Structural Engineers and the Climate Crisis

Reducing Embodied Carbon through the SE2050 Commitment

By Chris Horiuchi, S.E., LEED AP BD+C, Mark D. Webster, P.E., LEED AP BD+C, Mike Gryniuk, P.E., and Megan Stringer, S.E., P.E., LEED AP BD+C

In response to the scientific consensus that man-made emissions are driving warming global temperatures and other climate changes already causing havoc worldwide, the structural engineering community has created a voluntary program called the SE 2050 Commitment designed to reduce the emissions associated with building structures. This article shares details about the program, what's driving it, its overall goals, and how structural engineers can participate.

Structural Materials Impacts

Globally, the building and construction sectors account for nearly 40% of global energy-related carbon dioxide emissions in constructing and operating buildings. Current building codes and rating systems focus on addressing operating energy but do not typically give as much focus to the impacts *embodied* in building materials and products. However, more than half of all greenhouse gas (GHG) emissions are related to materials management (including material extraction and manufacturing). As building operations become more efficient, these embodied impacts related to producing building materials become increasingly significant. Structural elements, especially those of steel and concrete, serve as the significant carbon contributors of building material embodied carbon.

Climate scientists have determined that we must reduce man-made emissions to net-zero by 2050 to avoid the most calamitous impacts of climate change. Moreover, during the 30 years leading up to 2050, construction-related building emissions carry an even greater weight relative to the emissions associated with building operation (such as heating and cooling) since the construction emissions happen upfront.

What is SE2050?

SE 2050 stands for the Structural Engineers 2050 Commitment Program that encompasses the SE 2050 Challenge issued in 2019 by the Carbon Leadership Forum (CLF) and the SE 2050 Commitment Program developed by the Sustainability Committee of the Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE).

The SE 2050 Commitment Program is being developed with SEI's support in response to the SE 2050 Challenge, which states: *All structural engineers shall understand, reduce, and ultimately eliminate net embodied carbon in their projects by 2050.*

The Program's goal is to provide an accessible sustainability program, for individual structural engineers and structural engineering firms, with an accountable commitment strategy of active engagement on projects and sharing of information, all in the name of achieving zero net carbon structures by 2050.

Through this process, embodied carbon impacts of structural systems will be able to be tracked, trends assessed for various systems, and then achievable reduction targets established over time. This concept is modeled after the Architecture 2030 reduction targets for operational energy; SE 2050 will run parallel to Architecture 2030 and address structural embodied carbon.

continued on next page

Terminology and Concepts

Embodied carbon	The general team used to quantify the total impact of all greenhouse gases emitted (measured in CO_2-equivalent or CO_2-e since the measurement includes greenhouses gases beyond carbon dioxide) into the atmosphere by the extraction, production, transportation, construction, and maintenance of a material, product, or system. In buildings, structural materials generally account for 50% or more of the total embodied carbon. As buildings' and infrastructures' operational emissions trend towards net-zero, embodied carbon becomes drastically more critical to address and reduce. Carbon released during the production of materials and construction of buildings/infrastructure is emitted earlier than carbon released during operation and has a more immediate impact on climate.
Net-zero embodied carbon	When the upfront embodied carbon is reduced to the greatest extent possible. Then, the remaining embodied carbon is offset or sequestered so that the emissions over the building's lifecycle are effectively eliminated.
Carbon sequestration	The process of capturing and storing atmospheric carbon dioxide. Wood and other renewable materials, as well as concrete to some extent, can be used to sequester or "store" carbon within the material.
Life cycle assessment (LCA)	A method of evaluating the environmental impacts, including embodied carbon, associated with various stages of a product's or building's life. These stages include raw material extraction, manufacturing, distribution, construction/assembly, maintenance/repair, and disposal/recycling. For a holistic view of a structural system's embodied carbon, it is essential to conduct a whole building LCA (WBLCA).
Environmental product declarations (EPDs)	Third-party verified reports measuring the environmental impacts, including embodied carbon, of a product or material from a life cycle assessment. The location of a material or product's extraction and manufacturing can significantly influence the magnitude of its embodied carbon, both due to the mix of electricity production at the point of manufacture (e.g., renewable vs. fossil) and transportation impacts. EPDs can be industry-average, representing the impacts of product manufacture as a whole within a region, or product-specific, representing the impacts of a particular product from a particular manufacturer.

