable, accessible online database, with each project presenting the key participating actors along with a short summary, description of sustainability goals, circular economy strategies, and any key findings, recommendations and lessons learned. The database draws from international projects, but has a particular focus on supporting North American development with local case studies.

Project	Country	Use	Construction	CE principle	CE materials
Chartwell School	United States	Education	New Construction	Structural component reuse, Design for Disassembly	Wood,Steel,Other
Boulder Community Hospital	United States	Healthcare	Deconstruction of Existing Structure for Reuse, New Construction	Structural component reuse	Steel
Green Valley Road Bridge	United States	Bridge	Major Renovation of Existing Structure: Other	Structural component reuse	Steel
Circulating Matters	United States	Other	New Construction	Structural component reuse, Design for disassembly	Wood
Villa Welpeloo	Netherlands	Single-Family Residential	New Construction	Structural component reuse	Steel
K118 Kopfbau Halle	Switzerland	Office	Major Renovation of Existing Structure: Vertical Expansion	Structural component reuse	Steel
Mountain Equipment Coop	Canada	Mercantile	New Construction	Structural component reuse, Design for Disassembly	Steel,wood

FIGURE 3: Snapshot of Circular Economy Case Studies database

Embodied carbon calculation tools

The embodied carbon results of the ECIDs and database analysis are all subject to the influence of the calculation methods and embodied carbon factor databases used. The success in the UK of Elliott Wood and the IStructE's The Structural Carbon Tool (TSCT) has reaffirmed the value in providing an easy-to-use, free and structural-focused calculation tool to engineers to improve literacy and facilitate the use of frequent and standardised carbon calculation within project workflows.

Embodied Carbon Order of Magnitude (ECOM) is a current simplified tool to quickly find the embodied carbon order of magnitude of a scheme. ECOM allows users to determine approximate estimates of embodied carbon using data gathered from publicly available, industry-wide environmental product declarations (EPDs) that are applicable to North America. In most cases, they are the EPDs produced by the applicable trade organisation and constitute LCA modules A1–A3.

ECOM has proven a helpful tool for quick high-level discussions. However, it does not consider LCA modules beyond A1–A3, and it does not allow for easy comparison between schemes, or for variation beyond region-wide average data. To address these limitations, volunteer structural engineers and LCA specialists across North America are working to adapt TSCT for North American use. As part of this effort, the SE 2050 RWG is compiling an expanded database of Product Stage (A1–A3) GWP data for major structural materials in both Canada and the USA. The data aligns with the latest industry-average EPDs and reflects major geographical regions where possible. The adapted tool will also estimate emissions associated with the Transport Stage (A4) and Construction Process Stage (A5). This is expected to become a valuable tool for structural engineers across North America much as TSCT has become in the UK.

Report

Building the sustainability knowledge base of structural engineers and expanding their toolkit are important, but the ability of engineers to reduce their environmental impact is multiplied if the industry is working along agreed frameworks, and if sustainable practice is standardised and mandated. Two important documents have been published that take a major step in this process. Links to both resources are provided in **Box 3**.

Prestandard for Assessing the Embodied Carbon of Structural Systems for Buildings

To simplify the measurement approaches and provide consistency, the members of the SEI Sustainability Committee developed and published an ASCE/SEI Prestandard. The ASCE/SEI *Prestandard for Assessing the Embodied Carbon of Structural Systems for Buildings* recommends scope and a calculation methodology for assessing the embodied carbon emissions of structural systems. It breaks the assessment process into a manageable framework for the user, and introduces four important organising concepts: assessment tiers, material quantities scope and quality, environmental impact data quality, and suitable comparison methods.

Embodied carbon assessments are performed for a variety of reasons, but to be successful they require a clear goal and scope. The Prestandard requires the user to set a goal for the embodied carbon assessment, including the reason for the assessment, the intended audience, and how the results will be used. The Assessment Tier concept **(Table 2)** is used to establish minimum requirements of material quantity data and environmental data so that the assessment to ensure the process will be sufficient to meet the project goal. A Tier 1 assessment is the most simplified level. It focuses only on the primary structure, can use approximate material take-offs, and can use aggregated global or regional secondary data for embodied carbon factors. This tier is appropriate if the user wishes to study a structural system, quantify the cradle-to-gate embodied carbon, and inform

Table 2: Assessment Tier concept*

Tier	Manual approximation	Quantity take-off from design documentation	Contractor submittals or procurement records
Tier 1	A	A	A
Tier 2	P	A	A
Tier 3	N	P	A