The program has four components:

1) **Education**: Educate the structural engineering profession on the best practices of sustainable structural design and construction that will lead to net-zero embodied carbon by 2050.
2) **Reporting**: Engage in an embodied carbon tracking program within the structural engineering profession, thereby enabling the establishment of appropriate embodied carbon reduction targets until net zero is realized. Report on the current embodied carbon impacts and trends of various structural systems for different regions throughout the country.
3) **Reduction**: Reduce embodied carbon in building structures.
4) **Advocacy**: Advocate for embodied carbon reductions among engineers, architects, contractors, owners, and regulators.

Why Should Structural Engineers Participate?

Among the compelling reasons to participate in SE 2050 are to:

- Improve the health and welfare of humankind in accordance with the ASCE *Code of Ethics*.
- Address social inequities posed by climate change.
- Reduce negative environmental impacts of climate change, including loss of biodiversity and species extinction.
- Reduce property damage and costs associated with climate impacts, including sea level rise, storm intensity, and wildfires.
- Meet client demand for consultants that are addressing climate change.
- Improve staff recruitment and retention by addressing a deep concern for many younger engineers.

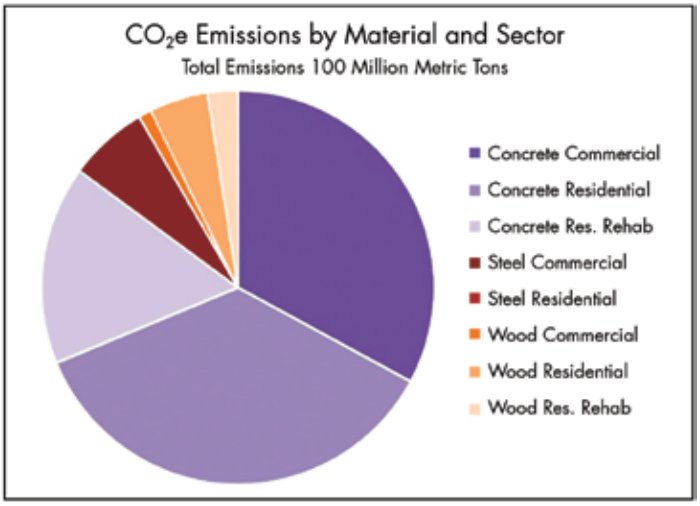
The Role of Structural Engineers

Society will not stop building with steel, concrete, timber, etc., any time soon. But building with improved versions of those materials and materials using emerging technologies will allow us to get to net-zero by 2050.

Getting to net-zero will require changes in both design and construction methods as well as in areas where structural engineers may feel "there isn't anything we can do." Structural engineers are responsible for educating the industry on opportunities for embodied carbon reductions, including demanding the availability of both production and documentation of lower impact materials. After all, any changes to the structure related to embodied carbon must be approved by the Structural Engineer of Record.

The SEI Sustainability Committee published the white paper, *Achieving Net Zero Embodied Carbon in Structural Materials by 2050* (**https://bit.ly/3vPtp3M**) to explain how this necessary goal can be achieved. It is estimated that design improvements by engineers and architects, combined with decarbonizing the electrical grid and advances in material production, can get us there. Sequestration in materials such as timber and concrete will be necessary to avoid relying on carbon offsets.

The paper reports that concrete accounts for over three-quarters of the carbon emissions associated with the three primary structural materials used in buildings (steel, concrete, and timber). Furthermore, over half the emissions associated with these materials are related to residential construction (see *Figure*). Structural engineers can help reduce concrete emissions by specifying mixes with less portland cement. Supplementary cementitious materials (SCMs) such as fly ash and slag can replace cement. Blended cements such as Portland-limestone (Type IL), Portland-slag (Type IS), and Portland-pozzolan (Type IP) with reduced carbon



Annual CO_2e emissions associated with structural materials used in new construction in the United States by building sector.

emissions are becoming increasingly available. New technologies such as CarbonCure and Blue Planet, which sequester carbon in concrete and aggregates, respectively, are further helping drive down the embodied carbon of concrete. Concrete suppliers also are developing lower-carbon concretes, including ECOPact (LafargeHolcim) and EF Technology (US Concrete). Structural engineers can decarbonize concrete and drive market innovation by specifying SCMs, blended cements, and new technologies where appropriate and available.

Substituting responsibly grown and harvested timber for other structural materials is also a promising strategy. Although the carbon cycle of forest ecosystems is complex and not fully understood, many studies suggest that sustainably managed forests can produce wood products that store enough carbon during a building life to offset emissions associated with harvesting, manufacturing, and construction, resulting in net-negative embodied carbon.

The white paper and other references point to numerous other strategies structural engineers can employ to reduce carbon, including material optimization and the use of salvaged materials. The reader is encouraged to review these resources to learn more.

Current Status

Forty-five engineering firms have signed on to the SE 2050 Commitment as of mid-June 2021. The SE 2050 team continues to develop the program and resources.

- The SE2050 team is currently developing specification guidance for reducing embodied carbon, a guide to embodied carbon in green building rating systems in both the U.S. and Europe, and case studies of projects that achieved embodied carbon reductions. Additional resources, including updates to Embodied Carbon Intensity Diagrams (ECIDs) and the ECOM tool, should be published this year.
- The SE 2050 database, made possible through funding by SEI Futures Fund, is currently in development and anticipated to rollout mid-year. A user guide for the database will be published prior to the database release.
- SE 2050 team members and advisors are working to help spread the word on the SE 2050 Commitment Program. Look for local and national presentations from SEI and NCSEA organizations to learn more about embodied carbon and the SE2050 program.

- The team is working to help guide initial signatories and make the process as simple as possible for all engineering firms. The signatory firms' commitment progress is being tracked, and periodic check-ins are scheduled.
- A sponsorship program will soon be published to encourage contributions to the program, allowing improvements to the database, website, and service to participants.

Conclusions

We encourage readers to sign up for updates at **https://se2050.org** and encourage their firm leadership to sign on to the program. Participants in the first year will need to:

- Submit a letter of commitment.
- Within 6 months (and annually thereafter), prepare an ECAP.
- Within one year (and annually thereafter), submit data for some of their projects to the SE 2050 Database. The number of required projects is capped at five in the first year and only embodied carbon needs to be reported. In the future, the database will also collect structural material quantities. All submitted projects will remain anonymous.

Resources

https://se2050.org

https://carbonleadershipforum.org/the-carbon-challenge

The ECAP must include the following elements:

- Education, including assigning an embodied carbon champion and offering an introduction to embodied carbon for all staff.
- A reporting plan describing how your firm will measure, track, and report project embodied carbon.
- Embodied carbon reduction strategies setting embodied carbon reduction goals and implementation plans (qualitative goals focused on education are appropriate for the first year).
- Advocacy, such as outreach to clients about the firm's participation in the program

The SE 2050 Commitment will be good for the climate, good for the profession, and good for your firm. Join us!▪

Chris Horiuchi is an Associate with Skidmore, Owings & Merrill in San Francisco, CA. He is chair of the SEI Sustainability Committee's Disaster Resilience Working Group and a member of the SE 2050 Commitment subcommittee.

Mark D. Webster is a Senior Consulting Engineer with Simpson Gumpertz & Heger in Waltham, MA. He is co-chair of the SEI Sustainability Committee and leads the Resources Group for the SE 2050 Commitment Program.

Mike Gryniuk is an Associate with LeMessurier in Boston, MA. He is chair of the SE 2050 Commitment subcommittee and serves on the steering committee of the SEI Sustainability Committee.

Megan Stringer is an Associate Principal with Holmes Structures in San Francisco, CA. She is active in the SEAOC sustainable design community and also serves as co-chair of the SEI Sustainability Committee.