Key
A = Allowed; P = Permitted; N = Not allowed
* Reproduced from Table 3-2 of ASCE/SEI *Prestandard for Assessing the Embodied Carbon of Structural Systems for Buildings*

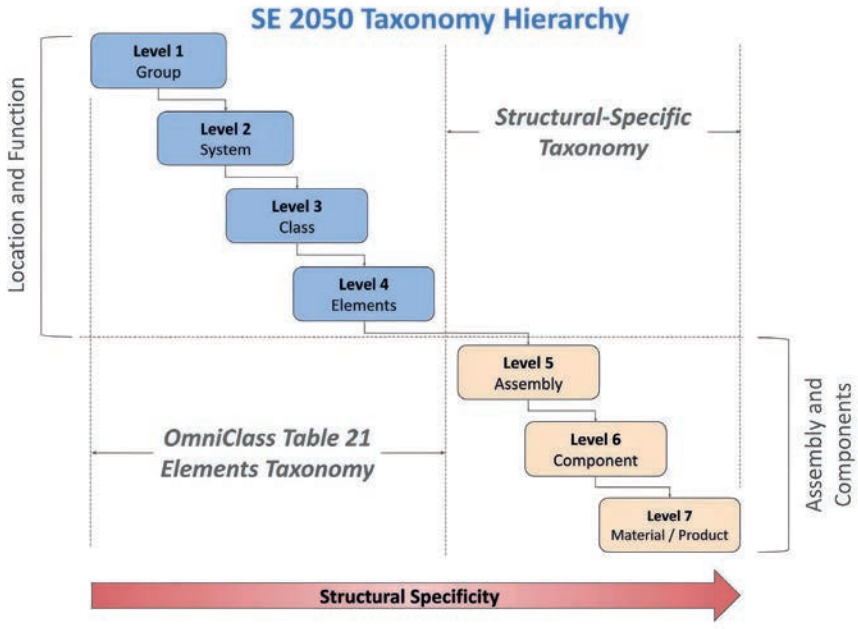


FIGURE 4: Structural Material Quantity Taxonomy hierarchy

early-stage design decisions.

A Tier 3 assessment is the most involved. It requires primary, accessory and ancillary element quantities to be included, based on contractor submittals or procurement records, and using product-specific EPDs. This tier is appropriate for precise calculations and to meet the stringent requirements of some green rating systems.

The Prestandard is peer-reviewed and published with the goal of standardising practices and reducing inconsistencies, but cannot typically be adopted within building regulations. It is under consideration for development into a future Standard which could be mandated for use.

Taxonomy of Structural Material Quantities

The *Taxonomy of Structural Material Quantities* is a new white paper that provides a hierarchical framework for categorising structural elements that can be cross-referenced across embodied carbon calculations. The taxonomy aims to address a gap in how engineers complete their calculations by closing discrepancies in scope for how material quantities and classifications are defined.

The taxonomy proposes a hierarchical framework with seven levels **(Figure 4)**. Levels 1–4 align with select portions of existing taxonomies – Table 21 of the OmniClass construction classification system that includes broad categories such as substructure, shell and interiors. Levels 5–7 build upon this OmniClass basis by introducing additional granularity for structural engineering elements. The implementation of hierarchical frameworks like the taxonomy can strengthen agreement between calculations completed using the Prestandard, and in the consistency and comparability of submission to the SE 2050 database.

Box 3. Report resources

- **Prestandard for Assessing the Embodied Carbon of Structural Systems for Buildings**
  www.structuremag.org/article/assessing-structural-embodied-carbon/
  https://ascelibrary.org/doi/full/10.1061/9780784486399.fm
- **Taxonomy of Structural Material Quantities**
  https://se2050.org/wp-content/uploads/2026/04/SE-2050-SMQ-Taxonomy-White-Paper_FINAL-March-2026.pdf

Conclusions

The UK, and IStructE in particular, have been impressive international thought-leaders on sustainability in structural engineering. However, there are many complimentary sustainability resources and independent developments and initiatives taking place in the North American structural engineering community.

The wider structural engineering industry can benefit from better awareness and familiarity across regions. Many of the resources developed by SE 2050 and the SEI Sustainability Committee can be found at **https://se2050.org** and are available for free.

These groups are always seeking feedback, case study contributions, and volunteer support to continue developing and improving these resources. If you have questions or would like to get involved, please reach out to **contact@se2050.org**.

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